TIINA KYMÄLÄINEN

SCIENCE FICTION PROTOTYPES AS DESIGN OUTCOME OF RESEARCH

REFLECTING ECOLOGICAL RESEARCH APPROACH AND EXPERIENCE DESIGN FOR THE INTERNET OF THINGS

Aalto University

Tiina Kymäläinen lives in Tampere, Finland, and has a Master of Arts degree. She has been working as a research scientist for more than fifteen years at VTT Technical Research Centre of Finland, where she has been studying emerging technologies – ubiquitous computing, intelligent environments and Internet of Things – from the human-driven and design-oriented perspective. To date, her dearest projects have been the design of virtual space computer game with floor sensor controls (Lumetila, 2001) and an interactive playground for children (UbiPlay, 2003), along with the work presented in this dissertation: the do-it-yourself smart experiences for the Internet of Things. Since Tiina is also a keen science fiction devotee, the dissertation has provided a unique possibility to engage her passion with work. She regards that it pays to give thought to the hypothetical socio-technical conditions and arrangements of the "naturalised" future technologies in the fictional experience environments, given that the human experience in the human-technology relationship ultimately remains more or less the same. This dissertation is Tiina's final demonstration for concluding her studies for the Department of Design at Aalto University School of Arts, Design and Architecture.

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”ME TEIMME TULEVAISUUTTA”, HÄN SANOI, ”JA TUSKIN KUKAAN
MEISTÄ VAIVAUTUI AJATTELEMAAN, MINKÄLAISTA TULEVAISUUTTA
OLIMME TEKEMÄSSÄ. TÄSSÄ SE NYT ON.”

“WE WERE
MAKING THE
FUTURE,”

HE SAID,

“AND HARDLY
ANY OF US
TROUBLED TO
THINK WHAT
FUTURE WE
WERE MAKING.

AND HERE
IT IS!”

Citation from H.G. Wells; *When The Sleeper Wakes* (1899).
Sitaatti: H.G. Wells; *Kun nukkuja herää* (1907), suom. Tero Valkonen.

Abstract

The dissertation introduces science fiction prototyping as an engaging mean of illustrating emerging technology research results. It explicitly demonstrates research that has been carried out for studying user experience in emerging contexts that can be found moving from ubiquitous computing to intelligent environments and, most recently, towards the Internet of Things.

The emergent vision of the Internet of Things has been built upon technologies that augment our environments with unobtrusive, cheap and efficient electronic components: sensors, identification tags, extensive communication technologies, and smart, low-cost devices. These devices are able to communicate via IP networks, either on their own or via intermediate devices; the concept may thus be understood as a network of physical objects accessed through the Internet. The vision is highly technology-driven, however, the empirical research focus for the dissertation has been on placing people in the centre of design. Accordingly, the emergent technologies have been utilised for solving public sector societal challenges: finding means of reacting to the demographic challenges, discovering meaningful activities for the well-being of the aged and people with severe paralysis, and encouraging the social innovation of enthusiastic amateur designers.

The article-based dissertation contains two parts, comprising published articles. The first part introduces four case studies that have aimed at constructing user-driven, do-it-yourself experiences for the Internet of Things. The motivation for the human-computer interaction research lies in the consideration that intelligent ecologies will not emerge in one step, but evolve through the design of the functional, physical environment, an idea introduced by the Ecological Approach to Smart Environments (EASE). The approach has provided the theoretical background for dissertation research by postulating that the users of emerging technologies are expected to be active, to show initiative, and to share, in a do-it-yourself manner, the responsibility for developing their personal technical ecologies. The case studies have been carried out by multidisciplinary research teams, with the objective of building proof-of-concept prototypes. The main contribution of the dissertation lies in demonstrating the design conventions for studying the do-it-yourself experiences: definition of the user ecologies that form around the technologies, the design strategy for carrying out the empirical research, and the critical DIY experiences that form around the technologies. The most significant contribution for the EASE approach is in demonstrating the linking of technology development with social practices through design.

The second part of the dissertation introduces three science fiction prototypes — short stories grounded on extensive user research of the first part — as the design outcome of research. The motivation relates to the acknowledged problem of "high fidelity" prototypes in the emerging technology research context — including the prototypes of the abovementioned research — the assertion being that while focusing on manifesting emerging technologies these are usually "ending up presenting merely incoherent scatter of incompatible technologies that expose only fragments of the field"*. The objectives for the low-fidelity science fiction prototypes of the dissertation were to demonstrate how to employ the grounding research, and how to deliver science fiction prototypes that place the experience design findings meaningfully in the centre of design. The main contribution of the dissertation is in introducing science fiction prototypes as radical, reflecting design outcomes of research — as design artefacts — and the accomplishing of a framework for designing science fiction prototypes that promote the findings of the experience design research in an inciting and thought-provoking manner.

The first set of articles includes internationally peer-reviewed academic publications: four case studies that have been executed in large, nationally and EU-funded research projects, in which the author's contribution has been to organise and carry out the design-oriented research. The second set of articles introduces three science fiction publications, written by the author, that have been equally peer-reviewed by international experts to assess their quality. The dissertation has deliberately pursued the division of these two parts in order to give them a conversational, vis-à-vis, relationship with one another. The focus of research has been on the connecting theme — the experience design — to which both parts have contributed. By way of conclusion, the versatile material presented in the dissertation implies that there is more than one way — even within a single research set up — to design the future for emerging technologies such as the Internet of Things. As far as the material is concerned, it implies the effort of taking into deliberation H.G. Well's notion of paying more attention to the kind of future we are currently making, especially for the people who will eventually be operating, interacting and living in the designed technology-augmented environments.

*
Citation from Greenfield (2006).

Tiivistelmä

TIETEISFIKTIOPROTOTYYPIT UUDEN TEKNOLOGIATUTKIMUKSEN ARTEFAKTITULOKSINA – TUTKIMUSKOHTEENA ESINEIDEN JA ASIOIDEN INTERNETIN KÄYTTÖKOKEMUS JA EKOLOGINEN SUUNNITTELU

Tämä väitöskirja esittelee tieteisfiktioprototyypit keinona kuvata emergentin, vasta kehitteillä olevan, teknologian tutkimustuloksia. Väitöskirjan eksplisiittisenä tutkimuskohteena on uusien teknologisten ekologioiden kehitys, joka on lähtenyt liikkeelle jokapaikan tietotekniikan ja älykkäiden ympäristöjen tutkimuksesta ja siirtynyt nykyisin erityisesti esineiden ja asioiden internetin ihmislähtöiseen kehitystyöhön. Väitöskirjan artikkelimuotoiset tieteisfiktioprototyypit keskittyvät kuvaamaan juuri näitä viimemainittuja teknologisia ekologioita sekä erityisesti niiden käyttökokemukseen liittyviä tutkimuslöydöksiä.

Tutkimuksen teknologiakonteksti, esineiden ja asioiden internet, on tällä hetkellä yksi tietotekniikkatutkimuksen uusimmista ja puhutuimmista aiheista. Esineiden ja asioiden internet viittaa ilmiöön, jossa ympärillämme olevat laitteet ja sensorit — lamput, kodinkoneet, valvonta-, kommunikaatio- ja medialaitteet, kehon sensorit, ajastimet, lämpö- ja kosteusmittarit — kytketään internetiin. Laitteiden ohjaukseen käytetään älykkäitä järjestelmiä, jotka vaihtelevissa määrin ohjaavat itse itseään tai niitä ohjataan käyttäjän taholta. Aihetta tarkastellaan väitöskirjan tutkimuksissa ihmisten itsensä luomista ns. tee-se-itse-, koti- ja vapaa-aikaan sijoittuvista teknologisista ekologioista käsin. Väitöskirjan empiirisiä tutkimuskohteita ovat älykäs vanhusten hoivaympäristö, kehitysvammaisille ja ikääntyville suunnattu musiikkiterapia- ja virikeympäristö, sekä harrastelijasuunnittelijoille tarkoitettu lisättyä todellisuutta hyödyntävä sisustussuunnittelupalvelu.

Artikkeliväitöskirja sisältää kaksi osaa: ensimmäinen osa kuvaa neljä esineiden ja asioiden internetin käyttökokemukseen tähtäävää tapaustutkimusta; toinen osa esittelee kolme lyhyttä tieteisfiktiotarinaa, jotka reflektoivat ensimmäisen osan tutkimuslöydöksiä. Väitöskirjan ensimmäisen osan tutkimusosuuden teoreettinen viitekehys on älykkäiden ympäristöjen ekologisessa suunnittelussa (ÄES), jonka mukaan uudet, älykkäät ekologiat rakentuvat vähitellen ja ihmisten itsensä toimesta. Ekologisen suunnittelun mukaisesti tutkimus toteutetaan yhdessä ihmisten ja pienryhmien kanssa, luovia ja osallistavia tutkimusmenetelmiä hyödyntäen. Väitöskirjan ensimmäisen osan tulokset keskittyvät kuvaamaan kuinka ekologiaympäristöjä tutkitaan käytännössä ja kuinka tutkimus toteutetaan; kuinka valitaan käyttäjät ja menetelmät; miten tutkitaan käyttökokemuksia ja kuinka rakennetaan prototyyppejä esineiden ja asioiden internet -teknologiaa hyödyntäen. Prototyypeiksi voidaan kutsua myös toisen osan tutkimusta reflektoivia tieteisfiktiotarinoita. Suurin motivaatio väitöskirjan tieteisfiktioprototyyppien kirjoittamiseen on ollut siinä, että teknologisessa tutkimuskontekstissa rakennetut prototyypit keskittyvät yleensä suurimmaksi osaksi demonstroimaan tekniikkaa, mutta usein juuri tuon teknologiavetoisuutensa vuoksi jäävät ekologia- ja käyttökokemuskuvauksiensa osalta kesken tai vajavaisiksi. Siksi tulevaisuuden kuvitteellisiin käyttöympäristöihin sijoitettujen tieteisfiktiotarinoiden tavoitteena on ensisijaisesti kuvata miltä esineiden ja asioiden internet näyttää ja tuntuu, sekä syventyä siihen mikä on tutkittujen uusien teknologiaekologioiden syvempi merkitys ihmisille arjen käyttökokemuksena. Vaikka väitöskirjan tieteisfiktiotarinat perustuvat suurimmaksi osaksi ensimmäisen osan tapaustutkimusten tuloksiin, niitä on täydennetty myös muilla — tieteellisillä, taiteellisilla ja filosofisilla — lähteillä. Siten väitöskirjan tieteisfiktiotarinat voidaan käsittää sekä radikaaleiksi, rinnakkaisiksi ja uudenlaisiksi tutkimustuloksisiksi, että taiteellisiksi artefakteiksi.

Kaikki väitöskirjan artikkelit ovat läpikäyneet kansainvälisen vertaisarvion. Väitöskirjan artikkeleita koottaessa asetelma on harkitusti sommiteltu niin, että väitöskirjan kaksi osaa ovat vuoropuhelussa keskenään. Molemmat osat edistävät omilla ominaisilla tavoillaan esineiden ja asioiden internetin käyttökokemuksen tutkimusta ja ekologista suunnittelua. Asetelman tarkoitus on osoittaa, että yhdessä tutkimuskontekstissa on mahdollista hyödyntää sekä tieteellisiä että taiteellisia — sekä rinnakkaisia että toisiaan täydentäviä — keinoja, joiden avulla voidaan myötävaikuttaa sellaisten emergenttien tulevaisuuden teknologioiden suunnitteluun kuten esimerkiksi esineiden ja asioiden Internet. Väitöstyö toivottavasti tukee H.G. Wellsin huomautusta siitä, että välillä on syytä pysähtyä ajattelemaan millaista tulevaisuutta oikein olemme luomassa. Siksi väitöstyön tärkeänä tehtävänä on myös jakaa tietoa emergenteistä teknologioista, varhaisessa kehitysvaiheessa — ja ymmärrettävässä muodossa — niille ihmisille jotka kuitenkin lopulta elävät arkensa näiden uusien teknologioiden keskellä.

List of publications

The dissertation is based on the following original publications that are referred to in the text as I–VIII. The publications are reproduced by kind permission of the publishers.

DESIGN-ORIENTED RESEARCH
Smart do-it-yourself experiences for the Internet of Things

KYMÄLÄINEN, T., HEINILÄ, J., TUOMISTO, T., PLOMP, J., AND URHEMAA, T. 2012. Creating Scenes for an Intelligent Nursing Environment: Co-design and User Evaluations of a Home Control System. In: *The 8th International Conference on Intelligent Environments* (IE2012), June 2012, Guanajuato, Mexico, 87–94.

KYMÄLÄINEN, T. Something to Remember Me by – Constructing Social Media Service for Seniors, In: *ACM Computers in Entertainment*; ACM Publication (Forthcoming).

KYMÄLÄINEN, T. AND SILTANEN S. 2013. Co-designing Novel Interior Design Service That Utilizes Augmented Reality: a Case Study. In: Cipolla-Ficarra, F. V. (Ed.) *Advanced Research and Trends in New Technologies, Software, Human-Computer Interaction, and Communicability,* IGI Global, Hershey, PA, 269–279.

LUHTALA, M., KYMÄLÄINEN, T. AND PLOMP, J. 2011. Designing a music performance space for persons with intellectual learning disabilities. In: *Proceedings of the International Conference on New Interfaces for Musical Expression* (NIME), May 2011, Oslo, Norway, 429–432.

KAASINEN, E., KYMÄLÄINEN, T., NIEMELÄ, M., OLSSON, T., KANERVA M. AND IKONEN V. 2012. A User-Centric View of Intelligent Environments: User Expectations, User Experience and User Role in Building Intelligent Environments. In: *Computers*, 2.1, 1–33.

RESEARCH-ORIENTED DESIGN
Science fiction prototypes as design outcome of research

KYMÄLÄINEN, T. 2013. IF Alice Arrives, THEN Wonderhome Adapts. In: *Workshop Proceedings of the 9th International Conference on Intelligent Environments*, Cloud of Things, Athens, July 2013. IOS Press, Netherlands, 262–273.

KYMÄLÄINEN, T. 2013. Dreamnesting – Co-created future vision of an intelligent interior design experience. In: *FUTURES*, Special Issue: Exploring Future Business Visions by Using Creative Fictional Prototypes, vol. 50, Elsevier, Amsterdam, 74–85.

KYMÄLÄINEN, T. 2011. Song of Iliad. In: *Workshop Proceedings of the 7th International Conference on Intelligent Environments*, Nottingham, England, July 2011. IOS Press, Netherlands, 185–196.

Author's contributions

ARTICLE I: main author. The article explains the development and co-design process of the Home Control System prototype. In the case study, Kymäläinen was mainly responsible for the user research and solely responsible for the co-design processes. The aim of the design-oriented research — the author's contribution — was to define the requirements of the nursing ecology for the system; how the system could support the daily tasks and routines of the patients in the nursing environment.

ARTICLE II: sole author. The article describes how the evaluations and co-design processes are reflected in the experience design of a Life Story Creation application prototype, and the contribution to value-centred design and value-sensitive design. The author's contribution to prototype development was to plan and conduct the user research: the initial acceptance evaluations and the longer period for observation and co-design regarding the prototype.

ARTICLE III: main author. The main author's contribution was to explain the background of the co-design process for the Interior Design Service presented, while the second author, Sanni Siltanen, described the technological context and findings relating to augmented reality (AR). The main author's contribution regarding the studies was the co-design process of the case study. Tasks as part of the research group involved the creating of scenarios, benchmarking of existing applications and conducting of a preliminary questionnaire for the end users and Pro-Am users.

ARTICLE IV: second author. The article describes prototype development and evaluations for the Music Creation Tool. As second author, Kymäläinen was responsible for the user research carried out in the project in the form of two evaluation sessions arranged with the music therapist and the end users. The first author was responsible for creating the Music Creation Tool and assisting in the evaluations.

ARTICLE V: second author. The second author contributed to the introduction and Chapter 5: "Users as co-crafters of intelligent environments", which presents a summary of the findings in relation to Articles I, II and IV.

ARTICLE VI: sole author. The article presents a science fiction prototype of Articles II and I.

ARTICLE VII: sole author. The article presents a science fiction prototype of Article III.

ARTICLE VIII: sole author. The article presents a science fiction prototype of Article IV. The prototype won the Creative Science Foundation's best science fiction prototype award at Nottingham Trent University on July 2011.

Contents

Preface

I have been involved with technology research and human-computer interaction at VTT Technical Research Centre since 1999. During this time, I have had the opportunity to take part in research from the earliest days of seeking to develop intelligent environments, complex technical systems, and research prototypes in a user-centred manner. My role in the research has been connected with user-centred design, user experience research, the deployment of various creative means for user research — sketching, co-design, visualisations, paper and animation mock-ups — and more concrete design tasks relating to user interface design — design of graphical user interfaces and graphic layout models, interaction design, concept design and various kinds of prototyping. This previous research has greatly influenced the forming of this dissertation, and many dear fellow researchers over the years — too numerous to mention — have helped me structure my thinking and, eventually, assisted in the maturing of this dissertation.

Regarding the foundational settings for the dissertation, I first and foremost kindly thank the Department of Design at Aalto University School of Arts, Design and Architecture for choosing my research plan suitable for their doctoral programme. I wish to express my appreciation to my supervising professor, Professor Turkka Keinonen, Head of Research, who first helped me to get started and, eventually, to structure and finish the project. I am also deeply grateful to Associate Professor Sampsa Hyysalo, the thesis advisor, who encouraged me to keep to the schedule, and arranged a doctoral candidate position for me in his INUSE research group. He has been a great inspiration to me and a group of fellow doctoral candidates during the theoretical studies in teaching us how to perform research. Subsequently, I am deeply grateful to the pre-examiners, Dr Jeannette Chin and Professor Giulio Jacucci, for their insightful comments and suggestions for accomplishing a high-quality publication of the dissertation. Eventually, I feel immensely privileged in having respectable Emeritus Professor Victor Callaghan acting as the external examiner of my dissertation.

Regarding the empirical work, I gratefully acknowledge the primary support given by VTT Technical Research Centre of Finland, my employer, in providing me with the opportunity to work in the engaging case studies that have formed the grounding work for this dissertation. The research for the first part of the dissertation was studied, for the most part, in the European research programme DiYSE: Do-it-Yourself Smart Experiences[a], which aimed at enabling ordinary people to create, set up and control applications for the Internet of Things. One of the case studies was carried out within the national Adfeed project, which was a project supported by TEKES as part of the Next Media programme of TIVIT — Finnish Strategic Centre for Science, Technology and Innovation in the field of ICT. My chief gratitude concerning these projects is towards the DiYSE project leader in Finland, Johan Plomp, who supervised most of the cases, and accordingly set out the research composition for the dissertation. I give grateful thanks to my current team leader and former HCI coordinator, Doctor Eija Kaasinen, who gave me a shoulder to lean on in commenting on my first research plan, and on the final dissertation manuscript. Warm thanks go all my friends and colleagues who were close to me at the time of my carrying out the research for the dissertation: Timo Tuomisto, especially for the philosophical conversations while developing the nursing home system for Alice, and for constantly reminding me that we were developing these systems for ourselves as well; doctoral candidate Sanni Siltanen, for walking the uneven doctoral candidate path together with me, and sharing interesting debates regarding emerging technology research; and Doctor Virpi

Oksman, for postulating the research set up for the Adfeed project. Warm thanks are also due to all the other dear colleagues and friends who worked with me in the projects: Juhani Heinilä, Timo Urhemaa, Doctor Pasi Välkkynen, Hanna Lammi, Matti Luhtala, Janne Laitinen, Markus Niiranen, Antti Väätänen, Minna Kulju and Minni Kanerva. I also warmly thank my former technology manager, Doctor Petteri Alahuhta, who provided great inspiration for beginning the work; subsequent technology manager, Doctor Tuomo Tuikka, for providing advice during the work; my team leader, Doctor Paula Savioja, and the Head of Research Area, Doctor Riikka Virkkunen, for their support in finalising the dissertation.

Regarding the inspiring people in the Aalto University School of Arts, Design and Architecture I am gratified I came to know the other doctoral candidates in the Department of Design, whose work in the seminars and doctoral courses I admired, as well as the critical and creative Master of Art students for whom I supervised, and with whom I worked. The dissertation work has also been profoundly stimulated by other departments in Aalto University School of Arts, Design and Architecture. Fate of Place, a philosophical reading group organised by Professor Laura Grödahl, provided deep food for thought, as did the screenwriting research network coordinated by Kirsi Rinne; both from the Department of Film, Television and Scenography. I wish also to thank the Graduate School in User-centred Information Technology (UCIT)[b] for the financial support, and for providing interesting lectures for the theoretical studies.

Yet most of all, I thank the serendipitous incidence of coming to know about the call for papers organised by the Creative Science Foundation[c] – a society that arranges forums, workshops and publication channels with the aim of finding means for interested parties to collaborate and publish creative science work. The incidence restructured the contribution of this dissertation profoundly, by introducing "a space-time vortex" that made possible the paradoxical combination of work and a passion for writing speculative science fiction. I express my deepest gratitude to all the creative scientists I was privileged to meet in conferences and workshops organised by the foundation, especially Brian David Johnson, futurist at Intel, who introduced the science fiction prototyping method and provided inspiration through his work and conversations. Finally, I am deeply grateful to all the anonymous reviewers who reviewed the papers and articles for this dissertation, especially for their witty and extremely valuable comments and great insights.

Ultimately, I am bound to acknowledge that none of this work could have been accomplished without the support and encouragement of my family. My heartfelt thanks go to my husband Timo, daughter Aada and son Ilmari, all of whom not only gave me mental support and endless encouragement, but kept my feet firmly on the ground. They also provided stimulation, and concrete evidence of the technology-mediated do-it-yourself culture: from creating 3D worlds in Minecraft and custom-made fabrics through an online service, to the sharing of do-it-yourself videos on Youtube, all the way down to building physical controllers for online simulator games. I am also deeply grateful to my parents-in-law, Ritva and Paavo Kymäläinen, and my parents, Emeritus Professor Kari Törmäkangas and Doctor Raili Törmäkangas, for their manifold support.

a. http://dyse.org/ Retrieved 11:57, 21 November 2013

b. The cooperation of several Finnish universities that teach and study humans and information technology.

c. http://www.creative-science.org; retrieved 14:56, 4 April 2014

LIST OF ABBREVIATIONS

AI	Artificial intelligence
AmI	Ambient intelligence
AR	Augmented reality
DIY	Do-it-yourself
EASE	Ecological Approach to Smart Environments
HCI	Human-computer interaction
IE	Intelligent environment
IoT	Internet of Things
IP	Internet protocol
IT	Information technology
RFID	Radio-frequency identification
RtD	Research through design
SFP	Science fiction prototype
Ubicomp	Ubiquitous computing
UCD	User-centred design
UI	User Interface
UX	User experience
VR	Virtual reality

1 Introduction

THIS ARTICLE-BASED DISSERTATION introduces research on complex system development that encompasses three large domains (see Figure 1): emerging technology research, human-computer interaction (HCI), and design. The first domain engages mainly computer science and various other engineering disciplines. Because development and engineering usually drives emerging technology research, this domain has played a dominant role in the multidisciplinary research presented in this dissertation. The second domain, HCI, operates within, or in close cooperation with, the technology development disciplines, and study in this field is of the role of the human in system development, covering e.g. behaviour, acceptance, and experiences towards the technologies. This dissertation, however, primarily belongs to the field of design. Therefore the

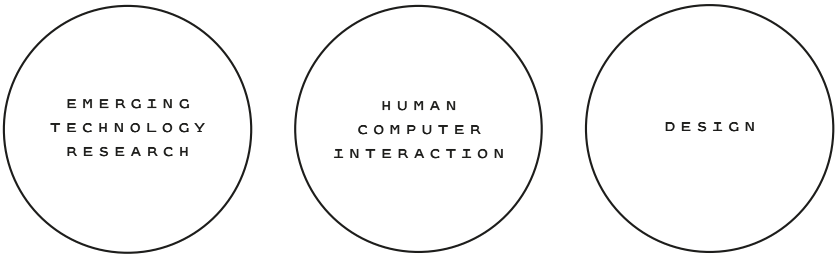


Figure 1.
The three domains addressed by the dissertation.

strong underlying perception lies in how the field of design is positioned next to, and in comparison with, the other two fields. Self-evidently, overlapping cannot be avoided, and the terminology of the accompanying fields needs to be explained.

This article-based dissertation presents an introduction, an extensive background research of the three domain areas, research gap formulation, theoretical background, formulation of the research questions, stating of the objectives, and two parts that comprise published articles. The extensive background review of the domain areas is due to the dissertation encompassing the three large domains mentioned above. The review has important aims: to clarify the emerging technology domain, starting from research on ubiquitous computing and concluding with that on the Internet of Things; to illustrate the human-computer interaction domain vividly through a practice-oriented review; and, eventually, to move into the design domain by contemplating designer's role in research. The following chapters serve to explain the main gaps, namely the challenges relating to emerging technology research, HCI and design, and to clarify the theoretical background and key research, namely the main theories, the do-it-yourself culture and experience design that represent the ultimate focus of the research, and ultimately, the science fiction prototypes that represent the final design outcome. The dissertation proceeds by formulating the research questions and objectives, and by considering the dissertation's contribution to the design discipline. The rest of the dissertation is divided into two sections: the first part introduces the research findings of four case studies aimed at designing user-driven, do-it-yourself experiences for the Internet of Things; the second part introduces three science fiction prototypes, which are short stories grounded on extensive user research of the case studies in the first part.

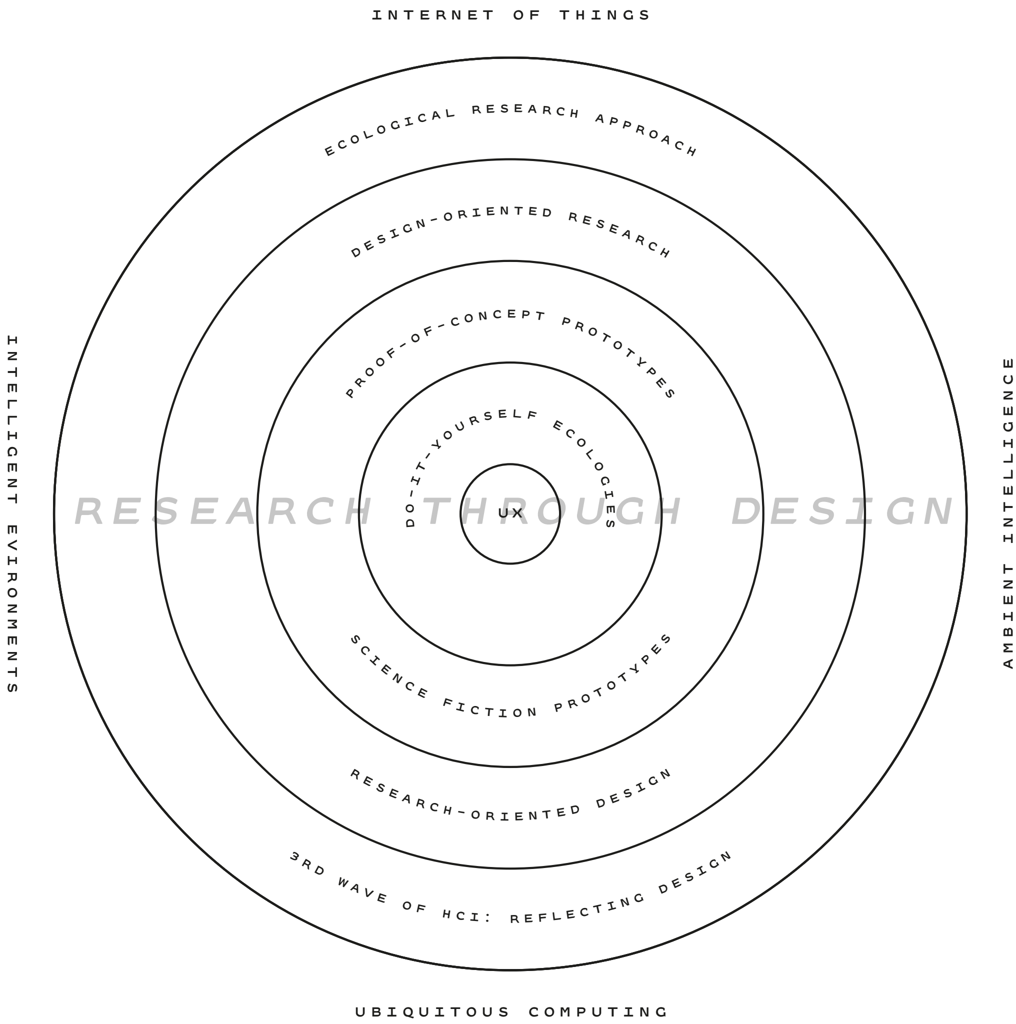
The motivation for research is related to the modularity and messiness interwoven with the emerging technology infrastructures (Harrison and Dourish, 1996; Bell and Dourish, 2007). Controversially, the dissertation is taking the stance of considering modularity and messiness as an asset, and a starting point for emerging technology research. However, the modularity and messiness quickly leads to the conclusion that there are difficulties in considering the arrangements for the technology research holistically. Holistic considerations are nonetheless necessary, when the main objective of the dissertation research is to place people in the centre of design. When reflecting the HCI research setup against this background, it becomes obvious that the research should provide opportunities for people to be affected by the systems in order for them to participate and influence the design processes (Schuler and Namioka, 1993; Greenbaum and Kyng, 1991; Thackara, 2005). The focus of enquiry then shifts from user needs and requirements towards the understanding of individuals, their concerns, desires, aspirations, values and experiences (Wright, Wallace and McCarthy, 2008). In this new research setup it is then the user – not the designer – who creates and communicates meaning (Dourish, 2006). Consequently, this leads to a situation in which the role of the designer in HCI transforms. For example, Kuutti (2009) remarks that it should be understood that when the new design solutions emerge the entire system changes – and this includes as well as the user as the designer. Subsequently, there is apparently a need for a third wave of design practices, based on design judgement and creative design, that recognises the transformed role of the designer in the creative design practice within HCI (Löwgren 1995; Bødker 2006; Wolf et al. 2006).

The main objective of the first part of the dissertation has been to demonstrate the concrete manner in which the do-it-yourself creation conventions may be employed for design-oriented research: how to choose the participants; what methods to use; how to study the technology in context of use, and how to study experiences in the Internet of Things domain. The demonstrating case studies are carried out by multidisciplinary research teams, in which the programmatic research aim has been to build proof-of-concept prototypes. Nevertheless, with regard to emerging technology research, the shared problem in all disciplines is the difficulty of using traditional scientific approaches in research. According to Zimmerman et al. (2010) this is a challenge mainly because of the difficulty – if not impossibility – of controlling the many relationships between variables in a situation where the research aims for distinct outcomes. As in the end, technology development, design research and HCI theories all reside implicitly within the resulting outcome of research – the constructed holistic artefact[1], which usually takes the form of a prototype.

The main contribution of the second part of the dissertation is the introducing of science fiction prototypes as radical, reflecting design outcomes of research. The objective for the "low fidelity" science fiction prototypes is to provide a more holistic and focused perspective for Internet of Things technologies in the nominated ecologies; the prototypes also consider motivational aspects of using the systems, socio-technical issues, and ultimately place the technologies in imaginary everyday settings. The design artefacts re-design the research settings by illustrating new experience environments: a nursing home for the aged, a music creation and sharing ecology for disabled children, and new means of creating and sharing the interior designs produced by amateur enthusiasts. In essence, the prototypes aim at illustrating the long-term use of IoT technologies and opportunities, in order to present how people will actually come to live with the emerging technologies.

The main contribution of the dissertation is explained in the nutshell in Figure 2. The Internet of Things, the emerging technology research domain, in this context has important contributing research agendas that require careful explanation. These preceding agendas involve research on ubiquitous computing (ubicomp), ambient intelligence (AmI), and intelligent environment (IE), which the dissertation will go on to clarify more specifically. The next layer of the nutshell is the field of HCI – for which the dissertation provides a contribution by employing the theoretical background of the Ecological Approach to Smart Environments (EASE) (Kaasinen and Norros, 2007) and evidence of the third wave of HCI (Bødker 2006) that has been introduced in the dissertation as reflecting design. The conceptual aim for the fields of design and HCI is to demonstrate the division of the two distinct design approaches that have emerged within HCI – design-oriented research and research-oriented design (Fallman, 2007) – and how they may contribute to emerging technology development processes. The dissertation's practical contribution is the production of high- and low-fidelity prototypes, the latter being designed explicitly in the form of science fiction prototypes (Johnson, 2011a). In Figure 2 these two practical contributions form the framing of activities. In essence all the design investigations may be considered as falling under the methodology that Zimmerman et al. (2010) entitled "research through design" (RtD) and specifically proposed for any processes that aim at iteratively design artefacts as a creative way of investigating potential futures. Conclusively, the fundamental objective of all the design investigations is to study the phenomena — the do-it-yourself ecologies — and particularly the experiences that emerge from the context of use. All these concepts constructing the nutshell in Figure 2 will be explained, layer by layer, in the following parts of the dissertation.

Figure 2.
The contribution of the dissertation in a nutshell.



1
The explanition how an artefact is understood in this disseration can be found from Appendix A.

2 Background of the domain areas

GENERALLY SPEAKING, ANY technological enrichment of our environments is tempting, because it is expected to provide unforeseen opportunities, new functionalities, consequent new experiences, and eventually even new perceptions of the world. Augusto (2007) elucidated this by saying that whether it is our home anticipating our needs and forecasting dangers, a transport station facilitating commuting, or a hospital room helping the care of a patient, there are strong reasons for believing our lives will be transformed in the coming decades by the introduction of a wide range of devices equipping many diverse places with computing power. Cook et al. (2009) enumerated the expected benefits of the emerging technologies as follows: increased safety, e.g. by monitoring lifestyle patterns or recent activities and by providing assistance when a potentially harmful situation is developing; comfort, e.g. by adjusting lightning or temperature automatically; and economy, e.g. by controlling the use of electricity and lights. Greenfield (2006) and Callaghan et al. (2009) perceived that computing equipped with tangible, gestural, and audio-channel interfaces is set to inhabit a far larger number and variety of places in the world than can be provided for by more conventional methods.

The following introduction to the emerging technology domain clarifies the most relevant concepts and research agendas regarding this dissertation: ubiquitous computing (ubicomp), ambient intelligence (AmI), and intelligent environment (IE), closing with the Internet of Things (IoT). Although these agendas for emerging technology research have been highly technology-driven, the dissertation approaches the concept from the human-computer interaction perspective, in which the research may be understood as the development of service ecologies. In essence, the dissertation has a strong emphasis on the user perspective, as in the empirical research the technical systems are constructed piecemeal and supplemented when necessary, in a do-it-yourself fashion. After introducing the technological research agendas, the introduction will illustrate the design-oriented human-computer interaction (HCI) research through a practice-oriented review that sheds light on the mechanisms people might employ when interacting with the new technologies. The chapter concludes with contemplation of the designer's role in research within the domain areas that have been firstly introduced.

2.1 EMERGING TECHNOLOGY RESEARCH

The emerging technology research domain is understood in this dissertation covering the technologies that pervade the environment from the traditional desktop: beginning with ubiquitous computing research and concluding with research on the Internet of Things. The domain introduction has the ultimate intention of stretching behind the latter term, since the Internet of Things is the most recent research agenda for emerging technology research — and the nominated technological context for the research carried out in this dissertation. The introduction will nevertheless first explain the historical relation of IoT to the preceding visions and research agendas. Ubiquitous computing (ubicomp) is an important concept, because all the others — including IoT and IE and others mentioned briefly — have evolved from it. The most substantial concept with regard to this dissertation, however, may be seen to be intelligent environment (IE) research, for this provided the background theories on which the conducted research rigorously leans. Ambient intelligence (AmI) is introduced here mainly because of its significance for the second part of the dissertation.

2.1.1 Ubiquitous computing

In the 90s, practically coinciding with the birth of the Internet, another influential technological vision was taking shape, to be given the name ubiquitous computing[2] (ubicomp). This vision greatly affected subsequent emerging technology research agendas, most recently the emergence of the Internet of Things, since much the same vocabulary has been repeated when describing its qualities. Mark Weiser (1991) was responsible for coining the term and publishing the vision for "the computer for the 21st century". His core testimony was that *"the most profound technologies are those that disappear; they weave themselves into the fabric of everyday life until they are indistinguishable from it"*. The highest ideal in ubiquitous computing is

2 Oxford Dictionary and Thesaurus defines the adjective "ubiquitous" to mean: present, appearing, or found everywhere (Augusto, 2007).

thus to make computers so embedded, so fitting, and so natural that they could be used without thinking. Dourish and Bell (2011) since labelled Weiser's vision a "technomyth", calling it a foundational story within computer science. They elucidated this technomyth as a motivation and celebration of the development of the ubiquitous computing agenda, in ultimately having shaped the technologies and given them meaning.

From the many definitions of ubiquitous computing, the following quotation by Mark Weiser (1993) is chosen here (because of its convenient allegory to literacy):

> "A few thousand years ago people of the Fertile Crescent invented the technology of capturing words on flat surfaces using abstract symbols: literacy. The technology of literacy, when first invented, and for thousands of years afterwards, was expensive, tightly controlled, precious — today it effortlessly, unobtrusively, surrounds us. Look around now: how many objects and surfaces do you see with words on them? Computers in the workplace can be as effortless, and ubiquitous, as that. Long-term the PC and workstation will wither because computing access will be everywhere: in the walls, on wrists, and in "scrap computers" (like scrap paper) lying about to be grabbed as needed. This is called ubiquitous computing."

This description defines ubiquitous computing as a vision of computing power that embeds invisibly in the surrounding environment and is accessed through intelligent interfaces. The vision has been interpreted as a continuum of the personal computer revolution, which Cook and Das (2007) projected to originate in a progressing computing industry and falling costs, leading to a situation in which one user is able to access more than one computer. This refers to the three waves of computing: the mainframe age — when many people share a single computer; the personal computer wave — when one person has the possession of one computer; and the ubiquitous computing wave — when each person shares many computers (described e.g. by Cook and Das, 2004). Emerging technologies are repeatedly described as being strongly reliant on the continuing validity of Moore's law[3] (Moore, 1965). The law implied that as the prices of processors fall dramatically, and computing power begins to permeate the world, we can afford to spend power freely, even lavishly, with the result that computing resources can be brought to bear on comparatively trivial tasks (Greenfield, 2006). It should be noted, however, that in the ubicomp vision, Weiser highlighted the role of totally human-centred computing, where the technology is no longer a barrier, but "works for us, adapts to our needs and preferences, but always remains in the background until required".

In being such an influential and persistent vision for computer science, ubiquitous computing has not been spared from critique. According to Greenfield (2006), Weiser initially never intended "ubiquitous" to mean anything but locally ubiquitous, present everywhere "in the woodwork" of a given, bounded place — not literally circumambient, embracing the entire world. Greenfield based his critique on the fact that the Web was not widely adopted at the time the vision was created. Bell and Dourish (2007) criticised the utilisation context of Weiser's ubiquitous computing technology; as according to them, the technology was originally intended for tightly restricted workplaces, and as such relied on large fixed infrastructure investments by commercial entities, and were mainly directed towards the needs of corporate efficiency. In addition, the flawless and seamless vision did not contemplate the messiness and obvious "seams" of the real world (ibid.). Bell and Dourish also criticised the undertone of the vision as being heavily biased towards the "proximate future", which continually placed its achievements out of reach while simultaneously blinding towards current practices.

It has been claimed that the many subsequent research agendas since ubiquitous computing have in fact been competing narratives determined by influential technology enterprises (Dourish and Bell, 2011). Ambient intelligence, which will be expanded on further, was the research interest at Philips (Aarts and Marzano, 2003), pervasive computing[4] was on the research agenda at IBM (Aark and Selker, 1999) and proactive computing[5] the focus of interest at Intel (Tennenhouse, 2000). These were the most notable endeavours, yet there were more — for example, social computing, affective computing and context-aware computing — that this dissertation, however, makes no allusion to. There have also been other, not merely technology-driven approaches that have a common denominator in their holistic approach to technology, such as everyday computing (Abowd and Mynatt, 2000), embodied interaction (Dourish, 2001b) and everyware (Greenfield, 2006). In later considerations, Weiser with Brown (1996) similarly remarked that the main problem in the computer-mediated information of a poorly designed ubicomp was that it caused people overload and increased stress, and they anticipated that the total cognitive burden imposed on the average user would become intolerable. They suggested a strategy for designing systems "that inform without overburdening" and labelled the approach as calm computing[6], which they stated to require different sets of interface modes compared to conventional systems. As a result, Weiser and Brown expected designers to craft calm interfaces, and justified this as a "sensible and humane thing to do". Although all consequent research agendas after ubiquitous computing have somewhat fragmented the original vision, they have also sharpened the focus and elaborated upon the nominated ideas and technologies.

A brief look at the relevant IoT literature (e.g. Atzori et al., 2010; Roelands et al., 2011; Miorandi et al., 2012; Gubbi et al., 2013) verifies the obvious historical continuum from ubiquitous computing to the Internet of Things. Gubbi et al. (2013), for example, have clearly identified that "we are now living the post-PC era where smart phones and other handheld devices have changed the environment to be more interactive and informative". However, if the ubiquitous computing vision is carefully re-examined, the integration of information technology into our lives still apparently falls short according to Weiser's standards. This is obvious, for example, if the contemporary perception of the technology-mediated environment is measured against Weiser's concluding statement in "The computer for the 21st century" (1991): *"There is more information available at our fingertips during a walk in the woods than in any computer system — yet people find a walk among trees relaxing and computers frustrating. Machines that fit the human environment instead of forcing humans to enter theirs will make using a computer as refreshing as taking a walk in the woods."*

2.1.2 Intelligent environments and ambient intelligence

The main influence for the Internet of Things research in this dissertation has been inherited from the intelligent environment research domain. In essence, the concept of intelligent environments was already included in the

3 Moore's law (1965) is one of the most influential observations in the history of computing. The prophecy pointed out that the prevailing industry trend was that ever greater numbers of transistors would be packed into an ever smaller space, with the number of transistors per unit area approximately doubling every 24 months, although in many later articles this has turned into an 18-month period. Moore's specific prophecy was: "Certainly over the short term this rate can be expected to continue, if not to increase. Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least ten years" (in p. 83).

4 Pervasive computing envisioned seamless application support that is executed on sets of networked computers integrated invisibly into everyday objects (Augusto, 2007). The main difference between ubiquitous and pervasive computing is that in the latter the devices are repetitively described as mobile (Saha and Mukherjee, 2003).

5 Proactive computing interest was in machine learning, data processing and algorithms, as well as personal experiences with digital technologies (Tennenhouse, 2000).

6 Calm computing was described as the technology "that informs but doesn't demand our focus or attention". Calm computing promotes technologies that enrich our lives by seamlessly capturing what goes on at the periphery (outside our attention) and bringing it to the centre of attention when needed (Weiser and Brown, 1996).

ubicomp vision as, according to Cook and Das (2004), Weiser himself defined a smart environment as "the physical world that is richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives, and connected through a continuous network". The definition is all embracing, and sounds remarkably similar to the forthcoming definition of the Internet of Things. The dissertation thus prefers to concur with the definition of IE defined by the discipline[7]:

> "Intelligent environments (IEs) use networked computing technology to create environments that are sensitive and responsive to the presence of people. Such environments are as varied as the places people inhabit encompassing settings such as homes, classrooms, factories, transport, clothing and online virtual worlds. They are constructed using a mix of innovative software and hardware concepts and, as such, promote the efficiency of transactions and activities, facilitate presence and participation, improve user experience and enable better or new lifestyles or methods of production."

Unmistakably, IE emphasises the idea in Weiser's original vision that the traditional computer and display no longer provide the only windows on the virtual world; computers will become scattered and embedded all around us, in a variety of devices, objects and locations. The advanced interaction techniques in IE suggest that communication takes advantage of natural interaction techniques; people are able to interact with computational systems in the way they would interact with other people. Coen (1999) suggested that in some sense the aim has been to make people interfaces for computers rather than computer interfaces for people; IE systems use cameras for eyes, microphones for ears and, ever-increasingly, a wide-range of sophisticated sensing technologies to connect with the real-world phenomena. The sensing technologies are able to detect a person's identity, position, gaze direction, voice analysis, facial expression, skin conductivity, activity and gestures within the environmental settings. Communication from the environment to the user also becomes highly distributed, and available in many form factors and modalities (Abowd et al., 2002). Abowd et al. perceived that the advance of these sensing and recognition technologies will challenge us to provide more human-like communication capabilities, and to incorporate implicit actions effectively into the subset of meaningful systems. Brummit et al. (2000) assumed that the need for perceptual information about the state of the world further differentiates intelligent environments from traditional computing. This means, for example, that the sensing devices allow the system to have context-sensitive information about locations, places, things, and other devices in the environment.

Lee and Hashimoto (2002) explicated IE as being capable of observing what is happening within the environment, building a model of the environment, communicating with the inhabitants and acting based on the decisions the inhabitants make. According to Cook and Das (2004), the most critical feature that separates intelligent environments from environments that are user-controllable is their ability to model inhabitant behaviour. They determined that an intelligent environment is able to acquire and apply knowledge about the environment and its inhabitants in order to improve the inhabitants' experience in that environment. By this they imply to artificial intelligence (AI)[8], which in most IE definitions is considered to be the key property in turning a conventional environment into an intelligent one. The environment is thus willing to serve spontaneously and proactively, i.e. the environment senses the person's needs and circumstances, and responds accordingly. It is to be emphasised that the environment learns from these actions on its own, based on the data from the user or from other devices or components, and consequently anticipates forthcoming events and reacts spontaneously. Augusto (2007), however, anticipated great challenges in adopting any form of algorithmic intelligence in real use, the chief challenge being that people may not want the technology executing such influential control over their environments.

Doctor et al. (2005) defined ambient intelligence (AmI) as "an information paradigm where people are empowered through a digital environment that is aware of their presence and context, and is sensitive, adaptive and responsive to their needs". In research literature, ambient intelligence has been almost inseparable from the concept of intelligent environments. Augusto (2007) provided the clarification that although much of the research in Europe has been carried out under the name of ambient intelligence, similar developments in USA and Canada have been referenced as intelligent environments. Aarts and Marzano (2003) described the notion of ambient intelligence (AmI) as having been coined in 1998 during a series of workshops organised at Philips, commissioned by the board of management (Zelka, 1998). The workshops were aimed at developing different scenarios presenting the world near 2020, comprising fully integrated user-friendly devices supporting ubiquitous information, communication, and entertainment. One reason that the concept of ambient intelligence is highlighted here is that it has gained ground especially in Europe, where the most influential benchmark of the research agenda was a report entitled "Scenarios for Ambient Intelligence in 2010" (Ducatel et al., 2001). This report was created by the European Community's Information Society Technologies Advisory Group (ISTAG) in 2001, and had relevance to much of the work carried out in European research projects under the title of ambient intelligence.

Artificial intelligence is accordingly considered a key factor in most AmI research, although as a notion it has been included to some extent in the previously mentioned research agendas. Cook et al. (2009) defined ambient intelligence as "a discipline that brings intelligence to our everyday environments and makes those environments sensitive to us". The features expected from AmI technologies may be defined as: sensitive, responsive, adaptive, transparent, ubiquitous, and intelligent. The employing of AI is illustrated, for example, in the research carried out by Hagras et al. (2004). Their study employs embedded agents to empower users by allowing them to use collections of computer-based artefacts to design novel systems suiting their preferences. The design of these systems is executed without the users needing to understand the technical complexities or programming. Russell and Norvig (2002) noted that with the help of embedded agents the system could act as an "electronic butler", sensing features of the users and their environment, reasoning about the accumulated data, and finally selecting actions that will benefit the users within the environment. Hagras et al. (2004) elucidated the foremost idea behind the AmI concept as the users not needing to programme individual devices or connect them together to achieve the required functionality. Cook et al. (2009) notified that while AmI draws from the field of AI, it nevertheless should not be considered synonymous with AI, as some technologies fall outside the typical scope of AI research; examples include human-centric computer interfaces and secure systems and devices.

Callaghan et al. (2009) reminded us, however, that while autonomous agents may appeal to many people, their acceptance is not universal: some people distrust autonomous agents, and prefer to exercise direct control over what is being learnt about them, when it is being learnt, and where that information is being

7 Citation from the International Conference on Intelligent Environments website. The conference is funded by the IEEE 'Systems, Man, and Cybernetics Society' and the Association for the Advancement of AI, together with technical sponsorship from 'IEEE SMC Technical Committee on Human-Computer Interaction'. Retrieved 21:52, 30 May 2014 from: http://www.intenv.org

8 Artificial intelligence (AI) is the intelligence exhibited by machines or software, and the branch of computer science that develops machines and software with intelligence. AI is the inclusion of some capacity for reasoning, planning and learning (Doctor et al., 2005).

communicated. In this respect, Callaghan et al. saw the opposing alternative to AmI being a person-centred approach, explained by the argument "Agent-based environments will continually adapt to the users' needs (ambient intelligence); user-based environments will empower people's creativity, to enable them to be the designers of their own building functionality". Rogers (2006) also proposed a contrasting human-centric approach, which would make use of human creativity in exploiting the environment and extending human capability. He specified his proposal as a "domain-specific solution" by saying "In terms of who should benefit, it is useful to think of how the technologies can be developed for particular domains that can be set up and customized by an individual firm or organisation." Kaasinen and Norros (2007) have coined this perception as a contextual methodology entitled Ecological Approach to Smart Environments (EASE), which will be introduced more specifically later. The EASE approach defines an intelligent environment as "...the cooperation between people and the environment when the technological offering is composed in a way that it is obvious to the people". From this perspective, the intelligence is thus not seen as a quality of people, technology or the environment, but an integrative ecology they construct, although Kaasinen and Norros assumed that the environment has certain intelligent qualities, such as adapting to the needs of the people. This dissertation supports this holistic definition, and the approach has subsequently been adapted to the ecological Internet of Things research.

2.1.3
The Internet of Things

The ubiquitous computing vision made an early assumption of the repetitive idea of the enormous change in relationship with people and information and communication technologies; the Internet of Things vision continues the path by describing the more natural way of interacting by using networked computing systems that are connected, not just to the Internet or other computers, but to places, people, everyday objects and things in the world around us (e.g. Weiser and Brown, 1996; Dourish, 2001b; Atzori et al., 2010). Miorandi et al. (2012) confirmed that the previously introduced IE and AmI share a number of aspects with IoT. After describing these aspects, they clarify the difference by saying that while previous AmI and IE applications have been developed mainly for "closed" environments – e.g. rooms and buildings in which a number of specific functions can be accommodated and supported – the Internet of Things expands the previous concepts, and integrates more open scenarios in which there is no need to consider new functions, capabilities or services at the "design time" as these can be accommodated at the "run time".

Ashton (2009) originally outlined the vision in 1999 by declaring:

> "We're physical, and so is our environment ... You can't eat bits, burn them to stay warm or put them in your gas tank. Ideas and information are important, but things matter more. Yet today's information technology is so dependent on data originated by people that our computers know more about ideas than things. If we had computers that knew everything there was to know about things—using data they gathered without any help from us—we would be able to track and count everything, and consequently greatly reduce waste, loss and cost."

As has been highlighted here, the Internet of Things vision firmly builds upon earlier research that, as highlighted e.g. by Callaghan et al. (2004), acknowledges the use of numerous "invisible", omnipresent, permanently switched on, communicating computers embedded in everyday artefacts and environments. Furthermore, the technologies will augment our environments with unobtrusive, cheap and efficient electronic components: sensors; radio-frequency identification tags; smart, low-cost devices; meters; surveillance cameras; vehicle telematics; and extensive communication technologies (Augusto 2007; Atzori et al. 2010; Miorandi et al. 2012). These "things" embedded in the environments constitute, combine and store the digital information; in domestic environments, for example, they can measure and monitor water and energy consumption and the use of devices, in precisely the manner Ashton proposed in his remark. To sum up, as Ashton's definition implied, a huge number of heterogeneous objects such as sensors, actuators, mobile phones and smart devices and, as more recently proposed, even animals and plants, will be connected to the global network. Together, these components create intelligent networks that collect a range of data, respond to events, and determine when and how to present information to people at the time and place they need it (Nakashima et al., 2010). This will change our perception of the world dramatically; for example Miorandi et al. (2012) deterministically envisioned the Internet of Things technologies allowing content and services to be all around us, always available, paving the way to new applications, enabling new ways of working, new ways of interacting, and new ways of entertaining; consequently ultimately leading to new ways of living.

When considering the outlining of the vision more closely, it should be remarked that Kevin Ashton (1999) originally coined the term, Internet of Things, to refer to "uniquely identifiable objects (things) and their virtual representations in an Internet-like structure". Azori et al. (2010) preferred to define the emerging technology context as "a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols". Miorandi et al. (2012) elucidated the term as being generally used as "an umbrella keyword for covering various aspects related to the extension of the Internet and the Web into the physical realm, by the means of the widespread deployment of spatially distributed systems; devices with embedded identification, sensing actuation capabilities". A more straightforward reference to previous technology visions has been presented in the roadmap of the European Commission (2008)[9], in which IoT is portrayed as "Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts". Roelands et al. (2011) placed greater emphasis on the change in our perception, by understanding IoT predominantly as "the virtual world of information technology integrating seamlessly with the real world of things". Azori et al. (2010) illustrated the significant transformation by making reference to the contemporary Internet, which, while emerging, dramatically and irrevocably changed the way we live, and continued by saying that the Internet of Things will have the potential to add a completely new dimension to this process. The foremost implication of all these definitions is thus the conceptual consequence, according to which the Internet transforms from being a merely virtual online space into a system that provides appropriate information, help and services in the real, physical world. Here, most of the vision declarations are unanimous regarding the ultimate aim of emerging technologies towards the vision of "anytime, anywhere, any media, anything" communications highlighted in the original ITU-report (ITU 2005)[10], which disseminated the outline for the Internet of Things.

Nevertheless, the apparent ambiguity in the definitions for the Internet of Things suggests the need for closer consideration of the terminology. Azori et al. (2010) asserted that the reason for the uncertainty

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In a report: Internet of Things in 2020, Roadmap for the Future, Version 1.1, 27 May 2008, INFSO D.4 Networked Enterprise & RFID INFSO G.2 Micro & Nano systems, in: Cooperation with the Working Group RFID of the ETP EPOSS. Retrieved 15:20, 12 June 2013 from http://www.caba.org/resources/Documents/IS-2008-93.pdf

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In a report at the UN net summit in Tunis in November, 2005: The Internet of Things, ITU Internet Reports, 2005. Retrieved 13:52, 20 February 2014 from http://www.itu.int/osg/spu/publications/internetofthings/

and ambiguity surrounding the term is the consequence of the expression itself – Internet of Things – which syntactically is composed of two terms: the first thrusts towards a network-oriented vision, while the second moves the focus on to generic objects – "things" – to be integrated into the common framework. Gubbi et al. (2013) explained the separation by saying that the main focus in the Internet-centric vision is on Internet services, whereas in the object-centric vision smart objects take centre stage. Atzori et al. also discussed a third implication for the IoT: the semantic-oriented vision, which emphasises that the number of items involved in the future Internet is destined to become excessive. Issues relating to how to represent, store, interconnect, search, and organise information generated by the IoT should therefore become the most challenging part of future research.

Miorandi et al. (2012) supported the Internet-centric vision, as they firmly believe that the Internet infrastructure in its current form will not disappear. They explained that, on the contrary, the infrastructure will retain its vital role as the global backbone for worldwide information sharing and diffusion, interconnecting physical objects with computing and communication capabilities across a wide range of services and technologies. Roelands et al. (2011), on the other hand, questioned the capability of the IoT to utilise the Internet infrastructure as such, since many objects will be unable to run the Internet Protocol (IP). When considering the information-sharing model built on top of the Internet, Gubbi et al. (2013) expected the IoT to have the potential to evolve entirely from the social networking web (Web 2.0) towards the ubiquitous computing web (Web 3.0). Azori et al. (2010) understood the main enabling factor for the Internet of Things to be ultimately the integration of several technologies and communications solutions. They consider that the main challenges in research will relate to the wired and wireless, sensor and actuator networks and the enhanced communication protocols of the next generation Internet. From the object-centric perspective, Azori et al. elucidated our contemporary environments as being equipped with things with no communication capabilities, or with only primitive intelligence. If these things were granted identities, for example through radio-frequency identification (RFID)[11] tags, and the subsequent ability to communicate and interact with each other and cooperate with their neighbouring objects, the environments will have the potential to offer a wide range of new applications and services. If the things were further augmented with senses – sight, hearing, taste, or touch – achieved through the use of sensors, they could then elaborate on the information perceived from the environment. Miorandi et al. (2012) defined smart objects as having the following abilities: to be identifiable (anything identifies itself), to communicate (anything communicates), and to interact (anything interacts), either among themselves, with interconnected objects, or with end users. They suggested that embedding electronics into everyday physical objects, by making them "smart" and allowing them to integrate seamlessly within the global network, will ultimately result in a cyberphysical infrastructure. They expected the development of the technologies and solutions for smart objects to be the main challenge in IoT research. Toma et al. (2009) considered that semantic technologies could play the key role in the IoT by exploiting appropriate modelling solutions for the description of "things", reasoning over data generated by the IoT, semantic execution environments and architectures that accommodate IoT requirements, and scalable storing and communication infrastructure. Azori et al. (2010) added the unique addressing of objects to the list. From the semantic-oriented perspective, Gubbi et al. (2013) expected the main challenge to lie in the resulting generation of enormous amounts of data, which have to be stored, processed and presented in a seamless, efficient, and easily interpretable form. They considered this challenge to be related to the presentation of the information, and call for novel and easy to understand visualisation and interpretation tools, widely accessible on different platforms, which can be designed for different applications.

This introduction to emerging technology research aimed at defining the terminology and approaches around the Internet of Things concept, as well as describing the challenges. In general, Greenfield (2006) called the challenges of emerging technology research "technically sweet", by referring to technical challenges that simply cannot be disregarded. But there is also a darker side to the advance of emerging technologies. The reverse of the coin is evident in the preceding visions describing Internet of Things research: the underlying statement in the Internet-centric, object-centric and semantic-oriented visions seems to be that the roles people play in the emerging technology context are not clear at all – in fact, it seems as if people have been removed entirely from the focus of research. This is most apparent in Ashton's (2009) remark in which he specifically emphasises the role of "things" – when appropriately defining the Internet of Things – on the expense of ideas and information that people generate on computers and Internet. He justifies the technology-driven approach by explaining that "people have limited time, attention and accuracy – and as such they not very good at capturing data about things in the real world". However, the fact remains that any of the new technologies are even still created for people; to benefit them, to assist them, or to liberate them from monotonous tasks. Another argument for looking at the other side of the irresistibly technically sweet challenges is the fact that these emergent technologies contain many built-in ethical and societal considerations. These issues can be associated, for example, with predictability, visibility, control, unobtrusiveness, privacy and security of the systems (Cook and Das 2004; Chin et al. 2004; Ikonen and Kaasinen 2008; Callaghan et al. 2009; Weber 2010; and Stahl 2013).

2.2
HUMAN-COMPUTER INTERACTION AND DESIGN

The design and research of emerging technologies require multiple perspectives if it is to account for all the opportunities, magnitudes and affordances, restrictions, regulations and boundaries that encompass the sum of ethical, societal and holistic considerations. The discipline that studies the human side of the technologies, with a more immediate or by the larger scale, is the human-computer interaction (HCI), which has evolved over some thirty years of searching for a suitable language of interaction for a world where information processing takes place in the human environment (Zimmerman et al., 2007). According to Hollan et al. (2000), HCI as a field emerged at a time when the dominant theory was human information processing psychology, and they maintained that this lineage still resonates in its research. Fallman (2003) argued that, in fact, HCI has emerged as a design-oriented field of research, directed at large towards innovation, design, and construction of new kinds of information and interaction technologies. In contemporary practice, HCI is nevertheless commonly considered a multidisciplinary field, combining both emerging technology development and HCI, and including various computer science disciplines, diverse fields of engineering, various social science disciplines such as sociology, anthropology, ethnography, ethics,

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Radio Frequency Identification (RFID) is a type of auto identification system, and refers to technologies that use radio waves to identify objects, locations or people. RFID is a generic term and does not refer to any particular technology. However, the term is more recently associated with a form of the technology called RFID tags. Radio-frequency identification (RFID) tags – tiny microchips attached to transponders – contain a small amount of data and send or receive it via radio waves, and via sensors that can receive information from the physical environment, such as pressure, touch, temperature, humidity etc., and transform it into digital information (Cook and Das, 2004; Ailisto et al., 2006; Azori et al., 2010).

behavioural sciences and cognitive psychology, as well as sundry other disciplines. Of necessity, the field also involves designers, whose roles have been specified in relation, for example, to graphic design, interaction design or industrial design. This dissertation limits itself to describing the practices carried out by what may be considered the ‘research through design’ approach (Zimmerman et al., 2010). Nevertheless, before giving more careful consideration to the role of the designer in HCI, the dissertation introduces the research and practices that have been carried out in the human-computer interaction domain for some fifteen years – through the lens of a designer[12].

In general, it should be stated that HCI research focuses mostly on the study of user interfaces (UI), natural interfaces and interaction mechanisms that facilitate a rich variety of communication capabilities between humans and computers. Abowd et al. (2002) pointed out that traditional HCI work has produced considerable guidance on human factors in the design of the graphical displays, multimedia systems and natural interfaces. As Abowd and Mynatt (2000) have explained, the goal of HCI research is to support common forms of human expression and to make greater use of our implicit actions in the world. The following practice-oriented HCI research examples range from the design of an immersive and spatial intelligent environment game (see Figure 3 and 4), through the design of affordances for intelligent environments (see Figure 6), to design of a graphical user interface for a HCI application (see Figure 8). Examples of the contribution of these briefly introduced research projects include offering support for users in technology-augmented environments (see Figure 7) and creating highly intuitive and natural environments by focusing on the interaction mechanisms and user experience of the systems (see Figure 9). It should be again highlighted that the objectives for the research projects presented have been profoundly technology-driven, although from the first project for which the author contributed the aim has been to involve people in the research processes. As the practice-oriented review aims to depict the design and research of the HCI domain it has been considered important to engage also other relevant research to the demonstrating examples. While serving as an introduction to HCI research, the review also has another important purpose: the interaction mechanisms it presents provide relevant background information for the research carried out for the dissertation. The few important interaction techniques that are still missing will be introduced in Appendix B.

The author began emerging technology research in the role of a graphic-, concept- and game designer for a project called Lumetila: Virtual Space – user interfaces of the future (1999–2001) (see Figure 3, left). The aim of the project was to develop a virtual spatial computer game with floor sensor controls. At that time, there was some research activity with spatiality and sensitive floors that often had more specific focus on developing the technology, for example monitoring the weight distribution, time variations and loads of an active floor (Addlesee et al., 1997), or identifying users by their “footfall signature”, as in the smart floor introduced by Kidd et al. (1999). Lumetila was special, however, in the sense that it focused on creating a more holistic spatial experience, and introduced the interaction technique in a game environment. In fact, the closest research for the Lumetila project was developed at the same time in the MIT Media laboratory, a project called KidsRoom, a perceptually-based, interactive, narrative play space for children (Bobik et al., 1999). The Lumetila project, however, aimed to create a highly immersive and spatial intelligent environment game for children. Spatiality in this context meant that, while playing, the user was expected to engage body movements to control the game. An important aspect of the project was study of the cooperation and communication challenges when multiple users occupied the environment simultaneously. Because of the author’s previous expertise and background as an animator, filmmaker and

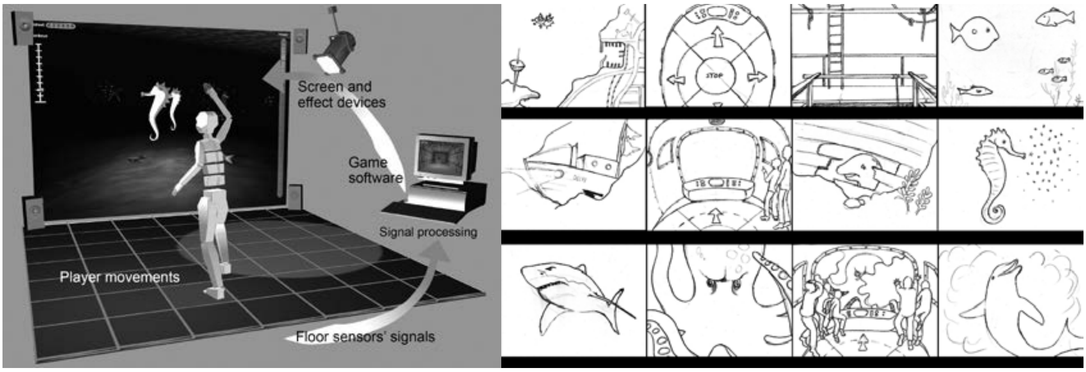

Figure 3.
The floor sensor game, Lumetila, was initially an illustrated storyboard that made the technology visible for all stakeholders in the project. The designer's task was to create several concepts that exploited the technology, one of which was chosen for further development.

graphic designer, the design interests were quite diverse. In the first phase, the task was to come up with the conceptual story: manuscripts for several haptic games and the screenwriting for the final spatial game (see Figure 3, right). The final game was an underwater submarine adventure in which the crew worked together to steer the vessel through dangerous situations, with the ultimate goal of saving a seal trapped in a shipwreck. The subsequent iterative design phases varied from creating the visual appearances of the game from early sketches, to final modelling and animation (see Figure 4, top). The game was evaluated several times during the development, the designer's role expanding into the field of user-centred design (see Figure 4, bottom). It should be noted that in the beginning the participants were not involved in the processes, the initial user evaluations taking place as the first version of the proof-of-concept was completed. Also to be noted is that the partners and company representatives often determined the initial conditions, such as the users' identities and place within the technical systems, whereas the effect, activities and interactions the environment supported were studied by means of a user-centred design approach. In the Lumetila case, it was critical to aim for a high-fidelity prototype that illustrated the prospects for the immersion and the spatiality of the technology environment. Successful later development of the floor sensor technology, for example, in elderly care projects, should also be noted; this utilises floor sensors capable of detecting falls and reporting incidents to emergency services (e.g. in Hakkarainen and Hyysalo, 2013).

The research findings from the Lumetila project were exploited in the project that followed, UbiPlay (2003—2004) (see Figure 5), which focused on finding means of commercialising the active floor system. From the project partners' perspective, the aim was to design an interactive playground for three generations: children, their parents and their grandparents. The augmented playground was intended to be adaptable for multiple purposes: for playing, learning and exercising (Mattila et al., 2006). The technological aim was to offer a platform for a self-programmable, interactive playground. The proof-of-concept platform consisted of sensor technology, video displays and computer software. The primary research aim was to increase understanding of the spatial interfaces, which may roughly be divided into two main categories: movement in space, which was given greater attention in the

12 The research — as well as the case studies introduced in this dissertation — has been carried out at VTT Technical Research Centre of Finland. VTT is a multi-disciplinary national research institute that is positioned between the academia and the Finnish industry and interacts with both.

Figure 4.
In the production phase, the designer's task was to design and animate the 3D objects of the game environment. The game was further developed according to user feedback collected from several different user groups.

Lumetila project, and bodily interaction, the primary focus of Ubiplay. The main difference between the two is that movement in space is based on declarative knowledge of the environment, while in bodily interaction a person uses the whole body to control the environment. The idea linking both concepts was that there was no need to carry any devices, as these were already embedded in the environment. Ubiplay, more than Lumetila, considered design as a social process in which all stakeholders participated, an idea firmly emphasised recently by Kettunen (2013). The principal focus when designing the project's spatial interaction was on the intuitiveness of the actions and operations. The designer's task included the concept development of, altogether, seventeen games. These were first written as short scenarios, and then presented as illustrations and animation prototypes. The author was also responsible for the early evaluations of the concept prototypes, which in this case were carried out in the initial phase of the project. The qualitative interviews were aimed at three specific groups of users of the interactive playground: children, their parents and their grandparents. As one of the project partners was able to commercialise the concept, the project was evidently quite successful. The bodily interactions were also successfully demonstrated in the case, and the programmable platform provided further material that would be under scrutiny yet again in the proof-of-concept prototype, presented in Article I of this dissertation.

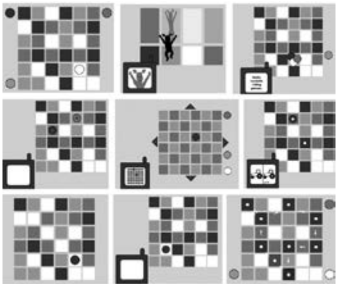

Figure 5.
The UbiPlay project developed an augmented outdoor playground that exploited sensor floor-tile technology. Project participant Lappset Group Oy later commercialised the learning and activity environments under the SmartUs brand.

The NASE project aimed at studying and designing affordances for intelligent environments. The theory of affordances, introduced by psychologist Gibson (1977), was adopted for the context of research. According to Gibson, affordances can be seen as the way people undertake cognition and action in the environment in order to make meaning of it. For example, an artefact can be designed to have recognisable affordances; the important thing is to take into account the previous knowledge about experiences. NASE also employed the notions of Gaver (1991), who was the first to conceptualise the affordances for technology interaction. According to Gaver, if an application makes suitable activities easily available at a given time, this results in pleasure and positive interactions. The NASE project sought to utilise tangible interaction technologies — touch and gestures — in the study of affordances (see Figure 6). Turvey and Carello (1985) introduced three different methods for sensing the objects of the environment: tactile, haptic and kinetic. The benefit of tactile interfaces is considered to be their being perceived without seeing the object, a notion that suggests they offer no disturbance to other simultaneous activities or other people in the environment. Miller and Zeleznik (1999) added that haptic interfaces could employ, for example, force feedback mediating information about a current change for the user, or tactile feedback leading or guiding the operation. Recently, the kinetic interaction and interfaces have found their way into commercial products, and are also utilised as one of the interaction techniques in Article IV. It should be noted, however, that in the research in early 2000, kinetic interfaces and gestures were mainly thought to be suitable for the elderly and disabled. One of the important technical objectives was to develop an affordance tool, which was an instrument that utilised tangible interaction technologies to gather and present information. The role of the designer in NASE was to create scenarios that presented employment of the affordances concept in specific domains: a museum, a playground, a shopping centre, and an outdoor game site within the geocaching activity. The prepared scenarios also described use of the affordance tool, as well as possible applications that could be built with it. The scenarios were evaluated with two user groups: application developers and experts of the specific sites — in this case, staff of the museum, experience exercise entrepreneurs, shop assistants, and child-minders. The designer's tasks also included design of the affordance tool's graphical user interface. Although the research eventually accomplished many exploitable results, the project left the impression that the theory might have remained too detached from the development process.

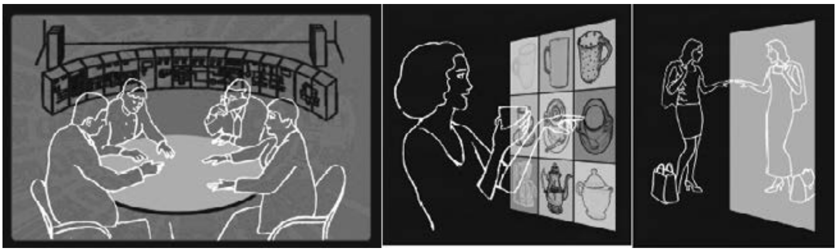

Figure 6.
The NASE project brought together a multidisciplinary team of researchers whose aim was to develop solutions for interactive environments that were embedded with various smart technologies. With regard to users, the tactile, haptic or kinetic solutions were expected to be understandable and easy to learn. To reach this aim, the project applied an interaction concept based on the theory of affordances.

The PointMe, TouchMe and ScanMe project (2004–2006) presented a physical selection paradigm for implementing an intuitive human technology interaction for mobile devices (Ailisto et al., 2006). The project was a mobile-device-driven concept of IE, which emphasised that it was the interaction between the user and mobile device that provided the functions and services embedded in the environment. In this respect, the mobile device was perceived as the universal remote control of the environment, an appropriate multi-function tool offering the available environment-related services. In mid-2000, the physical browsing paradigm seemed to be the most prominent interaction mechanism considered for IE. Before the mobile device could operate as the multi-function tool, the environment and physical objects needed to be embedded with critical components – information tags. Ailisto et al. (2006) described identification tags as small and inexpensive unique identifiers which, although attached to physical objects, have limited or no interaction with the object itself. Important criteria for identification tags are that they do not alter the physical essence of the related object, that they contain some information related to the object, and that they can be read from the near vicinity. Brumitt et al. (2000) were already using RF, IR and ultrasonic transceivers in their research at the turn of the millennium, constructing indoor beacons that operated using small tags attached to people, phones, remote controls, printers, computers, etc. They envisioned then that if all objects and people in daily life were equipped with radio-frequency identification (RFID) tags, or two-dimensional bar codes, these could be identified and thus inventoried by computers[13]. In the physical browsing project, the PointMe mode involved physically pointing at a tag, or symbol on a poster, and selecting it by means of an optical beam to connect with a website. In the TouchMe mode, the tag was chosen by touching it virtually with a reader. The ScanMe mode allowed the user to scan the environment for tags. Rukzio et al. (2006) made a comparison of these interaction mechanisms, finding that people preferred touching if things were near, pointing if things were far and there was a clear line of sight, and scanning only if all else failed. The role of the designer in the project was to abstract the information and create visual prototypes of the physical browsing paradigms (see Figure 7). In the subsequent EU project MINAMI, which also related to the use of mobile devices and tags, the design concern was to create agile concept prototypes for illustrating the actual use of technology. These technologies, it should be noted, have been commercially available for some time. For example, Miorandi et al. (2012) consider radio frequency identification devices and solutions to be a mainstream communication technology nowadays, and expect the Internet of Things to start by expanding through these identification technologies.

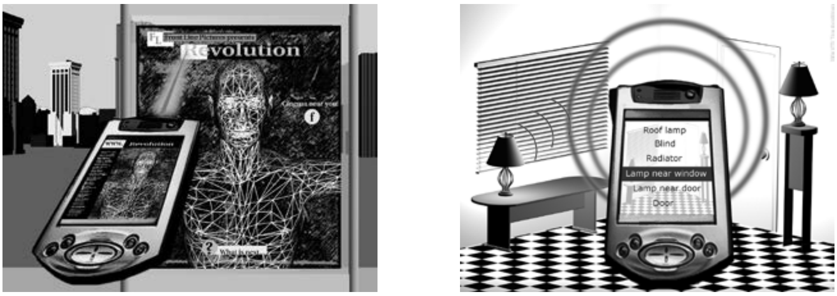

Figure 7.
An example of the means of operating intelligent environments by mobile device. The Point Me, Touch Me, Scan Me project studied physical browsing. In the left figure, the user selects a link on a poster by pointing to it. The mobile terminal reads the tag and opens the web page for the movie. In the right figure, the user scans the room, and available links for appliances are displayed in the graphical UI.

Confidential assignments, commissioned by industry enterprises, are another way of engaging in emerging technology research. In one such assignment, the designer's task included a working period of several months at Nokia premises, developing concepts, animated transitions and graphic design for the user interface of a forthcoming mobile service. Another confidential assignment included the design and user research for a gait recognition[14] demonstrator for Toyota (see Figure 8). The assignment included design of the graphic user interface and the user evaluations of a walking style recognition demonstrator. The gait recognition demonstrator detected the user's walking style by taking pictures of the motion; this was done by storing the person's unique pattern of walking style in the enrolment phase, and in the verifying phase comparing the acceleration pattern with the stored templates.

In a confidential assignment for the public sector, from the library of Tampere University of Applied Sciences, the objective was to outline a future intelligent library exploiting ubiquitous computing (see Figure 9). The designer's role included design of new concepts, both for the physical environment and a new kind of learning environment, and conducting user and expert interviews on which the final visualisations and concepts would be based. The design task made use of the findings from earlier research, and from personal practices and research carried out elsewhere, e.g. Newman et al. (2002) and Cooperstock et al. (1997). Visualisations in the case were used as early prototypes of the novel library. The project, although brief, provided an important junction connecting the knowledge gained from IE research and its deployment in an educational context.

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It is important to note here that the capability of unique identification of objects or 'things' has constantly been stated as critical to the success of the Internet of Things. Gubbi et al. (2013) have recently stated that identification tags permit unique identification of billions of devices, as well as control of remote devices through the Internet. For the aspirations of the Internet of Things, information tags indeed possess some overpowering properties; they are small, have a low-visibility profile, and are relatively cheap. The use of embedded tags, however, continues to be somewhat intimidating. According to Callaghan et al. (2009) some people consider RFID tags to represent a significant threat to our privacy and autonomy; organisations such as "NoTags" have been set up to raise public awareness of these issues.

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Sensor-based gait recognition is an unobtrusive biometric method that measures 3D acceleration i.e. the person's walking style (Ailisto et al., 2005) .

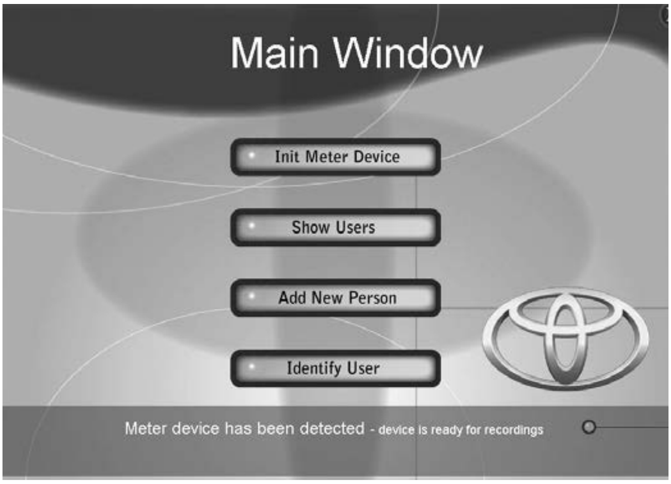
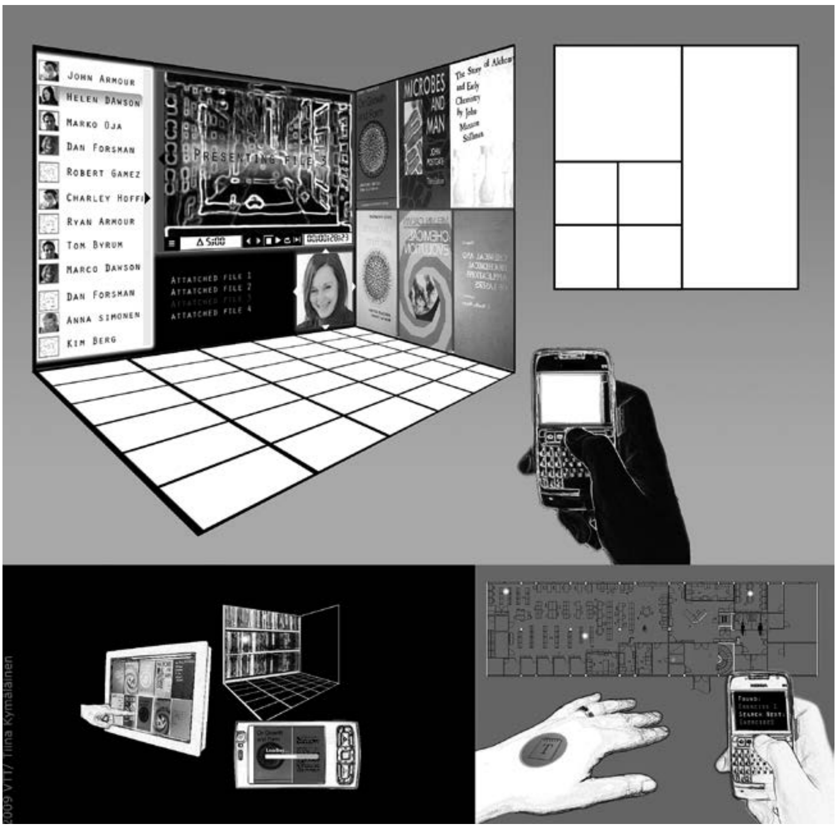


Figure 8.
User interface and user evaluations of a walking style recognition demonstrator for Toyota.

Figure 9.
The UbiLib project utilised ubiquitous technologies to create a future library with multiple, novel functions. Functions of the library were expected to include acting as a meeting place for students and offering remote seminar operations. One of its technological features was location of the information on an author or volume by mobile phone using RFID tags.



According to Zimmerman et al. (2010), HCI theory has been inspired by many of its constituent disciplines: psychological theories of human behaviour, engineering theory intended to improve the HCI practice, and anthropological theories of situated action and interaction. The specific role of design in human-computer interaction research is rather difficult to articulate adequately. Zimmerman et al. (2010) considered that design in the field of HCI is viewed much more as an attitude to doing the work than as a systematic method of inquiry. Wolf et al. (2006) criticised typical HCI usage of design as at best limiting, and at worst flawed. For this reason, Zimmerman et al. (2007) conducted a study of the terminological differences between the HCI and design disciplines. They came to the conclusion that within the HCI community the use of the term *design* to mean HCI practice was quite typical, as was use of the term *designer* to mean an HCI practitioner, such as usability engineer, interaction designer, software architect, software developer, and so on. Conversely, design communities generally use the term *designer* to refer to someone who has had training or extensive practical experience in such disciplines as architecture, product design, graphic design or interaction design.

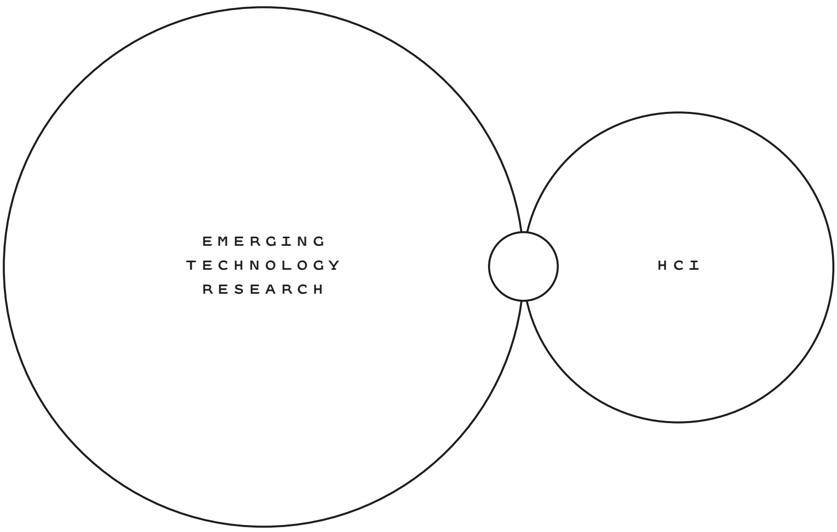


Figure 10.
The designer's role embraces HCI and emerging technology research.

Generally speaking, Löwgren (1995) described the main tensions in emerging technology research as being between the perspectives of normative development models of engineering and the concrete work of creative design. He maintained that the chief problem lies with engineering design assuming that the "problem" to be solved is comprehensively and precisely described, preferably in the form of a requirement specification, while, in contrast, creative design is as much about understanding the problem as the resulting artefact. Creative design work is thus generally seen to embrace wicked problems (Rittel and Webber, 1974) that oscillate between problem-setting and problem-solving (Cross, 2006). This has lead to a creative design process that is inherently unpredictable, and in which the designer plays a personal role in the process (Löwgren, p. 88). Wolf et al. (2006) preferred to call the designer's role in the process "formal iteration", which means that the designer in emerging technology research adopts a process of iterative refinement. The formality of the practice is an accommodation of the cultures of engineering and user-centred design. Zimmerman et al. (2010) asserted that if design researchers expect others to recognise the rigour and relevance of their contribution, they must engage in a critical discourse to better detail the role of design research within HCI, and its potential outcomes.

Accordingly, if the designer's role in emerging technology research projects is considered through the lens illustrated in the practice-oriented review, the designer — with emphasis on the design community interpretation — must operate between emerging technology development and human-computer interaction (see Figure 10). In essence, this means the designer must have an intimate understanding of the opportunities and requirements of both.

The designer's role in the early phase of emerging technology research, as illustrated in the practice-oriented review, involved familiarisation with the new technology concept and theory background, and exploring of design alternatives. Tasks in the development process included the input of personal expertise for the creation of aesthetic and usable visualisations, followed by the creation of prototypes, applications and interfaces. In the user research, the designer usually worked as part of a multidisciplinary team, for example by employing design-oriented methods. In the analysing process, the interpretation of results, and discovery of the implications for further development, became more productive when the designer applied the expert knowledge. The unarticulated aspect concerns the frequency with which the designer actively carries the implications of the field studies into the design artefact — an application or prototype — through a self-inward, iterative process, and in a distinct and concrete manner by implementing those findings. In this sense, the designer's role is reminiscent of *transdisciplinary* knowledge production, a term that Gibbons et al. (1994) proposed using instead of referring to multidisciplinary or interdisciplinary roles. The term suggests that research in the design context requires the crossing of boundaries between technical sciences and humanities (ibid.). Gibbons et al. stated that, for such purposes, design links knowledge with practice and context where it is created, acknowledges the versatility of knowledge creation processes and the versatility of the participants, and believes in the reflective creation of knowledge. If the author's role in research is considered in this way — as a transdisciplinary knowledge mediator — the lengthy introduction, the fact that this dissertation has drawn reference from versatile disciplines, and the presentation of complementary research outcomes, become justified.

The gap

AS DISCUSSED IN the introduction, Weiser's persistent ubiquitous computing 'technomyth' continues to offer wide motivation for emerging technology research, most recently for the Internet of Things. This is easy to verify by browsing the relevant conference and journal papers, which more often than not include references to Weiser's work. The infinite vision of the future in these articles appears to encourage the same seamless, pervasive, ubiquitous environments: the third wave of computing, outside the realm of the traditional desktop (Atzori et al., 2010; Miorandi et al., 2012; Gubbi et al., 2013). Bell and Dourish (2007), in their article "Yesterday's tomorrows: the notes on ubiquitous computing's dominant vision", earlier asked the reason for Weiser's vision of the future not coming to pass. Greenfield (2006) formulated the problem-space by referring to ubiquitous computing as a "hundred-year problem". He refines this by saying "It is a technical, social, ethical and political challenge of extraordinary subtlety and difficulty, resistant to comprehensive solution in anything like the near term". That being said, the main challenge to achieving completion of the persistent technology vision appears to lie in the holistic mind-set that will be unavoidable if, as anticipated, ambient technologies are to pervade the real world. Harrison and Dourish (1996) drew attention to this by suggesting that the modularity of information technology makes a holistic consideration extremely challenging. They considered the apparent modularity to be due to information technology (IT) being designed at different times, in different places, by different parties, and for different ends. For Bell and Dourish (2007), the greatest challenge related to the messiness interwoven in the infrastructures, a fact largely neglected in the emerging technology research. But what if this modularity and messiness could be considered an asset, or even a starting point, for emerging technology research?

As far as the foundational aim of human-computer interaction (HCI) is concerned, there has always been an attempt to create a holistic mind-set towards research on emerging technology. At any rate, the aim has certainly been towards placing people in the centre of research design. Approaches have been varied, particularly with regard to how and in what phases to engage people in the processes. Bannon (1986) introduced the second wave HCI theory in his article "From human factors to human actors". In second wave HCI, the intent was to take human actors — more specifically, people who were managing a particular practice in a particular setting — more seriously. This mind-set has since acquired further definition and evolved towards HCI that engages people more and more in emerging technology design processes. One influential movement was a paradigm called participatory design, especially popular in the Nordic countries, with a general aim of democratising design so that the people who would be affected by the systems could also participate and influence the design processes (Schuler and Namioka, 1993; Greenbaum and Kyng, 1991; Thackara, 2005). Thackara has supported the active user participation by arguing that complicated systems should not be designed and left for people to cope with; they should instead be developed gradually in the context of use, in a "case-sensitive manner", and in firm collaboration with users. Subsequent HCI approaches have attempted to find alternative methodologies for user-centred design, for example by seeing people in terms of felt life, empathy, and the aesthetics of everyday experience. The focus of enquiry has shifted from user needs and requirements towards an understanding of individuals, their concerns, desires, aspirations, values — and experiences (Wright, Wallace and McCarthy, 2008). These new methodologies have suggested a different sensibility towards HCI, an alternative way of relating to familiar precepts, such as knowing the user, iterative design and user involvement (ibid.). According to Hassenzahl and Tractinsky (2006), the shift in HCI from traditional usability to studying the user experience has taken place because traditional user-centred and usability approaches have provided insufficient means for measuring all aspects of HCI. More recently, Roelands et al. (2011) suggested the need for a return to experimentally driven, participative research approaches, more compellingly to allow the involvement of different stakeholders in the design of their context-specific experiences. Nevertheless, Dourish (2006) has reminded designers and engineers of their unavoidably limited influence on system use and interpretation in use. Dourish maintains that it is the user — not the designer — who creates and communicates meaning, and it should also be the user — not the designer — who manages the coupling. For HCI these new construction demands suggest that the users should be expected to be active, to show initiative, and to share the responsibility for developing their personal ecologies (Plomp et al., 2009). Consequently, the role of the designer in HCI has transformed. The role – rather than being objective, with the designer standing outside the user's situation – is instead one in which designer and user are mutually influencing each other in an empathic dialogue (Battarbee, 2004; Wright and McCarthy, 2007). Fisher et al. (2004) explained that the designer in this mind-set essentially no longer designs objects, but become a "meta-designer", creating design environments for unskilled users or various design blueprints that allow users to design their own products. They maintained that the ideal would then be a design that is permanently unfinished; a design that stimulates new interpretations and provides opportunities for adjustments.

Emergent technology, HCI and design research has always emphasised the role of the research outcome; the design artefacts that in the emerging technology research context are usually high-fidelity prototypes. But what if the prototypes – the creation of flexible platforms in the specific domains and contexts – turn out to be entirely unsatisfactory? What if, at the end of the day, the prototypes fail adequately to represent the benefits of extensive research, thoughtful user participation and detailed user evaluations? Or employ technology that is too immature to work efficiently? Or end up being merely rough interpretations of "what could and should be", and consequently inadmissible as holistic artefacts? For the artefacts it is typical that they have a meaning related to the purpose of their use (Kuutti, 2009). According to Kuutti it is important to understand that the design knowledge concerning artefacts is only partially explicit, i.e. those in the form of specifications, programmes, description of modelling methods, and a large part of the knowledge is embedded in ways of designing, hence not explicit and taken for granted. Furthermore, Bødker (2006) has been one of the leading critic of the active engagement of users in design, saying that at a certain level HCI research has taken active user participation too much for granted. According to her, this "taken-for-grantedness" in participatory methods has led to a lack of reflection, or reflexivity, on behalf of designers. Bødker has gone on to say that, for this reason alone, second generation methods such as participatory design must be ready to take on new methodological challenges. She thus proposed a completely new manner of carrying out the work, labelled as the third wave for HCI. The third wave relates to multiplicity, context, boundaries, experience and participation, the topics addressed in order to discuss the handling of new challenges brought on by emerging technologies. According to Bødker, in terms of methodology the third wave partly moves away from the commitment to users and towards a more exploratory "take-it-or-leave-it approach". She suggested taking up the challenge by providing alternatives through design-prototyping, where the questions asked have nonetheless been carefully examined and the answers digested in cooperation with users. Concurrently, Löwgren (1995) and Wolf et al. (2006) endorsed the need for a third wave of design practices that will be based on design judgement and creative design, and that recognises the role of the designer in creative design practice within HCI. Wolf et al. stated that design evolves only by applying design judgement and engagement in a variety of HCI practices. This is in accordance with Löwgren, who earlier suggested that the third generation of design methodology should focus on the specific competence of the designer, and consider design as a distinctive kind of thinking in which usability includes the social context, coping with novelty, design for improvisation and design for adaptation. Zimmerman et al. (2010) later proposed a design practice called "research through design" (RtD) that necessitates researchers focusing on the new understandings of technology and research of the future, instead of those of the present or past. In Bødker's manifestation towards the third wave of HCI, she proposed an art-focused breakdown as an intriguing approach to facing the new challenges ahead of us, but left open the question of "how the third wave could develop a productive, reflexive practice that makes more than artistic statements to provoke us".

4 Theoretical background

4.1 ECOLOGICAL RESEARCH APPROACH FOR STUDYING SMART EXPERIENCES

The contextual methodology for the design and research of the do-it-yourself IoT ecologies introduced in this dissertation is based on the Ecological Approach to Smart Environments (EASE)[15] (Kaasinen and Norros, 2007). The ecological approach to design in this context refers not to ecologically sustainable design or green design, but to the linking of technological change with social practices (Keinonen, 2009). The main idea behind the EASE approach is to consider that intelligent ecologies will not emerge in one step, but evolve through the design of the devices, sensors, actuators and

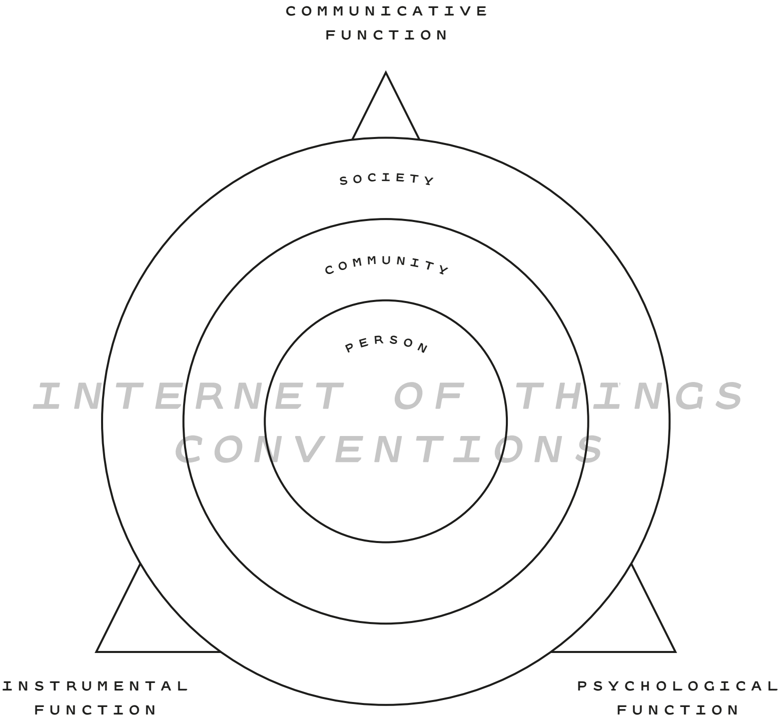


Figure 11.
Central concepts of the EASE approach placed in the Internet of Things research context (as interpreted from the figures from Kaasinen and Norros, 2007, p. 94 and p. 287). Adapted with permission.

applications used in the environment, and through the design of the functional, physical ecology (Kaasinen and Norros, 2007). It should be noted that other approaches have also aimed for the same conjuncture. A closest contextual concept for the EASE approach may be seen to be distributed cognition, which seeks to understand "the organisation of cognitive systems" (Salomon, 1993). This operates at the level of cognitive science, and like most theories in the field, takes cognitive processes to be those that are involved e.g. in memory, decision-making, inference, reasoning and learning (Hutchins, 1995; Salomon, 1993). Hollan et al. (2000) found distributed cognition specifically helpful in understanding interactions among people and technology, and thus a suitable integrated theory for HCI. The shortcoming of the theory for this dissertation research, however, is that it is too task-oriented, it is tailored especially to workplaces, and does not define the actual, specific practices. Yet in many respects the EASE approach owes a great debt of gratitude to distributed cognition theory, for example in the way the approach emphasised beginning HCI research with ethnographic studies of the phenomena of interest, and with natural histories of the representations employed by practitioners. For the dissertation research EASE provides a strong holistic approach to intelligent ecologies, including the long-term and systematic analysis of the ecologies and levers using multiple perspectives of design. The approach underlines the phenomenon of perceiving human-technology systems from the point of view of relationships and interactions. But most of all, it acknowledges the role of experiences in HCI research.

15 The EASE approach is developed in a national research project on smart environments, in which a great number of Finnish research institutes cooperated on research into systematic methodologies for the creation of smart environments and ecologies.

In essence, the EASE approach emphasises the potential of technologies for creating new relevance by merging with non-technical environments and human practices. With the ecological research approach, the environments should be understood from the point of view of the practices they enable, and their quality refers to the development potential of the human, social, physical and technical systems as a whole (Keinonen, 2009). Thus, the objects of design should not be understood as technical devices, or even isolated interactions between humans and products, but as broader practices (ibid.). Acquisition of a more comprehensive understanding of the motivations, routines and values of the human actions accomplishes a widening of objectives for the design. The approach pays particular attention to the circumstances where the interactions take place, and where the environment enables, adjusts or restricts the interaction (Vincente, 1999; Norros et al., Kuutti et al. in Kaasinen and Norros, 2007). Plomp et al. (2009) envisioned the EASE approach providing a prominent research agenda for the continuum of ubiquitous computing that they prefer to call "participatory digital ecology".

Figure 11 describes the central concepts of the EASE approach. The conventions arising from the emerging technology context – in this case, the Internet of Things – have been placed at the centre of design (in Figure 11, represented by the triangle). The corners of the triangle represent the functions influencing the conventions that form around the technologies, and strategies that may be employed for evaluating them. The instrumental function illustrates how the technology influences the environment, the psychological function how it influences the person, and the communicative function how it influences culture and society (Kaasinen and Norros, 2007; p. 68). It should be noted that all functions include the concept of user experience, although according to the EASE approach the communicative function would be a particularly interesting subject for study through experience design.

The theoretical foundation for the EASE approach lies in ecological psychology. According to Gibson (1986), ecological psychology proposes that we should study information transaction between living systems and their environments, especially as it pertains to the perceived significance of environmental situations for the planning and execution of purposive behaviours, including those of a social, scientific, or artistic nature. Moreover, according to Gibson, the observation of human activities should begin from the perception of the environment. For Gibson (1986), the environment is not the same as the physical world, if one means by this the world described by physics. The observer and his environment are complementary, as are the set of observers and their common environment (ibid. p. 15). Gibson's ecological psychology considers the shape of the terrestrial environment, or what may also be called its layout, and sees that the emphasis of perception is on the cycles and changes at the terrestrial level of the physical world. When this thought is implemented in the Internet of Things research context, a terrestrial level of the physical world may consist of technology, or "the things" afforded by the environment. Regarding this dissertation, an important remark from Gibson is the idea that the environment persists in some respects and changes in others. "A living room, for example," he says, "is relatively permanent with respect to the layout of the floor, walls and ceiling, but every now and then the arrangement of the furniture in the room is changed." These components and events of the environment fall into natural, nested units (ibid.). This proposal for the time scale of the environment, which Gibson prefers to call events, and notion about the nested units, are important concepts for ecological IoT research, because this deviation may form the foundation for the perception on which to ground the design layout using ecology ingredients, from technical to service layouts. Interestingly, Gibson explains that the most radical changes in the environment are "going out of existence" and "coming into existence", which can be considered as the "magic" of the intelligent service layers of the environment: the retrieving of the pre-configured states that may cause changes to the conditions of an intelligent environment, and which is why eventually the environment "persists in some respects and changes in others".

Philosopher Don Ihde (1990) has further considered the ecological relationship between human and technology from the position of the experience. In his view, a person's relationship with the environment is always natural, immediate and indigenous. This subjective experience may, however, be communicated and shared, and further controlled and classified in a research set up. In an environmental context, Sundström et al. (1996) uses the term "ecology" to describe qualitatively the relationships between people and the environment, choosing to push the definition of the environment beyond physical and biological limitations in order to include all aspects of a specific experience. This idea of considering environments more as ecologies is a most important notion regarding this dissertation, allowing the perception of the environment to be thrust towards ecological thinking, and provides a highly appropriate conceptualisation for laying the ground for experience design investigations. Accordingly, it is the subjective experiences that provide opportunities for design, and not the physical qualities of the environment.

Furthermore, the EASE approach considers that observation focusing on a singular person constitutes the main weakness of ecological psychology, neglecting the wider social network that forms around the technologies. The EASE approach maintains that the technologies should be studied as to how they serve people as part of the ecologies. The EASE approach has found supportive analysis from the "information ecology" proposed by Nardi and O'Day (2000), who have used the term to describe the systems comprising people, use, values and technology in a particular local surrounding. These multifunctional and continuously evolving information ecologies form part of the principal focus of this dissertation.

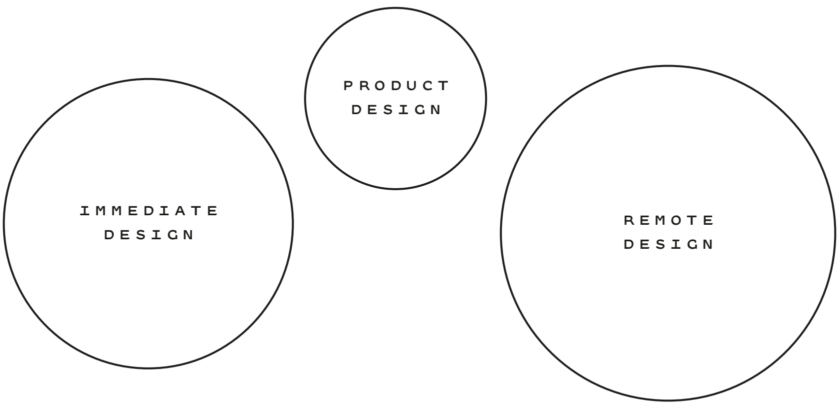


Figure 12.
Three modes for designing intelligent environments according to the EASE approach.

The EASE approach provides a model for ecological design comprising three internally coherent modes (see Figure 12): traditional product design that aims at creating generally appealing solutions, immediate design for dealing with users' immediate and situated challenges, and remote design, which elaborates on preconditions for design such as knowledge, platforms and standards (Keinonen in Kaasinen and Norros, 2007). The need for the model has been justified by a discussion that addresses a set of conflicting design tensions, relating to technology, innovation, competence, readiness and generality, within the design of complex human-technology systems (ibid.). The first mode, product design, is outside the scope of this dissertation, although intelligent products, artefacts and devices are unquestionably important components of the Internet of *Things*. Emphasis in this dissertation is on the other two modes — immediate and remote design — considered the pragmatic modes for study in the research settings. According to Keinonen (2009), immediate design refers to a mode of design characterised by responsiveness to users' current needs, intensive user participation, continuous incremental improvements, and the utilisation of open, do-it-yourself developmental platforms. Immediate design takes place on site, and aims at solving problems directly. Remote design works for general solutions, principles or understanding of the individual contexts and implementations; it creates foundations related to concepts, infrastructure, methodology, regulations, competence or resources, upon which others may develop products or local practices (ibid.). It should be noted that this complementing factor in approaches is evidently present in many contemporary practice-oriented technology studies. For example, Kawsar et al. (2008) noted the two diverse technical requirements in practical end-user construction processes. Their practice-oriented perspective on the challenge was a two-fold framework that suggests first building simple, easy to use tools and user interfaces that allow users to deploy the artefacts and applications. Secondly, they suggest composing the general infrastructures for building the augmented artefacts and generic pervasive applications. They also make the important remark that although these two requirements — in their case, user interface and infrastructure — are contrasting, it is hard to draw a clear distinction between the two because both are tightly coupled and complement each other. Mioradi et al. (2012) recently drew attention, within the Internet of Things context, to the functionalities and resources provided by smart objects when they are integrated into services. They stated that these need to be defined from a service-level perspective as architectures and methods for "virtualising" objects by creating a standardised representation of smart objects in the digital domain which is able to hinder the heterogeneity of devices, and methods for seamlessly integrating and composing the resources of the smart objects into value-added services. In the case studies presented in this dissertation, the distinction between these two requirements has been attempted by extricating the complementing design modes under separate projects.

The strength of the EASE approach lies in its underlining of the importance of focusing on practices that include both technology — in the IoT context comprising the architecture, infrastructure, easy-to-use tools, user interfaces and smart objects — and people. This necessitates, however, that the designers are able to understand and influence the complicated, intertwined socio-technical phenomena. The research carried out for this dissertation focuses on the physical and digital environments, multimodal systems and haptic interfaces, modifications in the context of use, the supportive ecology, and the creating, configuring and sharing activities, which create the experiences.

4.1.1 Do-it-yourself culture as the context for HCI research and design

The EASE approach suggests the do-it-yourself development as an intriguing opportunity for design. In the first part of the dissertation the research focuses on the do-it-yourself experiences for the Internet of Things. The do-it-yourself concept can be broadly understood as a vibrant making and crafting culture, combined with learning, creating and sharing activities. Kuznetsov and Paulos

(2010) defined DIY as a culture that aspires to explore, experiment and understand by doing things by oneself. The roots of DIY culture can be traced back to the Arts and Crafts movement (1860—1910), but the concept discussed here — the technology-driven and networked DIY culture — can be firmly associated with the DIY movement beginning in the late 80s and early 90s. This technology-mediated DIY culture may be considered as part of wider phenomena that involve e.g. the maker movement, hacker communities, digital fabrication and prosumerism. The research presented in this dissertation, however, highlights the role of amateurs — even people with no computational skills — who will eventually deploy and benefit from the technologies. The term DIY is therefore most suitable for the context: the connotation in the term is that next to anyone is capable of performing a variety of creating, configuring and sharing tasks. Nevertheless, an important part of all contemporary technology-mediated concepts of the wider phenomena is that they involve communities that are mainly ad hoc groupings drawn together by shared interests. And important common denominator in all the concepts is also that the communities work without gatekeepers or without geographic restrictions, and the services around the activities would not exist at all without the user-generated content (Gauntlett, 2011).

The early experiments for the technology-driven DIY movement were related to music creation activities, when easy availability of computers and MIDI made the production and recording of music accessible, both in terms of the tools and of not needing the specialised skills of instrument-playing in order to create music (McKay, 1998). More recently, rapidly increased availability of new technologies and social sharing provided by Web 2.0 has made DIY tools available for many other endeavours. Thousands of DIY communities share or create their projects by technology-driven and networked means; communities that focus on handicraft, everyday home improvement, guerrilla gardening, experimental music, citizen journalism, solving of social problems (e.g. sustainability and environmentalism) and amateur astronomy (Leadbeater and Miller, 2004; Kuznetsov and Paulos, 2010; Rushkoff, 2010; Gauntlett, 2011; Hyysalo et al., 2013). The integration of social computing, online sharing tools, and other HCI collaboration technologies has made it possible to adopt DIY cultures and practices more widely (De Roeck, et al., 2012). Subsequently, the Web has provided a forum where people can share their projects in a more organised way, and where finding like-minded persons is easy. Such sites as YouTube, eBay, Facebook, Flickr and Wikipedia, have taught ordinary people how to contribute and collaborate online. Online DIY communities — such as Instructables, Dorkbot, Craftster, Ravelry, Etsy, Spoonflower, Crafster and Adafruit — have spurred “single hobby” enthusiasts to find means to collaborate and share their work through computing. Within these communities, users create and import their personal content in the public virtual spaces of Web 2.0, while others add value by commenting, recommending or tagging the content (Plomp et al., 2009).

Turning to the sharing mechanisms of the Web, according to Gubbi et al. (2013) we are now in a phase in which we have ascended from the creation of static web pages (www) to sharing them by social networking (Web 2.0), as illustrated above. The next phase is towards the ubiquitous computing web, identified as Web 3.0[16]. In this “web of things”, or “web of services”, DIY activities may relate to modularised embedded computer systems and mashup[17] systems that recombine

16
It should be noted that this future network has been envisioned for some time now, and the use of the Web 3.0 concept varies in understanding of it as the semantic web, web of services, or web of things, depending on the context. In the context of this dissertation, the emphasis is on the two latter connotations.

17
A mashup, in web development, is a web page or web application that uses content from more than one source to create a single new service displayed on a single graphical interface. The term implies easy, fast integration, frequently using open application programming interfaces (API) and data sources to produce enriched results that were not necessarily the original reason for producing the raw source data (Lanier, 2013).

data and components derived from multiple sources. The profuse advances that have been achieved through decades of emerging technology research — namely, ubiquitous computing and intelligent environment research — have contributed to the process. Nowadays, there are also many commercial technical platforms that provide the means for physical combination and configuration of sensors and devices, platforms such as Rasperry Pi[18], mbed[19] and Arduino[20] (Callaghan, 2013). These platforms enable even layman DIY-enthusiasts with limited computational knowledge to aggregate sensors and smart devices, design the mashup systems, and produce self-created smart experiences. According to Roelands et al. (2011), to have real societal impact, the tangible interaction provided by these new technologies should be seen in the light of next generation manufacturing ecosystems.

4.1.2 DIY in the emerging technology research context

The manner for defining the research setup for DIY technologies finds support from the conceptualisation of Callaghan et al. (2009). They presented three broad alternatives for defining the research and development of the intelligent systems. In the first set up, a user is provided with a system with fixed programming, which leads to delivering limited functionality, as in automation and similar systems. In the second, more flexible approach, the system is employed by autonomously self-programmable intelligent agents, an approach that requires only implicit involvement from the user. In the third case, people may be intimately and explicitly involved in the programming of collectives of devices, which they may also have defined themselves. This last do-it-yourself approach for configuring intelligent ecologies has been nominated as the context for the research of this dissertation, although, as Callaghan et al. remarked, it is more laborious for the people using the systems. Study of the case is also laborious, as the traditional roles of design and usage are expected to change. There is one important and major advantage, however: people will have more control over their technical systems and ecologies.

The DIY approach promoted in this dissertation was previously initiated, for example, by Abowd and Mynatt (2000), who anticipated that the real goal for ubiquitous computing should be the provision of many single-activity interactions that together promote a unified and continuous interaction between humans and computational services. This proclamation could be viewed as the early seeds sown for HCI research relating to the Internet of Things. Newman et al. (2002) also predicted that, as we move towards a world in which computation is ubiquitously embedded in our environments and in objects, the range of possible interactions and interconnections among computational devices will explode. They believed that in such a future, users would wish to create configurations and combinations of these devices, as well as personalised configurations that no application developer could foresee. Later, Chin et al. (2009) studied the possibility of people being involved in programming tasks, and created a vision for future appliances and applications that could be constructed from aggregations of elementary network services. This dissertation research continues the process by taking a stance on people's need to do things by themselves, mashing up, using the ready-made tools, applications and configurations, and sharing the outcomes as smart experiences in the Internet of Things.

Beckman et al. (2004) anticipated that the concept of end-user sensor installation might offer several overall advantages, enhancing users' sense of control, reducing costs, accommodating diverse deployment environments, and increasing user acceptance of the technology. Cook et al. (2009) expected the approach to advocate a new focus for HCI research, which included the investigation of the mechanisms for supporting and enriching human socialisation and interaction, and orienting research toward community and cultural enhancement. Wulf et al. (2006) promoted an idea that the new goals for HCI should evolve from "just making systems easy to use" to "making systems that are easy to develop". According to Chin et al. (2006), the major contribution of the end-user installation would be that it transfers the focus of design from the manufacturer to the end user, a shift that aims to empower the lay-user, and thus challenges the nature of the current appliances; all attributes that might contribute towards more profound changes in social activities. Edwards and Grinter (2001) anticipated that, as computers enter homes in greater numbers, people will in any case find themselves becoming systems administrators, upgrading hardware and performing software installation and removal. Plomp and Tealdi (2004) have suggested that these domestic technologies would be suitable particularly for home control and automation, personalised entertainment applications as multi-user environments, and creation of applications that support elderly people in their homes, and for health care, particularly, in preventive care and providing security for outpatients.

From a purely technological perspective, Newman et al. (2002) proposed a construction philosophy for DIY. They call their approach *recombinant computing*, which dictates that computing environments may be created from the bottom up by creating individual entities to be part of an elastic, ever-changing whole. This philosophy also dictates that these entities may be designed and introduced with the thought that they might be used in many different ways and under different circumstances. The *pervasive interactive programming* (PiP) technique proposed by Chin et al. (2006) also positions the user at the centre of the system's programming by exchanging autonomous learning for explicit user-driven supervision. They offer non-technical end users the possibility of configuring and customising sets of coordinating pervasive devices without the need to employ conventional programming methods. Later, Chin et al. (2009) also proposed a *soft-appliance vision*, introduced for the purpose of expedient DIY device ecology, and anticipated that there is a yet greater need to find a way of categorising the social and technological relationships. They stated that the technical challenges relate to the nature of the hardware, the form of the software, how the communities of devices are formed and managed, how group coordination is programmed, how the relationships are described, how the system is maintained and debugged, and how the system deals with the mobility of devices and users. According to Callaghan et al. (2006) the key challenge in end-user empowerment lies in how lay-users will associate the devices and functions in both familiar and novel arrangements for making highly personalised systems. They explain that the significant aspect of the DIY paradigm is how it allows the coordination of numerous devices to provide new meta-appliances, or virtual appliances, so that the lay-users can create novel meta-functions that consequently allow them to become the designers of their personal systems.

Interchangeable and adaptable technologies are important building blocks in the DIY IoT ecologies, but are not enough to embrace the large research spectrum that needs to be addressed (Roelands et al., 2011). At the core of the technology-augmented DIY ecologies are the people who are constructing and configuring the systems (ibid.). In the "making is connecting" paradigm, it is inevitable that the owners of problems — that is, people with constructing and sharing needs — are allowed to act as designers, as proposed by Fischer et al. (2004). Understanding people, their personal background, their different levels of computational thinking and their different levels of

18 http://www.raspberrypi.org/ retrieved 14:27, 1 June 2014

19 http://mbed.org/ retrieved 14:36, 1 June 2014

20 http://www.arduino.cc/ retrieved 14:47, 1 June 2014

skills and experiences is also an important qualification for an accepted and acknowledged DIY IoT. People must be allowed to take control of their personal, smart surroundings, and at the same time, lower their barrier for IoT creation activities. The research in the case studies presented in the first part of this dissertation, by developing customisable technologies for the aged and people with severe paralysis, focuses on the means for constructing incremental and intelligent user-driven DIY ecologies. The selected approaches have been expected to answer the call presented by Bødker (2006), according to whom most user design approaches seem to have failed to recognise that there are several mediators, and that experiences come from a mixture of sources. According to Bødker, we are stuck with the idea that new design should always replace the existing mediators, rather than exist together with them. Bødker continues by saying that in order to provide methods to achieve this, there is a need to work towards an understanding of how the mediators in the networks or configurations can be isolated, analysed and replaced in the configuration (ibid.).

4.2 EXPERIENCE DESIGN

The EASE approach firmly suggests that the focus of ecological research should be moved away from technology design towards experience design. Consequently, experience design is at the core of investigations in the ecological research carried out for the first part of the dissertation, as well as in the design of the reflecting artefacts that are the outcome of the research. By the manner of approach, the dissertation has taken a stance on the wider discussion concerning user experience (UX) being a key focus to be addressed in the design and development of emerging technologies and, especially, in HCI.

The considerations surrounding experience design have tended to draw from the field of phenomenology[21], the philosophy of the phenomena of the experience. Harrison et al. (2007), for example, stated that the paradigm shift in the field of HCI has its base in phenomenology. Husserl (1970), who developed phenomenology around 1920, wanted to reconnect science with real world concerns by developing the philosophy of human experience on a rigorous scientific footing. Husserl's motivation lay in the concern that the domain of science and mathematics was increasingly "an abstract and idealised realm of dimensionless points and frictionless surfaces", which had supplanted the real world of lived experience where practical concerns were worked out (Dourish, 2001a). Phenomenological theories have argued that abstract categories, for instance, are things that need to be imposed on the world through our interactions with it, and with each other — rather than things that exist within it. Subsequently, there have been many followers, for example Heidegger and Schultz, who have developed and revised Husserl's philosophical work. Harrison et al. (2007) considered that the phenomenologically situated paradigm — the third paradigm in HCI, as they prefer to call it — focuses on meaning and the creation of meaning, which is based on human experience and represented through multiple perspectives, and the relationships amongst those perspectives. Bødker (2006) anticipated that emotions and experiences are keywords in the third wave of HCI that she promotes. Forlizzi and Battarbee (2005) view user experience as especially attractive for design research as it covers the wide area of attributes that relate to aesthetics, joy, emotions and affective aspects of the technology use. However, when trying to define the term experience, the problem arises from the lack of proper, or at least widely acknowledged, definition. This dissertation prefers to draw a reference on the experience design explorations of Dewey's (1934) pragmatism. Dewey (1934) defines experience as follows:

"Experience is a matter of the interaction of organism with its environment (environment that is human as well as physical). The organism brings with it through its own structure, native and acquired, forces that play part in the interaction."

Wright, Wallace and McCarthy (2008) also draw reference to Dewey, and elucidate that etymologically "experience" stands for an orientation towards life as lived and felt in all its particulars. It tries to accommodate both the intensity of a moment of awe and the journey that is a lifetime (ibid.). What Dewey's definition already suggests is that the path for studying experiences is not an easy one to follow; there is a certain need to make a distinct orientation. Battarbee (2004) found defining experience particularly difficult because of its dynamic – even paradoxical – nature. Experience has also been pronounced a difficult subject for research because of its subjective, private and unique nature: for no other person can know exactly what an experience is for someone else (Pine and Gilmore, 1999; Forlizzi and Ford, 2000; Buchenau and Fulton Suri, 2000). Also, the fact that experience arises from the interplay of a great many factors makes the phenomena a complex subject for research. Hassenzahl (2010a) found the study of experiences challenging and complex mainly because the designed artefacts require the investment of time and effort to grow meaningful. Nevertheless, even with these difficulties, attempts have been made to categorise experiences. Pine and Gilmore (1999), for example, differentiated between passive and active experiences, and experiences that are immersive as opposed to those that are absorbing. Another important categorisation is provided by Hassenzahl et al. (2010b), who associated the sources of positive experiences with universal psychological needs – connected with competence, relatedness, popularity, stimulation, meaning, security and autonomy – that they maintain important when designing interactive technologies.

Nevertheless, Dewey (1934) already criticised philosophers who spoke of experience by referring to singular experiences that had a beginning and an end. Dewey further criticised the psychological conceptions that expected experiences to be something occurring exclusively inside a self or mind or consciousness, something self-contained and sustaining only external relations to the objective scene in which it happens to be set (p. 257). He considered experiences to be founded upon life that is a uniform march or flow: "It is a thing of histories, each with its own plot, its own particular rhythm of movement; each with its own unrepeated quality pervading it throughout" (p. 37). He compared experiences to a flight of stairs that "proceeds by individualised steps, not by undifferentiated progression, and an inclined plane is at least marked off from other things by abrupt discreteness". Furthermore, Dewey disapproved of going over an experience after its occurrence. He stated that in this way it is only possible to find one property rather than another sufficiently dominant and claim that it characterised the experience as a whole. For these reasons, Dewey found it important to make a distinction between "experience" and "an experience". He described "experience" as the constant stream happening in our consciousness, while "an experience" is an event that has a beginning and an end. This is also the manner of relation adopted by the EASE approach towards experience design investigations.

Accordingly, the categorisation of experiences produces knowledge mostly about "an experience". Another problem in categorising experiences is the difficulty in providing concrete means upon which to establish the design. These concrete means have been described as difficult mainly because the experiences cannot be produced with absolute certainty – the user

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Phenomenology (in philosophy) is the study of the structures of the experience and consciousness. Phenomenology (in architecture) also absorbs the concept of subjectivity, making the thing and its unique conversations with its place the relevant topic, and not the thing itself. The brief and narrow description retrieved 21:38, 24 April 2014 from: Wikipedia.

experience itself cannot be controlled or predicted (Plomp et al., 2009). The most difficult phase in the experience design studies is therefore *the design for experiences*, a difficulty firmly emphasised by the EASE approach. According to Desmet and Hekkert (2007), designing for experience means to "deliberately influence the experiential impact of new designs". Forlizzi and Battarbee (2005) stated that designing for experiences should focus on the interactions between people and products, and towards the experiences that result, and that the investigations should include all aspects of experiencing: physical, sensual, cognitive, emotional, and the aesthetic. Wright, Wallace and McCarthy (2008) proposed experience-centric design for a solution that emphasises the power of dialogue and co-production in the experience design context. They see the emphatic approach to design as part of a broader pragmatic approach involving the understanding of users and their lived environment through empathy; "knowing the user in their lived and felt life". This approach is closely allied with what Battarbee (2004) defined as co-experience. She explained co-experience to mean that the design of a shared experience is created in social interaction driven by the social needs of communication, for which the participants contribute together. Wright and McCarthy's (2010) emphasis has been on the felt experience that bridges the individual and the collective or cultural levels. They maintain that the felt experience consists of a number of steps that include the anticipation of experience, as well as reflection and recapitulation. Shedroff (2001) proposed that in design for experiences a straightforward design strategy might work best. His view is that the practical solutions require an initial understanding by the designers and developers of what makes a good experience. The following task is then to translate the principles into the desired media, without the technology dictating the form of the experience. Shedroff determines that a good experience may be interconnected with the person's feelings, values or basic needs. Greenfield (2006) complemented this by saying that eliciting a good user experience in technology development often means accounting for the physical design of the technology, e.g. the human interface, the flow of interaction between user and device, and understanding of the larger context in which the interaction is embedded.

One attempt to design for experiences is the design of prototypes. Bødker (2006) pointed out that designers of emerging technologies must deal with the new multiple, experience-oriented technology, the continuing openness of which often requires technological experiments in order to understand which questions to ask. According to Bødker, this gives design prototyping a new role, investigating not only transparency and operationalization of interaction, but controlled reflexivity too. Bødker nevertheless accentuated the importance of technology not being just "dumped" on people – there is a need for careful examination of the questions to ask, and to have respect for the answers that are delivered. With regard to experience-driven design, experience prototype – as introduced by Buchenau and Fulton Suri (2000) – is thus an important concept, referring to any kind of representation, in any medium, designed for understanding, exploring or communicating what it might be like to engage with the product, space or system to be designed. Buchenau and Fulton Suri emphasise the experiential aspect of whatever representations are needed to (re)live or convey an experience successfully with the artefact; such experience prototypes create a shared experience and provide a foundation for design. The experience prototypes are used to understand existing experiences and contexts, to explore and evaluate design ideas, and to communicate ideas to various audiences. Experience prototyping can provide inspiration, confirmation or rejection of ideas based upon the quality of experience they engender.

Furthermore, Dewey (1934) emphasised the concentration on aesthetic potentials in the experience. Wright, Wallace and McCarthy (2008) suggested

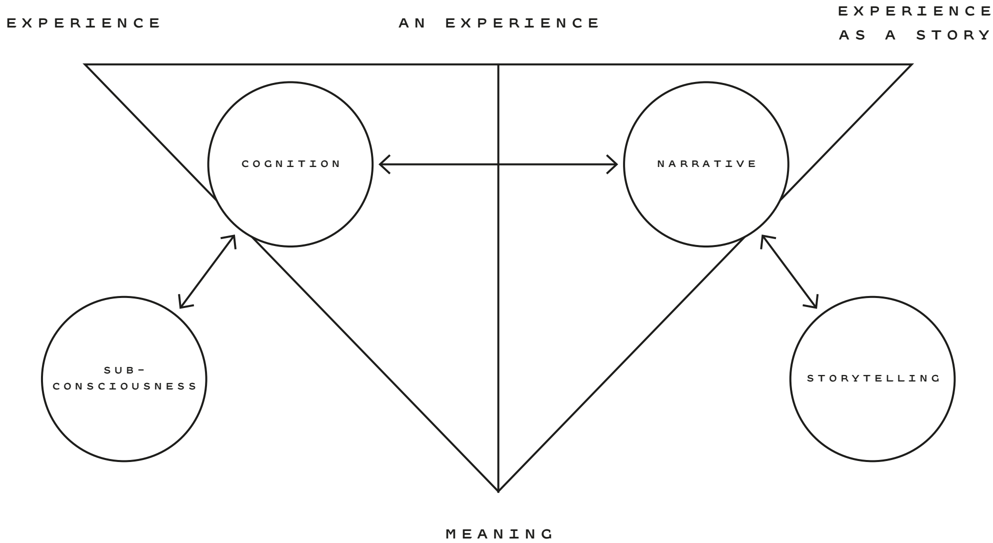

Figure 13.
Forlizzi and Ford (2000) framework for designing experiences.
Adapted with permission.

putting aesthetic experience at the centre of theorising about human-computer interaction, not only for describing how to analyse and evaluate people's interaction with the technology, but for considering the way to approach the design and making of digital artefacts. According to Wright and McCarthy (2007), in referring to aesthetic experience "the lively integration of means and ends, meaning and movement, involving all our sensory and intellectual faculties is emotionally satisfying and fulfilling". Each act relates meaningfully to the total action, and is felt by the experiencer to have a unity or a wholeness that is fulfilling (Wright, Wallace and McCarthy, 2008). They make a reference to Dewey in describing the particular qualities of the aesthetic experience as "creative, enlivening and expressive". Furthermore, the aesthetic experience involves senses and values in inclusive and fulfilling activity that is considered worth engaging in for its own sake (ibid.).

Forlizzi and Ford (2000) acknowledged Dewey's intellectual considerations for experiencing design through aesthetics, as well as his distinction between "experience" and "an experience". For the purpose of continuing discussion on this topic, Forlizzi and Ford introduced "experience as a story", a term originally coined by Schrank (1990), as a third category for experience design. The interest is incontestably in finding what Dewey earlier labelled as "the completing experience". Dewey explained the need by saying: "Between the poles of aimlessness and mechanical efficiency, there lie those courses of action... accumulating toward an end that is felt as an accomplishment of a process" (p. 40). According to Forlizzi and Ford, "experience as a story" relates to memories and providing meaning for "an experience", and it has most relevance when sharing user findings.

Forlizzi and Ford's framework presents four components for experience design: sub-consciousness, cognition, narrative, and storytelling (see Figure 13). Sub-consciousness, as interpreted for this dissertation, is the automatic, fluent and routine experiences Dewey defined as "the uniform march or flow". Forlizzi and Ford's framework uses the term "cognition" to represent experiences that require users to consider the activity. Cognitive experiences are important because people might perceive the affordances of the context in a new way, or new knowledge may be created which may result in learning. Narrative is used in the framework to represent experiences that are formalised after experiencing an artefact. The final part in the framework is the storytelling experience, which Forlizzi and Ford consider to be "on the highest mental level giving meaning to experiences". It is the experience after being reflected upon and made personal by relating it to aspects that have personal significance; it also is a way of communicating experiences to others (ibid.). Forlizzi and Battarbee (2005) later confirm that stories and storytelling provide a solid basis for experience design. As the repository of experience, they contain almost everything that is required for a deep, appreciative understanding of the strengths and weaknesses of a present service, and of what needs to be redesigned for the future (ibid.).

Forlizzi and Ford originally introduced the experience design components for product design and used "experience as a story" in a metaphorical sense, although in the context of this dissertation the concept has been used literally to create a story out of "an (elicited) experience". The literal approach for presenting the design outcome finds support from Bate and Robert (2006) who consider that as an inner subjective, immaterial phenomenon, the experience can never be accessed or observed directly, but only indirectly through the words and language people use to describe it when they look back on it. In this sense, the experience is not ''real'' at all – as at the time it actually occurs – but a reconstruction or reconstitution of something lived through: an elapsed, recalled experience (ibid.). Therefore, according to Bate and Robert, the words translate happenings into experience, and this is the reason why narrative and storytelling should play an important part in the armoury of improvement methods.

4.3 REFLECTING DESIGN THROUGH THE SCIENCE FICTION PROTOTYPES

Godet and Roubelat (1996) suggested that in the face of the accelerating pace of change, the uncertainties of the future, and the increasing complexity of phenomena and interactions, an antifatalistic, pre-active (anticipating changes) and pro-active (provoking changes) attitude is essential. They see that our modern societies demand anticipation, firstly because the acceleration of technical, economic and social change necessitates a long-term vision – "the faster you drive the further your headlights must shine" – and secondly because factors of inertia inherent in structures and people's behaviour mean that we must "sow the seeds of change today if we wish to harvest them tomorrow".

In many computer science research articles, especially those relating to intelligent environment, ambient intelligence and ubiquitous computing research, there have been frequent references and side remarks associating the research with science fiction[22] films and literature. For example, Cook and Das (2007) describe the birth of ambient intelligence thus: "*Most of us have come across science fiction movies where doors opened when someone approached, or computers were able to identify the interlocutor without their name being explicitly mentioned. Some of those features were far-fetched for the technology available at the time, but gradually, some features that indicate sensible autonomy on behalf of the system were targeted by industry – and consequently, ambient intelligence was born.*" Clarke et al. (2000) conclude their intelligent environment research relating to iSpace by illustrating intelligent habitats of the future. They make a reference to Star Trek, which they consider encapsulating many of the aspirations encompassed by the research area, and anticipate that research on intelligent environments is likely to form the basis of mankind's successful exploration of deep space, where it is inevitable that people must survive in wholly technologically supported artificial environments (ibid.). Lee and Hashimoto (2002) remark that this persistent association with science fiction is due to forceful imageries of future worlds that provide extremely good reference points for real-world engineering.

Greenfield (2006) also sees this work the other way around, remarking that the hegemony of ubiquitous computing has long been apparent in the science fiction genre. The development of ubiquitous computing has been locked into something Greenfield calls "a co-evolutionary spiral"[23]. This means that the stories told in movies and novels have come to shape the course of real-world invention, and these in turn serve as seed stock for ever more elaborate imaginings; and so the cycle continues. Bell et al. (2013) explains that science fiction authors offer both expansive and complex, fully developed futures that have integrated social, economic and technological considerations, while others use a more scenario-based approach that focuses on specific social, technical or economic problems. Dourish and Bell (2014), who firmly recommend reading science fiction alongside ubiquitous computing research, suggest that science fiction does not merely anticipate, but actively shapes the technological futures through its effect on our collective imagination. They perceive that visions of the future shape the collective understandings of the relationship between science and progress, and between people and technology, and as such have a profound, albeit little documented, impact on ubiquitous computing and its discursive practices. Dourish and Bell illustrate this with an example of the studies conducted by Penley (1997), who explored the extent to which the research and engineering activities of NASA were frequently and quite explicitly founded upon the visions of exploration and expansion embodied by the Star Trek television series. As it is, the series appears to have provided an extremely large set of referenced ubiquitous artefacts and innovations. A widely referenced example of an artefact inspired by Star Trek is the physical form of the original communicator: the clamshell phone design and those of the early PDAs (presented e.g. by Evangelista, 2004). Birtchnell and Urry (2013) in turn have identified that the most commonly referenced science fiction 3D -printer is the Star Trek "replicator" alongside a "bio-matter resequencer", which produces usable material from waste. An example of the most commonly referenced innovation from science fiction literature is perhaps Arthur C. Clarke's (1945) speculative communication satellite.

Greenfield (2006) sees nothing new in this, saying "science fiction merely extends the earlier tradition; folklore is replete with caves that open at spoken command, swords that can be claimed only by a single individual, and mirrors that answer with killing honesty when asked to name the fairest maiden in the land". In his opinion, science fiction, disguised in ubiquitous computing, is merely restaging the old tales, only this time with technology in the central role. Johnson (2011a) explains in more detail that the symbolic relationship of science fiction and science fact stretches back across hundreds of years. He claims that scientific research and technology has inspired writers to dream up thrilling stories and amazing new worlds, and generations of scientists have in turn had their imagination set on fire by science fiction stories that inspire them to devote their life to science. Johnson expands on the evolvement of science fiction by explaining a more radical movement in the 70s that formed around hard sciences (e.g. computer science, astronomy, physics and chemistry). According to Steele (1992), this form of imaginative literature

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Thacker (2001) defines science fiction as "a contemporary mode in which the techniques of extrapolation and speculation are utilised in a narrative form, to construct near-future, far-future or fantastic worlds in which science, technology, and society intersect".

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It should be remarked here that Arthur C. Clark had already explicated the co-evolutionary spiral of the science fiction and technology development by saying: *"All of the pioneers of astronautics were inspired by Jules Verne, and several (e.g., Goddard, Oberth, von Braun) actually wrote fiction to popularise their ideas.* (Johnson, 2009a)"

used either established or carefully extrapolated science as its backbone. Greenfield (2006) remarks that creating this kind of science fiction takes a futurist immersed in the art of storytelling to take the notions and turn them into something compelling. He sees that at its best, science fiction is the synthesis of all research carried out in prototype development, compiled with other research and literature. Greenfield comments that the ideas and knowledge illustrated by science fiction are in fact already present in academic papers, but unfortunately these will never touch people outside the research communities. According to Greenfield, when technology is situated in a conventionally engaging narrative, the set of notions about interaction possibilities leap from the arcane precincts of academia into the communal imaginary. Bleecker (2009) adds that *"productively confusing science fact and science fiction may be the only way for the science fact to reach beyond itself and achieve more than incremental forms of innovation"*. Callaghan et al. (2009) firmly suggest that scientists who are busy in developing emerging ubiquitous, ambient and intelligent technologies should put some effort into developing trustworthy and transparent tools, for without the trust of the general public in reliable sources the full potential of emerging technologies will never be realised.

4.3.1 Implications of science fiction for research on emerging technology

The problem with the emerging IoT technologies that are the subject of this dissertation is that we have yet to gain much knowledge of experiences regarding their use. Furthermore, the preceding research on ubiquitous computing and intelligent environments, already familiar through the extensive amount of work conducted in these fields, has been found to contribute messy, hybrid and piecemeal experiences. In fact, the conversations about emerging technologies, it has been argued, are less about the future — even the near future — than about the things that exist now (Greenfield 2006; Dourish and Bell 2014). Nevertheless, all this suggests there is sufficiently enough existing material already for beginning a highly realistic imagining of the latest descendant of ubiquitous computing.

Examples presenting the co-evolutionary spiral in the emerging technology research context are provided by, among others, Coen (1998), who introduced a research project related to the Intelligent Room, entitled HAL. The project was named after the sentient HAL — Heuristically programmed ALgorithmic — 9000 computer that controls the spaceship's systems and interacts with the ship's crew in the science fiction film '2001: A Space Odyssey' (1968). This film was one of the first to introduce artificial intelligence to a wider audience[24]. In project HAL, Coen furnishes a test bed, akin to a combination of home and office, to support a wide range of activities. According to Coen, the film assists in defining and exploring the things the intelligent environment should embrace, e.g. the sensory capabilities the environment required, and, more importantly, in determining the roles such environments could potentially play in our lives. Coen reasons that the future visions generally give valuable insight into how AI systems might participate in the real world, and provide directions for further research in the sub-AI disciplines whose systems contribute to the creation of complete intelligent environments. Another research making reference to the HAL 9000 computer was introduced by Lee and Hashimoto (2002). They explain that the computer's valuable potential with regard to their work lay in its high intelligence, citing its ability to observe human activity with its distributed cameras and to control subordinate systems as its expanded actuators.

Ubiquitous computing and its descendants have also had more profound reasons for engaging science fiction means to research, namely their potential for taking a stance on the social aspects of the technological solutions, which often have further implications that cannot be anticipated in the research context. As Greenfield (2006) phrases it: "ubiquitous computing contains an inherent, unsettling potential for panoptical surveillance, regulation and rationalisation". There are many references in which the implications of the technologies have been speculated upon in connection with concerns relating to privacy, security, visibility, control, ethics, legislation and governance. At the individual level, the social implications have related among others to reputation, credibility, status, trust, respect and the presentation of self. It has been suggested that these issues may well have been the cause for serious objections to the widespread introduction of emerging technologies. Callaghan et al. (2009) suggest that one way in which people might be made to acquire more trust in emerging technologies – and specifically in the autonomous agents – lies in the technology having explicit built-in rules reflecting the values and needs of people. Here they refer to Isaac Asimov, who explicitly addressed the problem in the "I Robot" series, in which he proposed a set of three rules designed to protect humans from the robotic technology they created. These rules could be summarised as "1) protect humans, 2) obey humans and 3) protect yourself. Callaghan et al. use the rules and transfer them to ubiquitous computing systems. The first rule aims at ensuring user safety, which is always considered paramount. Rule two aims at ensuring that access to the system is safeguarded, adhering rigidly to the user's wishes. The third rule aims at allowing users to particularise the ubiquitous environment to satisfy their individual needs.

The on-going debate over emerging technology research relates to the concern about who should be allowed to exercise control over the technologies: should it be the individual, government, commercial organisations, or some combination of these? Callaghan et al. (2009) points out that the level of distribution or centralisation of those exercising control over emerging technology systems may be found in key positions in the developing political systems around the technologies. Bohn et al. (2005) anticipates the reason for the general audience finding ambient intelligent research rather disturbing: namely in its requests for proactive environments, leading to the belief that the developed systems have some kind of emotional intelligence. In general, people reject the idea of having someone observe their emotions, and especially if someone is trying to influence them. Furthermore, technology driven by the embedding of autonomous agents was expected to arouse the opposite reaction to the feeling of being in control – this, in fact, has been raised as the single most important factor in the successful adoption of emerging technologies (Edwards and Grinter, 2001). Bohn et al. (2005) point out that when the technology is referenced by such phrases as "the walls have ears" and "if these walls could talk" the situation will become disturbing to many. Do et al. (2006) anticipate especially the use of image processing through video cameras as a potential kind of sensor as being a controversial idea. They foresee that constant monitoring and surveillance by artificial intelligence would be seen as the ultimate, global Panopticon[25]. Coen (1999) speculates that Bentham's Panopticon could indeed be considered the very first intelligent environment in which residents (inmates, the insane, or students) could never be precisely sure when they were being observed by the central Observer (the warden, doctor, or graduate advisor). Bohn, et al. (2005) argue that individual models – even those seemingly innocuous, such as walking patterns or eating habits – may be combined to provide highly detailed information on a person's identify and lifestyle.

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It should be noted that in a reference by Callaghan et al. (2009), the film is criticised as presenting AI overly destructively, and providing "first appearances" of the artificial intelligence concept that are far too negative.

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Panopticon, or Inspection House, as Bentham himself presented it in the 1787 letters, has been described as the ultimate scheme for organising all incarceration in a manner that optimises visibility and inspectability (Bentham, 1798). Panopticon has been described as an Orwellian structure in which a hive of rooms (or cells) could be kept under the constant scrutiny of an unseen Observer.

This has led to a paradox that in order to be useful, the system has to know, but once it is allowed to know, others can know too (Callaghan et al., 2009). In the Internet of Things context, Weber (2010) raises an issue relating to security and privacy, endangered by the emerging global Internet-based technical architecture facilitating the exchange of goods and services in global supply chain networks. Atzori et al. (2010) comment further that the possible threats deriving from a widespread adoption of IoT technologies should be considered wisely: "if the everyday objects become information security risks, the IoT could distribute those risks far more widely than the Internet has to date".

However, reactions of people towards the technologies are difficult to truly anticipate. Elsewhere, studies show that the people themselves are seldom aware of the privacy threats that might be related to emerging technologies. For example, Bonino and Corno (2011) demonstrate in their research relating to networked home automation systems that people tend almost exclusively to focus on the functional requirements, while they nearly omit non-functional requirements relating to privacy or security, which the researchers had *a priori* expected to be of critical importance. In addition, it seems currently to be the case that when new artificial intelligence technologies are introduced, for example in many mobile and medical devices, the audience proudly applaud the "panoptical surveillance" features of the technologies that work so well on their behalf.

4.3.2
Science fiction prototypes

As mentioned earlier, prototypes and test beds are usually the core means for studying human-computer interaction in emerging technology research. Koskinen et al. (2011) hold prototyping in high regard "because of the prototypes' distinct property to confront the world". Fallman (2007) cautiously reminds us, however, that many of the prototypes may be wholly or partly faked, and if implemented, may be unstable and lack some expected functionality. This has been true especially of high-fidelity proof-of-prototypes that often try to encapsulate many, even opposing, research objectives. According to Bell et al. (2013), the contemporary capacity to present and manipulate concepts and ideas without the physical form enables a shift away from the need to produce and be locked into a prototype "in hand". For such intents and purposes, Johnson (2011a) coins the term "science fiction prototyping". He describes science fiction prototypes as being "stories grounded in current science and engineering research that are written for the explicit purpose of acting as prototypes for people to explore a wide variety of futures". Bell et al. (2013) find Johnson's definition laying down a rationale for the conceptual form of prototypes that "shifts markedly from the traditional prototype found in engineering that expects a tangible and solid form to be presented".

Accordingly, Johnson (2011a) has turned "the co-evolutionary spiral" of science fiction and fact into a method: science fiction prototyping, which he introduced as a tool for the emerging technology research. According to Johnson, science fiction prototypes serve a purpose for the scientists and engineers in stretching their work; or, on the other hand, they can be created by any interested party who wants to influence the work of researchers. An important benchmark of this type of use is the "Uber Morgen" or "Tomorrow" project (2010) [26], a collection of science fiction stories made by acknowledged science fiction authors. The authors; Scarlett Thomas, Markus Heitz, Douglas Rushkoff and Ray Hammond, were first introduced to the future technologies in the Intel laboratories, and then requested to explore the new innovations and imagine them in the science fiction prototypes. The project has later continued by engaging science fiction professional and amateur writers around the globe to write the "Tomorrow project anthology" (2013)[27]. The authors have written convincing and creative stories about the future that are familiar yet advanced in their technological connections, including dystopias that challenge humanity and in which we may not want to live. It should be noted that the employing of science fiction in emerging technology research has been proposed before in works from Love (2001); and later Shedroff and Noessel (2012); Dourish and Bell (2014). Johnson, however, considers that the science fiction prototypes are most expedient when they are used explicitly as a step or input in the development process. In this case, the outcome would then be fed back to a scientific process, to shape the science research and outputs. Johnson (2009b) illustrates this type of procedure by first familiarising himself with the research of Egerton et al. (2008), and then creating a science fiction prototype of the material, entitled "Nebulous Mechanisms" (2009b). In fact, the process is highly iterative, as the prototype is part of series called "Nebulous Mechanisms: The Dr. Simon Egerton Stories", which present the adventures of Jimmy, the robot, and doctor Egerton. The process necessitated the familiarising with several research articles; however Johnson (2011a) has explained that he draws inspiration from other literal sources as well. Johnson sees the science fiction prototyping method making it possible to illustrate how to interact with emerging technologies, how to study the alternative designs and business models, how to introduce new technological paths and, ultimately, how to consider the ethics and values of the technologies. He sees the prototypes as primarily about humanising feelings concerning where the science is going — once created, the prototypes give the development team a new perspective on their work, allowing them to make adjustments, and sometimes even to uncover patterns or to unify the ideas into applied scenarios.

What do the science fiction prototypes in emerging technology research context then converse? The authors write about people's complex relationship with technology, potential effect on society and environment, change in lifestyles, or transposition of realities (Kovalchuk, et al. 2011). For example in the 6th and 7th international conferences on intelligent environments, the sessions on the science fiction prototyping for research innovation discussed e.g. about human values, spirituality, relationships, physical and psychological health, ambient assisted living, the complexity of the systems and information overload. Most presentations were about science and engineering, in which the emerging technologies related to the sensing- and interaction technologies: e.g. gait recognition (Loke and Egerton, 2010), natural language processing (Tassini, 2011), sound conditioning (Kultys, 2011), brain computer interfaces (McCullagh 2010; Kovalchuk 2011; Grian 2011), augmented/virtual/mixed realities (Clarke and Lear 2010; Hales 2011), artificial intelligence (e.g. WU and Callaghan 2011; Grian 2011), robots (Egerton et al 2011; Johnson 2011b) intelligent environments and embedded systems (Kovalchuk, 2011), Internet of Things (McCullagh, 2011), ubiquitous computing (Tassini, 2011), wireless sensor networks (Loke and Egerton 2010; Scholz et al. 2011) context-aware computing (Tassini, 2011; Scholz et al. 2011) nano computing technologies (WU and Callaghan, 2011), mimetic science (Hales, 2011) and human space exploration (Peldszus, 2011). On top of the contributions from science and engineering, diverse set of disciplines participated in the conversations, such as: business, architecture, humanities, creative arts, genetic engineering, and education.

It seems that the ethical issues and social consequences have taken the main devotion to be addressed with the science fiction prototyping method. Love (2001) began the crusade in her short essay by introducing an anti-capitalist demonstration against robot economists who accessed to the latest global

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Open access electronic article, retrieved 21:07, 31 May 2012 from: http://www.intel.com/content/dam/www/public/us/en/documents/technology-briefs/intel-labs-tomorrow-project-complete-brief.pdf

27
Open access electronic article, retrieved 11:18, 5 June 2014 from: http://isef.tomorrow-projects.com/2013/10/cautions-dreams-curiosities-anthology/

macro and micro-economic financial information. Later, Clarke and Lear (2010) in their science fiction prototype "We all wear dark glasses now", as well as Graham (2011) in his prototype "Interaction Space", issued complex societal problems; McCullagh (2013) focused on social and ethical issues with respect to long-term healthcare planning and our "inevitable technological migration" towards a surveillance society and Nelder's (2013) prototype explored the specific social consequences of the super-enhanced hearing innovation. Stahl's (2013) ethical considerations related to privacy and intellectual properties surrounding the organisations' innovations. In this Stahl drew a reference to ETICA project, which identified eleven emerging socio-technical systems that are currently being seen as having the potential to significantly change the way humans interact with the world in the medium term future. Birtchnell and Urry (2013) discovered that for the social scientists, the usefulness of the method lies not only in fantasising about the speculative technologies, but also in encouraging vatic insights into the possible unintended consequences and social practices emerging from people's varied engagements with technology and involvement in innovation.

An important devotion for the science fiction prototypes in the research context is to illustrate the long-term solutions for the technologies, and introduce new opportunities and designs applicable in more distant future. Callaghan et al. (2009) illuminated the justification for this by saying that as we will move into the longer-term future, there is a great possibility that we will become completely dependent on the technologically supported environments. For example, if humankind ventures outwards, towards the habitation of other planets, people will need to live in permanent space stations, planetary colonies or in spacecraft engaged on inter-planetary journeys (ibid.). In their article they speculated with an experimental community that has to be reliably autonomous and self-governing at all the levels of critical safety, but hypothesised that individuals will probably still retain a strong desire to personalise aspects of their environment.

4.3.3
Creative science cycle

Erkan Bostanci[28] presented an informative visualisation of how the creation process in science fiction prototyping works (see Figure 14). He perceives that at the beginning of the process cycle there are "the pink dreams of a better world". He suggests these dreams may relate, for example, to a healthier world, and consequently the technology to consider in the prototype might be e.g. the wearable system tracking health status. Another dream may be a more comfortable world, in which the employed technology might be e.g. an intelligent house adapting to the behaviour of the user. In the context of this dissertation, the pink dreams relate to finding solutions to the demographic challenge: reducing social exclusion of the elderly and disabled, and finding means for the culture of mass amateurisation.

Bostanci further explains that once all these dreams come together (in Figure 14; the integrator symbol) they feed the research. Research will produce the output, although there might be some delay, for example due to the technological or financial challenges. When describing the challenges in science fiction prototype creation, Nelder (2013) found the problem relating to the procurement budget cuts, bureaucracy, political intervention, long run design and development cycles, commercialising the technological innovations and the accelerating commercial technology race. Conclusively, Bostanci considered that there are two types of output in the process. For the concrete part, there is an application, prototype and some publications. For the abstract part, there are more dreams, because we will never be satisfied with what we have, or because we may end up thinking something in the research was not achievable. Kovalchuk (2011) described these challenges vividly in her prototype "The Ministry of Interfaces (Doors)": *"How often do we break our head and fists knocking into a door to find an entrance or escape, eventually realising it was a wall that would never open? How often do we waste our energy trying to explain to some one our ideas, discovering at the end that both parties were actually talking about similar things but in different terms? How much time do we spend on writing reports or product specifications getting annoyed about the (often pointless) process of "moving boxes around"? There are so many templates, so many ways to present and to interpret data. How many valuable thoughts and ideas were lost just because we had no facility to write them down at the moment they occurred to us?"* Bostanci's remark could also be complemented by considering a relatively usual research set up for emerging technology research: for explaining the results that take a stance on these more abstract outputs, or the holistic considerations of emerging technologies, the available means barely extend beyond the discussion part of the article. The science-fiction prototyping method introduced by Johnson (2011a) is explicitly introduced for such a tool, for the purpose of concretising the abstract research, and for producing more dreams. Because in the end, as Bostanci concludes, the "Creative Science Cycle" is meant to keep on going, eternally.

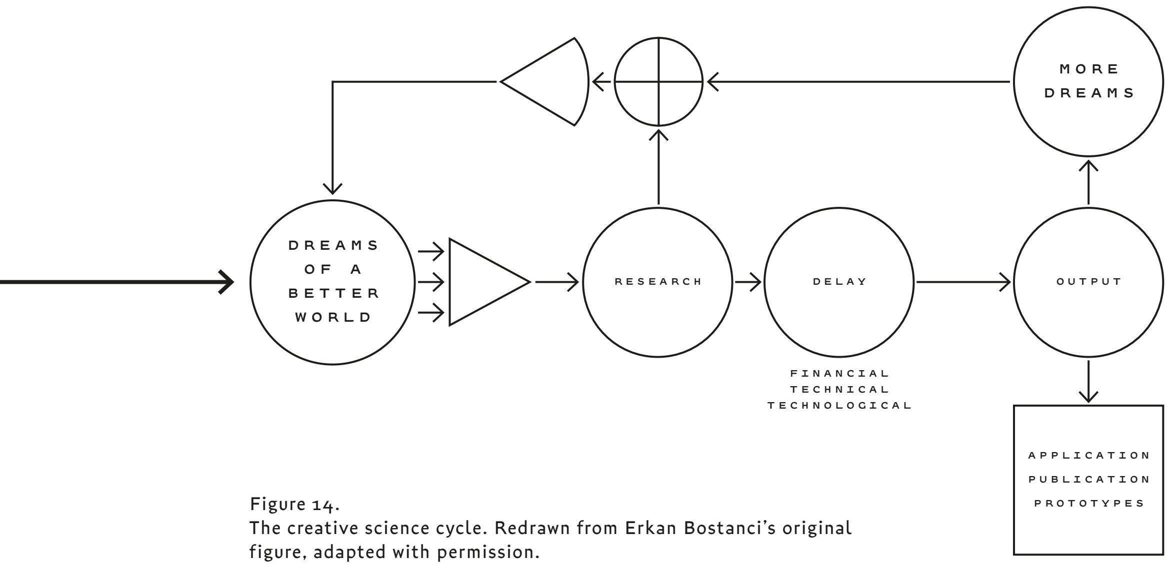

Figure 14.
The creative science cycle. Redrawn from Erkan Bostanci's original figure, adapted with permission.

4.3.4
Relation to Scenarios

To all those working within disciplines that study emerging technologies, the science fiction prototypes may sound a bit like scenarios, which have unquestionably been in common use in the emerging technology development processes. In that context, a scenario has usually been considered as a short story, typically created at the beginning of the project, for combining the ideas of the research group. The processes for creating scenarios are usually highly interactive, with all research participants contributing to the practice. In the analysis of current and envisioned technology scenarios, Carroll (2000) discovers that where the HCI discipline envisions scenarios to analyse and evaluate human

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At the University of Essex, 25 August 2011.

goals and activities, software engineering envisions the use of a system in order to articulate system requirements and software structures for implementing those requirements. According to Carroll, technology scenarios have often been used to generate requirements, to uncover missing features, to verify and validate requirements, and to integrate analysis of functional and non-functional, or "quality", requirements, such as security, safety, reliability, portability and cost. He goes on to state that in HCI work scenarios have been used to support design brainstorming and prototype development, to generate issues and trade-offs in a design, and to provide usability walk-throughs for ensuring that the system features are evaluated relative to a specified context of use, design space analysis and use representations.

Scenarios, particularly in the ubiquitous research context, have always played a critical role in illustrating emerging technologies. Among others presenting scenarios, Mark Weiser's (1991) future vision of the workday of Sal later became an important reference for the discipline. In the Easyliving project, Brumitt et al. (2000) used a scenario to describe the development of an architecture that aggregated various devices. Coen (1998) also described the previously mentioned HAL system by means of a scenario that he used to help explore and define the technologies for the system. An important benchmark for European ambient intelligence research was the ISTAG report (Ducatel et al., 2001) containing four widely cited scenarios. The scenarios aimed at the year 2010, and include implications of ambient intelligence technologies for the societies. The emphasis in these scenarios was on user-friendliness, efficient services, user-empowerment, and support for human interactions. In later publications, Augusto and Nugent (2006) presented a scenario for an intelligent house, with the aim of describing how the house reacts to normal, everyday situations; Callaghan et al. (2009) focused on privacy-related issues and the individual's right to control the collection and use of personal information, and Iacucci and Kuutti (2002) presented concept designs of mixed realities and wireless devices.

All these scenarios have tried to illustrate more than merely the operational aspects of the developed technologies. Greenfield (2006), however, illustrates a typical mainstream scenario in ubiquitous computing as follows: "*By entering a room, you trigger a cascade of responses on the part of embedded systems around you. Sensors in the flooring register your presence, your needs are inferred (from the time of day, the presence of others or even the state of your body) and conditions in the room are altered accordingly*". The illustration of Gene Becker, the principal investigator at Samsung, of the scenario practice is spiced with humour and irony, as for him the ubiquitous computing scenarios seem to be constant variations of the same future "*to the point where they seem like a familiar and tired joke*" (Greenfield, 2006). He explains a general ubiquitous computing scenario in which a user selects the suitable alternative rendering the technology or domain:

> "You walk in the [conference room/living room/museum gallery/hospital ward], the contextual intention system recognizes you by your [beacon/tag/badge/face/gait], and the [lights/music/temperature/privacy settings/security permissions] adjusts smoothly to your preference. Your new location is announced to the [room/building/global buddy list service/Homeland Security Department] and your [videoconference/ favourite TV show/appointment calendar/breakfast order] is automatically started."

In general, Greenfield (2006) accuses the technology-driven scenarios of decomposing all possible situations into them: every party to an interaction must be named, as well as all the attributes belonging to each of them. He believes these scenarios also neglect to model fuzzy, indirect, imprecise behaviours; the

"AI-hard" fuzziness, indirection and imprecision that is all around in everyday life. Schwarz and Liebl (2013) criticises that in the context of HCI scenarios are often created solely for the purpose of enhancing the creativity of designers. Buxton (2007) considers the problem with scenarios to lie in the fact that they try to tell, show, explain and convince rather than invite, suggest and question. His suggestion for changing the situation is to provide more advanced tools for users to speculate about the alternatives.

Erickson (1995) has appropriately elucidated the difference between stories and scenarios. For him, the most obvious difference is that stories are concrete accounts of particular people and events, in particular situations, whereas scenarios are often more abstract, being scripts of events that may leave out details of history, motivation, and personality. Scenarios also describe events at a greater distance, and there is less chance of identification with a protagonist, if one truly even exists (ibid.). Erickson further assumes that stories are more real, in the sense that the people, events, and situations to which they refer are real. In contrast, the reality of scenarios is more tenuous, rarely referring to particular events. He considers the main strength of stories to be that they are personal: the protagonist, as well as the audience, cares about the outcome. Erickson further states that the most important characteristics of stories are that they describe mostly about atypical situations: they are about events that are exceptional in some way, events in which the protagonist has triumphed, or foundered, in the face of great odds. Scenarios, in contrast, are usually about typical situations: they are intended to capture normal prototypical situations and chains of events.

For clarification, it should be noted that other disciplines, such as futures studies and strategic planning, have taken a somewhat different approach to the scenarios. Godet and Roubelat (1996) see scenarios as devices to be employed for stimulating strategic thought and communication within companies, improving internal flexibility of response to environmental uncertainty and provide better preparation for possible system breakdowns, and reorienting policy options according to the future context on which their consequences would impinge. Futures studies makes a clear distinction between the different attitudes towards the ideas of change, evolution or progress in societal systems. For example, Mannermaa (1991) distinguishes between the more traditional scenario paradigm and evolutionary futures research that aims to study complex, self-organising evolutionary systems. According to Mannermaa, the scenario paradigm in future studies assumes that the future is not wholly predictable but constructs alternative futures. The scenario model has been a more or less well established branch in futures studies, with much research already carried out. Mannermaa has promoted the evolutionary paradigm that assumes complexity, and conceives of (the present and) the future as multiversal realities that are examined and developed through prototypes. Bell et al. (2013), in fact, suggest using science fiction prototypes for studying the evolutionary futures. In essence, they consider the main difference between scenarios and science fiction prototypes in this context to be that scenarios act as the mechanisms for testing strategic direction, while prototypes offer a mechanism for analysis. The scenario is thus a specific set of predictions that depicts a future that could occur, and actively encourages its realisation, whereas prototypes express "hope", and an approximation of the future that is a consolidation of inspiration (ibid.).

4.3.5 Employing science fiction prototyping to other disciplines

It should be noted, that although Johnson introduced the method at first as a tool for the emerging technology research, the method is adapted for other disciplines as well. One discipline that has made a good use of the science fiction prototyping method, was the abovementioned futures studies — a discipline that focuses on the wider social, technical or economic areas of research ranging e.g. from the future of governance, business, transportation to agriculture. In fact, there has been a long history within the discipline that has acknowledged the influence of science fiction (e.g. Miles 1993; Love 2001; and Bergman et al. 2010). Actually, if there are currently any parallel concepts with the science fiction prototyping method, they can be found from the field of the futures studies. The discipline earlier proposed such research approaches for studying the evolutionary futures as the event descriptions of the "black swans" (Taleb, 2007) — events which are unforeseen but have massive consequences for society —, forecasting of the weak signals by "wild cards" (e.g. Mendonça et al. 2004) and methods such as e.g. "the futures windows" (Heinonen and Hiltunen, 2012). Bell et al. (2013) recently promoted the use of science fiction prototypes for studying the evolutionary futures, as according to them, most impact is achieved with views of the future that are presented as prototypical stories, which plant a seed that germinates and comes to fruition in a more distant future. They assumed that any totalising predictions of the future are anyhow flawed, biased and ultimately fix specific aspects of an imagined future, and justify the use of science fiction prototypes by arguing that "a revolutionary technology defies predictions".

Consequently, there has already emerged a co-evolutional spiral with future studies and science fiction prototypes. An example of this is the science fiction prototype "Virtual suicide and other ethical issues of emerging information technologies" by Stahl (2013) that has been based on foresight research project, which investigated the ethical issues of the emerging technologies. Even more substantial evidence of the co-evolutional spiral has been presented in articles that aimed to make visible the influential concepts of future studies. For example, Johnson (2013) illustrated the black swan -events in his article "Engineering uncertainty: the role of uncertainty in the design of complex technological and business systems" by exploring the increasingly complex computational system by architecting open sourced AI to the robot, Jimmy. Also, Birtchnell and Urry (2013) tackled the black swan -events by experimenting with their prototype the use of complex geometries and laser sintering of metals in high-risk products. Schwarz and Liebl (2013) in turn made an argument that cultural products, such as the science fiction prototypes, can be used to detect weak signals of change in the environment. They emphasised that technological developments go hand in hand with the changes in sociocultural practices, and expect more evidence on the usage of science fiction prototypes in detecting weak signals to imagine the future.

Another discipline that has been acquainted with the method is the economy and business sciences (Graham 2011; Graham et al. 2013; Wu 2013). Graham et al. (2013) explored the use of creative fictional prototyping to motivate and direct research into new high-tech products, environments and lifestyles. In their prototype Graham et al. considered the co-creation paradigm in an online environment and the possibilities to further refine the dominant logic of services marketing. Wu (2013) take up on a challenge by completing the science fiction method by introducing "imagination workshops" that aimed to provide an evolutionary model of the science fiction creation process. The workshops employed existing science fiction prototypes as their source of inspiration, and the process includes several feedback loops. The novel contribution of her model included the delivery of simple product specifications and business models as outcome of the process.

4.3.6 Science fiction prototyping as a tool for design

Godet and Roubelat (1996) encourage a reactive and proactive approach towards foresight. For this reason they have interpreted a future vision as *"a description of a future situation and the course of events which allows one to move forward from the original situation to the future situation"*. The definition connects the aims of strategic future planning quite apparently with design, as if reflecting the way Herbert Simon (1969) has understood design: *"Design is devising courses of action aimed at changing current situations into preferred ones"*. Dourish and Bell (2014) interpreted science fiction as "a genre that is explicitly future-oriented and in which technology and its role feature as a recurring leitmotif". They also find this definition to apply in the ways in which design-oriented research is typically carried out: with an explicit focus, not only on the extrapolation of current technological opportunities, but on the imaginative and speculative figuring of a world in which emerging technologies can be applied.

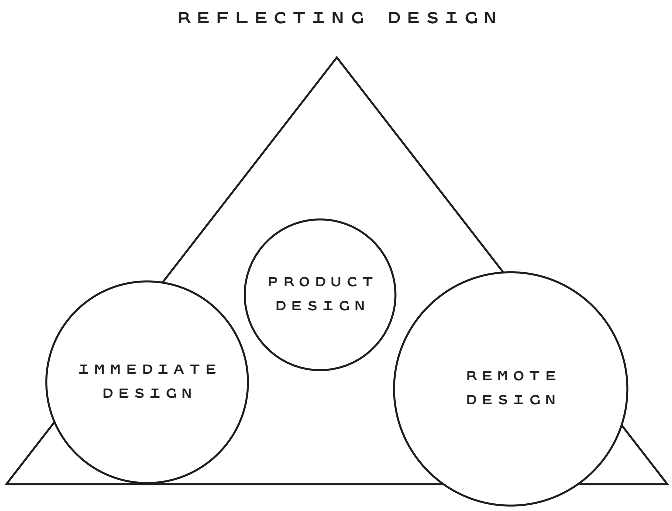

Figure 15.
Reflecting design exploring the findings of design research carried out in modes of the EASE approach.

Consequently, Dourish and Bell (2014) suggested science fiction to be employed as a tool for design. According to them, this design tool could reveal new information or a streamline of the development process where the traditional scientific method could not (in p. 37). Bleecker (2009) also found the use of future visions and science fiction to be potentially productive tools for the design of new technologies. According to him, the physical prototypes, conceptual inventions and building the actual technology could be described as "conflantation of design, science fact and science fiction". The future-oriented attitude, however, is not completely unfamiliar to previous design research. For example, Sengers et al. (2005) introduced reflective design as a critical approach for technology design by arguing that reflection on unconscious values embedded in computing, and the practices that it supports, can and should be the core principle in technology design. Another reference for the future-oriented attitude may be found from critical design. According to Wolf et al. (2006), critical design aims at delivering a designer's reflective, evaluative and communicative explanation of the designer's own design judgements and the activities in which the designer has engaged (p. 524). Zimmerman et al. (2007) explicate the difference between critical design and more common design practices as in the outcome of research: where the making in the latter practice usually focuses on creating commercially successful products, researchers in critical design create artefacts intended as carefully crafted questions. These artefacts are subsequently intended for stimulating discussion around an interesting topic. The common determinant for both reflective and critical design lies in their providing a unique design space for investigating important and new topics. Wolf et al. (2006) consider this to be "the shared reflection combined with an insightful and forward-looking attitude that is embodied in the practice of the design".

This dissertation will be proposing science-fiction prototyping for the design field as an extension to these design methodologies that have future-oriented attitude with an aim to deliver reflecting, radical research outcomes. In the context of the dissertation, "reflecting" has been used for its denotation to the important preliminary research, as well as to the resulting new design artefacts. Reflecting design is introduced in order to explore the findings of design research carried out in the first set of articles, and to continue the design process in order to propose more radical, future-oriented artefacts (see Figure 15).

Research questions 5

ABOWD AND MYNATT (2000) have previously pointed out that emerging technologies must always serve a real or perceived human need, because, as Weiser (1993) noted earlier, the whole purpose of ubiquitous computing was to provide applications that serve humans. Based on the previous knowledge and the identified gaps in the fields of emerging technology research, HCI and design, the first objective for the research carried out for this dissertation lay in the observation according to which our environments are gradually becoming intelligent (Kuutti et al. in Kaasinen and Norros, 2007). The inclusive hypothesis for the dissertation is therefore that the do-it-yourself approach may provide a suitable development model by constructing an incremental, user-initiative Internet of Things. The research fills the gap in the considerations that expect employment of IoT technologies to be limited only to using and controlling the technology, in supporting people by contrast to shape the technologies according to their preferences. The EASE approach (Kaasinen and Norros, 2007) has been nominated as the contextual methodology for studying emerging technologies; however, the proposed modes of approach have not yet been implemented in the design for the Internet of Things or verified by empirical research. The dissertation has made a commitment to the proposal of Plomp et al. (2009) in which they suggest engaging to study "participatory digital ecologies" — small groups, communities and societies that can produce and modify content within the ecologies. The DIY communities have been expected to represent early adopters of the new cultural practices that reform and repurpose the technologies, exemplifying a vibrant creative spirit that, according to De Roeck et al. (2012), is often misunderstood and certainly understudied by HCI. This dissertation anticipates that the design research for the Internet of Things should focus on evolving, messy technology-augmented ecologies constructed in the manner, as DeRoeck et al. propose, of Lego bricks: one system at a time.

Abowd and Mynatt (2000) were also among the first to suggest that, while undertaking research, researchers should aim at building compelling stories from the perspective of the end user concerning how the build system or infrastructure would be used. Their proposal goes beyond merely suggesting the creation of scenarios, having stated that the purpose of these compelling stories is to provide not simply a demonstration vehicle for research results but the basis for evaluating the impact of a system on the everyday life of its intended population. The gap in current HCI research found by this dissertation is the one expected to be filled by the third wave of HCI approaches. The dissertation has taken up the challenge proposed by Bødker (2006) by offering a solution for the "art-focused breakdown", with the intention of introducing a reflective practice, as well as an artistic statement, to provoke people influenced by the technologies. The second part of the dissertation thus suggests a supplementing concept for the EASE approach, introduced here as reflecting design for radical innovations. Reflecting design is meant to explore the findings of the design research carried out in the modes of the immediate and remote design of the EASE approach, and to continue the process in order to propose more radical, future-oriented artefacts for Internet of Things ecologies. The science fiction prototyping method (Johnson, 2011a) has been nominated as the doctrinaire method for delivering the design artefacts, as the outcomes of research from ecological research of technology, with the reflection of how it is specifically conducted.

The initiative for the research carried out for this dissertation has accordingly come from the long-term pragmatic research question of HCI within the emerging technology research context:

- How to design emerging technologies that place people meaningfully in the centre?

Placing people "meaningfully in the centre" refers here to an engagement in which people are allowed, within the emerging technology ecologies, to perform the kind of tasks, activities and interactions with the technologies that they find to be important. This means that the technology is co-designed with people, and developed around the experiences they have expressed, observed and exhibited as feeling towards the systems. Also, by placing people meaningfully in the centre the design outcomes of research are proposed to be presented in a manner that illustrates the arrangements between people and the technical ecologies in well-defined, comprehensible and engaging ways. In conclusion, the experiences found from the user studies will be placed at the centre of the design investigations, but with the "experience as a story" (Schrank, 1990; Forlizzi and Ford, 2000) mind-set leading the process.

The focus of research in this dissertation is thus on the experiences that form around the use of technology in do-it-yourself Internet of Things ecologies. According to this focus, the pragmatic question has been divided into two more specific sets of research questions guiding the research efforts. The first set of questions, for the first part of the dissertation, is:

1. How to construct do-it-yourself ecologies for studying the experiences of Internet of Things technologies?
- How to define the user ecologies that form around the technologies?
- What are the critical DIY experiences that form around the technologies?
- What is the design strategy for carrying out the empirical research that is based on the EASE approach?

The first question aims at defining the do-it-yourself user ecologies; this is carried out by defining the characteristics and involvement level of the participants in the nominated ecologies: a nursing home for the aged, a music therapy context for the disabled, a community for enthusiastic amateur life story authors, and an interior design context for professional-amateur designers. The human ecologies may be seen as part of more complex technical ecologies that describe the relationships between people, technologies and the environment in a given context. The second question focuses on the experience design research that is expected to deliver critical design implications for emerging technologies. The emphasis is on the do-it-yourself experiences that are reflected on the literary findings related to creating, configuring and sharing activities. It should be noted that the first part of the dissertation understands these experiences in the sense Dewey (1934) defines "an experience": as an event that has a beginning and an end. In addition, at the core of the investigations are the new experiences that emerge when the proof-of-concept prototypes are introduced to the ecologies. These new experiences are understood more as "experiences", described by Dewey as "the constant stream happening in our consciousness", "uniform march" or "flow". Lastly, the third question considers how the initiative people of the ecologies should be involved in the IoT research projects; the methods to be employed for design research and for defining the strategy. The design-oriented research pursues design strategies and conventions for the construction of do-it-yourself IoT ecologies by grounding the research in the immediate and remote design modes of the EASE approach.

The second set of questions relates to the second, reflecting design part of the dissertation, and focuses on the following:

2. How to create experience-driven science fiction prototypes as design outcomes of research?
- How to employ the grounding research in order to create design artefacts?
- How to design science fiction prototypes that place the elaborated research findings, experiences, meaningfully in the centre?
- What is the framework for designing experience-based science fiction prototypes?

In the second set of questions it has been essentially important to demonstrate how to aim at designing reflective, future-oriented science fiction prototypes that highlight the role of experiences towards emerging technologies. The first question considers the key findings from ecological research. As the grounding research aims to create design artefacts, the focus must be clear and well defined. In addition, the aim is to elaborate research findings by considering what other essential knowledge supports the artefact creation. Reference here is to the intellectual considerations of Dewey (1934), who suggests aiming towards experience through aesthetics. The second question deals with the well-defined focus – the main research findings – which in the research context refers to the experiences. The question explicitly aims to describe the impact of the emerging technologies on human experience. The second question also attempts to find means for engaging new experiences that have been discovered from the ecological studies. It should be noted that the second part of the dissertation understands experience in the sense introduced by Forlizzi and Ford (2000), namely "experience as a story", the third category for experience design. The hypothesis is that by answering both sets of questions it will be possible to conclude with a framework that describes the design strategy for constructing science fiction prototypes in terms of the experience design outcome of ecological research on emerging technology.

Design-oriented research and research-oriented design

METHODOLOGICALLY, THE DESIGN contribution of this dissertation falls under the research approach proposed by Zimmerman et al. (2010) which they entitle *research through design* (RtD), a research approach that employs methods and processes from design practice as a legitimate method of inquiry. They state that RtD lends itself to addressing these problems through its holistic approach of integrating knowledge and theories from across many disciplines, and describe its iterative approach to reframing the problematic situation and the preferred state as the desired outcome of the research. Zimmerman et al. emphasise that they do not consider RtD as a new concept, but more as a combinatory design theory. Nevertheless, the approach has been found to be a suitable background design theory for this dissertation for the purpose of describing the part played by design practices in the overall construction.

A major contribution of this dissertation to RtD and HCI disciplines is that it includes two parts: two sets of articles presenting examples of research and design outcome that have a conversational, *vis-à-vis*, relationship to one another. The reflective conversation between the two has been inspired by the proposal of Daniel Fallman (2007) in which he draws a distinction between two design approaches — design-oriented research and research-oriented design — essentially to clarify the role of design in the field of HCI. Fallman states that this distinction is important as, with regard to the aim and scope of design, and especially the role that the research plays in these different conducts, it serves to strengthen the roles of both approaches and explains their distinctive cultures. Fallman perceives that design-oriented research — where research is the "area" and design the means — seeks to produce new knowledge by involving typical design activities in the research process. In research-oriented design — where design is the "area" and research the means — the primary objective is the creation of new artefacts and answering the real problems and real-world obstacles that are faced in the process. According to Fallman (2007), when considering the engagement between the two approaches, the main disparity between research and design from this perspective is not that primarily design only produces artefacts and research only knowledge. In design-oriented research, within the field of HCI, the knowledge that comes from studying the designed artefact, whether in use or from the process of bringing the product into being, should be seen as the main contribution — the 'result' — whereas the artefact that has been developed becomes more of a means than an end (ibid.).

Keinonen (2006) specifies what Fallman calls the "area" by introducing the models of art and research interfacing and interacting within academic activity. For the "areas", Keinonen proposes two distinctive non-overlapping fields of activities: Field of Art (Fa) and Field of Research (Fr). In addition, the practices conducted in both fields can be described by individual actions: Action of Art (Aa) and Action of Research (Ar). With these concepts he further outlines the models through which art and research may interact. From the eight different models he presents, two have been considered important for this dissertation. The first of his models is "Research interpreting art" (see Figure 16).

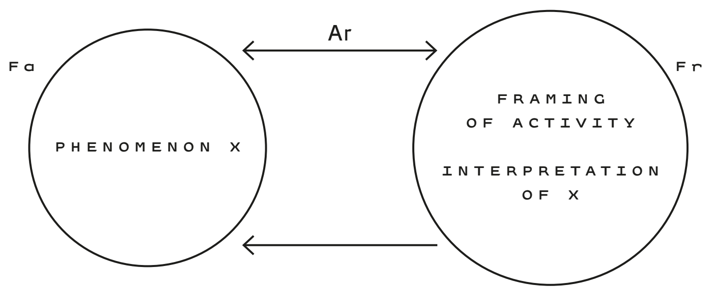

Figure 16.
Research interpreting art (redrawn from the original figure by Keinonen, adapted with permission).

In this case, a researcher, or a team, conducts research project in a research context concerning phenomenon in the Field of Art. The activity has its foundations in research, and aims primarily at contributing to research. The second model (see Figure 17) is "Art interpreting research", which Keinonen considers to be the mirroring approach to that above. In this case an artist creates a work of art about a phenomenon that takes place in the Field of Research. The activity has been framed based on art-driven criteria and interpreted as a work of art. Keinonen has identified an example of the model as being science fiction literature and films, which he describes as creating visionary projections that utilise and further elaborate the results of research and technical development. According to Keinonen, the elaboration and contribution is certainly required, instead of merely visiting or exposing the results.

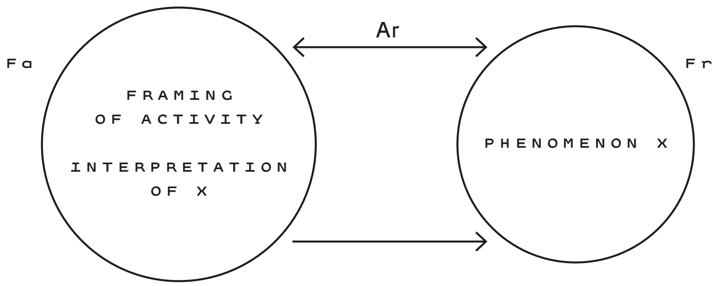

Figure 17.
Art interpreting research (redrawn from the original figure by Keinonen, adapted with permission).

The models proposed by Fallman and Keinonen are precisely the division that the two sets of articles of this dissertation aim to demonstrate. Design-oriented research has been presented in Articles I–V, and research-oriented design in Articles VI–VIII. However, an important contribution to Fallman's deviation is that the two approaches have been used here within the same research context, in which case they promote the reflective conversation that they postulate to each other. The contribution of this dissertation for design-oriented research is in the portrayal of the design oriented-research process in a particular research context and in demonstrating how the prototypes have been used for building knowledge. For research-oriented design, the contribution is in demonstrating how the artefact has been used as the primary outcome, regarded as the main "result" of the efforts undertaken. Fallman explains that the resulting artefact takes on a more explicit role in what the designer emphasises as the design contribution, while a further notable sign of research-oriented design at work is the level of completeness and styling of the resulting artefact. The science fiction prototypes of this dissertation have been presented explicitly as artefacts that have resulted from profound preliminary research work; they are the design outcome of research-oriented design – research carried out in the grounding design-oriented part of the process (see Figure 18). Presenting each science fiction prototype as an artefact that is a type of implicit, theoretical contribution also supports the Research through Design approach advocated by Zimmerman et al. (2010). The supremacy of these artefacts consists in the description of how they codify designers' understanding of the current state, including the relationships between the phenomena and the framing of the activities within them, and the description of the preferred state as an outcome of the artefact's construction.

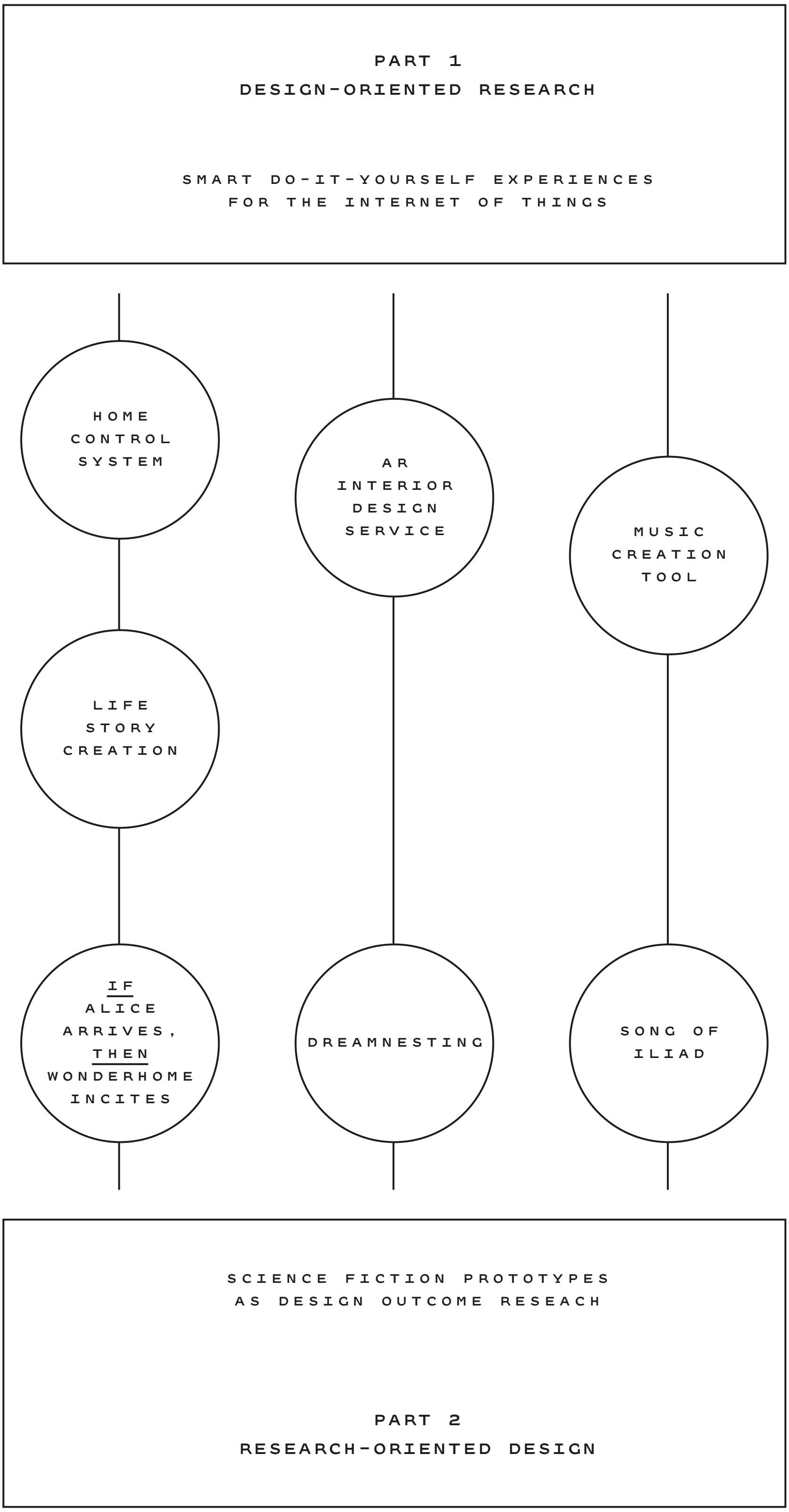

Figure 18. The dialogue between the articles.

Objectives

7.1 DESIGN-ORIENTED RESEARCH

The objective for the first, design-oriented research part of the dissertation (Articles I–V) is to converse about the problems arising from the ways in which people expect the Internet of Things to be deployed. The technological objective initiating the research is formulated as the affording of platforms on top of which people who lack technical skills may create configurations and applications, by installing, using and re-using components, capabilities and devices. The principal motivator for the people in the ecologies thus lies in the idea that the do-it-yourself ecologies can be constructed piecemeal and supplemented when necessary. The objective, grounded by the EASE approach, is to study the IoT technologies by constructing ecologies around them. For the purpose of studying the technology-mediated DIY ecologies, two modes of the EASE approaches have been identified as feasible for the construction of the specific intelligent DIY experiences: 1) the remote design mode for creating an ontology-based creation and configuration system, and 2) the immediate design mode for creating smart experiences and applications mediated by the Internet. The objective for the remote design mode is to construct the underlying architecture — the smaller-scale infrastructure — in a way that allows piecemeal construction of applications that can be supplemented when necessary, and also to identify a technical service ecology initiated by the users. The objective for the immediate design mode is to construct smaller-scale platforms and applications that employ the IoT technologies. The consequent objective for both modes is to study the do-it-yourself experiences, which are expected to have a motivating role in determining a user's relation to IoT technologies.

The EASE approach also introduces the objectives for defining the DIY research activities for HCI. Firstly, the approach suggests developing new models of interaction that incorporate the relationship of the technology with the physical world. Secondly, the approach suggests focusing on the emergent methods to assess the utility of the technologies that focus on gaining richer understandings of the settings. This is clearly a broader objective for HCI aimed at studying the emergent technologies. The employing of emergent methods is expected to be an attempt to build conventions for describing the systems under construction. The two construction objectives of the EASE approach also set grounds for the HCI studies. From the HCI perspective, the use of ontologies sets expectations for studying how users reason about more high-level concepts when creating and configuring their IoT ecologies. The remote design research concentrates on the ontology-based creation and configuration paradigm[29]. The primary objective is in the finding of suitable means and methods for the DIY IoT construction processes that would better support the creating, configuring and sharing of smart experiences, and fulfil the demands of the people operating within the ecologies. In the other case study focusing on the remote design mode, the technical objective lies in the defining of service ecologies[30]. The objective is to define the optimal service ecology for an interior design service. The immediate design of smart experiences and applications is expected to provide more straightforward concepts for composing and configuring existing services, and a direct response to the "making is connecting" paradigm. The immediate design objective is concerned with defining the DIY ecologies and practices, experimenting with the methods and extracting the key experiences. The first research context for the immediate design is identified from the shared online ecologies and social media platforms[31]. The objective for the case study is connected with developing an easy DIY system for the elderly for creating and, especially, sharing their retrospections; the final prototype is a web-based application exploiting social media platforms. The research employs aspects of a notion by Plomp et al. (2009), in which they consider the do-it-yourself paradigm through the created experiences. They propose a pragmatic approach, limited to supporting the sharing of (past) experiences and the creating of shared experiences. The second research context for immediate design was identified from a tangible product and software development environment[32]. The objective for the case study aimed at providing tools, software and smart instruments for disabled people to play music, with a more long-term objective of creating a social technology-mediated environment for sharing their creative work.

The objective for the second, research-oriented design part of the dissertation (Articles VI–VIII) is related to addressing more holistically the experiences of emerging technologies, the social and subjective concerns on the verge of the adaption of technologies, the implications and ramifications of the technologies, and finally, the aesthetic aspects and qualities of the experiences. The main reason for offering alternative design outcomes of the remote and immediate design processes (presented in Articles I–IV), i.e. the proof-of-concept prototypes, was that they only partially illustrated the ecologies under scope, and not, for example, some of the important and rich findings of the empirical research that were related to the experiences.

For creating the fictional stories orienting from research, the creation process leaned firmly on Brian David Johnson's (2011a) science fiction prototyping method. The objective was to follow Johnson's framework for creating science fiction prototypes. The framework consists of five steps:

1. Pick the technology, science or issue to explore with the prototype. Set up the world; introduce people and locations.
2. Introduce the scientific inflection point.
3. Explore the implications and ramifications of the science for the world.
4. Introduce the human inflection point with the technology; modifications or fixing the problem, the new area for experimentation.
5. Explore the implications, solution or lessons learnt.

The immediate objective for the reflecting design was to employ the extensive knowledge gained from the ecological research in order to deliver an alternative, complementary design outcome. A further objective in this dissertation was to consider the science fiction prototypes explicitly as experience design prototypes that aim to understand existing experiences, explore design ideas and use storytelling as a medium to communicate about the design concept. The objective was thus to explore how the research findings work in fictional experience ecologies, in contrast to studying and developing prototypes in the controlled research contexts. The immediate objective was to find the means to illustrate the experience design findings, and complement them with aesthetic and philosophical inspections that would be very difficult to encapsulate in the proof-of-concept prototypes. The construction objectives originated from the earlier design-oriented research, as the empirical research provided the premises for design. For example, the participants in the study were determined explicitly as the important protagonists and side characters for the prototypes: their needs, time of use and settings. A challenging objective for the reflecting design emerged from the complexity of the emerging technology research field: modelling the dependencies of the people, technology and environment, and the countless ways of connecting and interacting with the technologies. The design-oriented research also provided abundant information on the interactions with the technology. A conceptual research objective related to the offering of long-term solutions for the technologies. The novelty of the technologies, especially the advanced interaction mechanisms and algorithmic intelligence, was hypothesised to evolve and intrigue for more agile and more radical approaches.

Fallman (2007) projected that although research-oriented design may relate to, seek influence in, and even contribute

29 Presented in Article I, which explains the co-design and evaluations of the Home Control system.

30 Presented in Article III, which illustrates the DIY interior design services supported by augmented reality (AR) technology.

31 Presented in Article II, which explains the process of the Life Story Creation application.

32 Presented in Article IV, which illustrates the evaluations of the Music Creation Tool.

to research, i.e., the generation of knowledge, in different ways, its main motivation and goal is the production of new artefacts. Thus an important design objective for the science fiction prototypes of this dissertation has been to create self-governing design artefacts (Binder, et al., 2011) – design outcomes presented in the form of literature. In the artefact creation process, the science fiction prototypes leaned on the design objectives proposed by Lundequist and Ullmark (1993):

- The designer's picture of the design must be consistent and logical, containing no internal contradictions.
- It must cover all the relevant data at hand.
- If more than one design is possible, the simplest and most elegant one must be chosen.

The purpose of employing these objectives for the science fiction prototypes was to examine and reconstruct the artefact with aesthetic judgement and emphasise the considerations of long-term use.

7.3 DESIGNING FOR THE EXPERIENCES

The common factor for both parts – design-oriented research and research-oriented design – of this dissertation has been the experience design approach that was at the core of investigations. The objective for the design-oriented research aimed at carrying out experience design investigations by understanding how IoT technologies could support the creating of good and satisfying experiences, as Shedroff (2001), Forlizzi and Battarbee (2005) and Wright et al. (2008) have proposed pursuing. As was mentioned, the design-oriented research understands experience in the sense in which Dewey (1934) defined "an experience". The experiences in the DIY context, as reflected from the categorisation by Pine and Gilmore (1999), were hypothesised to be more active and absorbing in nature. The experiences were tackled on the level of cognitive experiences defined by Forlizzi and Ford (2000) in their framework (see Figure 13). This is because the design-oriented research work was expected to produce new knowledge from the context of use, by deliberating users' experiences towards their activities. The findings relating to "an experience" were reflected to experiences found from relevant DIY literature. Furthermore, in the Forlizzi-Ford framework the narrative formulation was used to represent experiences that were formalised after experiencing the prototypes; in the dissertation they will be described as the new experiences provoked by interactions afforded by emerging technologies. These new experiences have been understood more as "experiences", which Dewey described as "the constant stream happening in our consciousness".

After determining the experiences it is presumably still very difficult to find decent methodologies for designing for experiences, *per se*. The objective for the experience design strategies was followed by conducting careful studies and investigations in the nominated ecologies with the co-design approach that aimed at building prototypes. People have been legitimately placed in the centre of the technology-augmented ecologies and the experiences studies before, after and during the prototype development, using various means and methods. The dissertation has taken note of Shedroff's (2001) proposal, in which he suggested a straightforward design strategy in the design for experiences. The design objective has been thus to translate the elicited experiences into the desired media without the technology dictating the form of the experience.

The experience design for the second, research-oriented design part of the dissertation went much deeper by setting itself an objective of finding out how to reconstruct and deliver the experiences. However, it should be highlighted here that the second part would not exist without the first part. The objective arose from the exploring of experiences in a broader sense; in addition to contextual, physical, temporal, sensory and cognitive factors, the presented experiences included the aesthetics, joy, emotions and affective aspects of the technology use, as suggested by Forlizzi and Battarbee (2005). The objective was to place aesthetic experiences in a key role in the prototypes, putting the aesthetic experience – as Wallace and McCarthy (2008) have suggested – at the centre of theorising about human-computer interaction. Dewey (1934) illuminated the process: "the aesthetic cannot sharply be marked off from the intellectual experience, but the latter must bear an aesthetic stamp to be itself complete". In addition, the objective was to emphasise the positive experiences by measuring the elicited DIY experiences against the sources of positive experiences that can be associated with universal psychological needs – competence, relatedness, popularity, stimulation, meaning, security and autonomy – that Hassenzahl et al. (2010b) found important when designing interactive technologies. Consequently, the second research-oriented part has understood experience in the sense Forlizzi and Ford (2000) introduced as the third category for experience design – "experience as a story" – which is related to memories and providing meaning to "an experience".

To include the findings with the experience as a story manner of approach, Johnson's science fiction prototyping method was extended using two complementing frameworks. The initial objective was to select the frameworks from among the key frameworks presented in the experience design field (e.g. McCarthy and Wright, 2007; Hassenzahl and Tractinsky, 2006; Hassenzahl, 2010a). These frameworks, however, focus more on defining the components of user experience, emphasising the characteristics of the user, product attributes, context, system and system performance as factors that influence user experience. As a consequence, they were found to be more relevant when studying the early experience design implications. Subsequently, the most suitable heuristics for constructing the new experience ecologies within the science fiction prototypes were identified from the work carried out within the co-creation paradigm: 1) the co-creation framework by Gouillart and Ramaswamy (2010) and 2) the construction of an experience environment, proposed by Prahalad and Ramaswamy (2004). The frameworks established their appropriateness on the fact that the focus in them was on the end of the process. Also the science fiction prototypes aimed to explore the means to build experience environments as test beds for demonstrating the "naturalisation" of the technologies – how they become taken for granted in everyday use. Justification for the frameworks can be found also from the remark by Schwarz and Liebl (2013) who considered that science fiction prototypes should not been created for the purpose of serving as a scenario in a HCI design process, but rather they are designed to form part of the customer's world, which they in return can relate to.

In the Gouillart and Ramaswamy (2010) co-creation framework, the human experience has appropriately been placed at the centre of the design. The first task in their framework was to identify all stakeholders affected by the process, with the focus on the experiences of a few key stakeholders. The subsequent objective was to understand and map out the interactions among the stakeholders. In their framework, Gouillart and Ramaswamy suggest building platforms for implementing ideas for new interactions, and for continuing the dialogue among the stakeholders to generate further ideas. For this objective the dissertation applied a more explicit framework for constructing an experience environment, proposed by Prahalad and Ramaswamy (2004). In the context of this dissertation, the framework provided means for illustrating the impact IoT may have on human experience. This framework provides means to pierce into the ecology construction on a more detailed and subjective level, as it aims for new, optimal ecology that imagines new value constellations. The important objectives for the experience environments, according to Prahalad and Ramaswamy, are the following:

1. The experience environment should offer opportunities for people to co-construct their own experiences on demand, in a specific context of space and time.
2. Personal meaning will be the knowledge, insights, enjoyment, satisfaction and excitement that the individual derives from the event.
3. The involvement of the communities engages the consumer emotionally and intellectually.
4. New opportunities afforded by the evolution of emerging technologies should be introduced for the stakeholders.

The aim was to consider all these objectives within the prototypes as experience requirements that the protagonist and the immediate characters undergo at some point in the storylines. The emphasis was on the subjectivity of the experiences, which will be brought out and made visible. The concluding objective was to achieve an experience design process that aims at *designing for experiences* that are close to Dewey's original definition: *"Experience is a matter of the interaction of organism with its environment (environment that is human as well as physical). The organism brings with it through its own structure, native and acquired, forces that play part in the interaction."*

7.4 STRUCTURE OF THE DISSERTATION ARTICLES

Article I introduces the evaluations of the Home Control System for a nursing ecology that focused on developing a test bed: a smart environment fitted out with sensors. The remote design research built a prototype system with a user interface that helped people to create customised Internet of Things setups for the physical space. Article II presents an immediate design research study of the Life Story Creation Service for elderly amateur writers. The service prototype was an application dedicated to the content creation and sharing of work through Web 2.0. Article III presents the AR Interior Design Service that aimed at providing support for amateur interior designers in their design tasks and introduced augmented reality as a prominent technology within the service. Article IV illustrates the Music Creation Tool development in the music therapy context for disabled people. The tool consisted of software and smart instruments that were designed for easy and intuitive use. Article V presents the summary of the design-oriented research carried out for Articles I, II and IV from the user expectation perspective.

The science fiction prototypes presented in Articles VI–VIII elaborate the design-oriented research findings presented in Articles I–V. The prototypes extended the research beyond the achievements of the proof-of-concept prototype development and imagine how people would subjectively experience emerging technologies that are placed in the new experience environments. Article VI introduces Wonderhome – an intelligent and inspiring nursing home for the aged. The protagonist in the prototype, Alice, is connected to the outside world, to her past experiences and even to her late husband Frank through various Cloud of Things technologies. Article VII introduces the protagonist

Abby and an intelligent interior design ecology, in which she creates interior design dreams for her forthcoming home, while at the same time providing new employment for herself with a network of clients that want to share her designs. Article VIII describes innovative music therapy tools for the disabled. The creating, configuring and sharing experiences are confronted by a young disabled boy, Iliad, who finds new friends around the globe while composing music.

The following will contain the summaries regarding the empirical research and main findings of the dissertation.

PART 1
:
DESIGN-ORIENTED RESEARCH

8 Smart do-it-yourself experiences for the Internet of Things

8.1 OVERVIEW OF THE CASE STUDY SETTINGS

It should first be noted that the emerging technology programmes and research organisations are influential for the context of the pragmatic research as they regulate some of the efforts that may be taken for determining the theoretical contribution of research. They also set ground for the expectations towards the outcome, which in many cases are prototypes developed with the contribution of several research partners, and with a multidisciplinary approach. The first, design-oriented research part of the dissertation has been carried out for the most part in the European research programme (ITEA2) DiYSE: Do-it-Yourself Smart Experiences, which ran from 2009 until 2012.

There were 40 partners from seven European countries contributing to the research that aimed at removing barriers for user-generated Internet of Things applications (Roelands et al., 2011). The case studies carried out in the DiYSE programme are presented in Articles I, II, IV and V. The author's contribution to these studies was carried out within the human-computer interaction (HCI) research, and took the form of organising user research, carrying out the design-oriented research and co-design sessions, studying user involvement with the low-fidelity user interface sketches and paper mock-ups, creating service ecologies and, finally, constructing the high-fidelity prototypes. One case study, presented in Article III, was carried out within Adfeed – a project supported by TEKES as part of the Next Media programme of TIVIT[33]. Here it was important to concentrate more on the service ecologies rather than the technologies. The author was responsible for the design-oriented research, and as part of the research group the tasks involved creating scenarios, benchmarking existing applications and conducting a preliminary questionnaire for the end users. These settings regulated the employing of the approaches to research and the design outcomes being the proof-of-concept prototypes.

8.1.1 Home Control System for an intelligent nursing ecology

The first remote design research on the Home Control System (presented in Article I) was aimed at supporting elderly people in living more independently in their homes and in an intelligent nursing home. The developed technical system was a proof-of-concept prototype that included a tool enabling the combination of networked objects in the environment (see Figure 19). The focus was on controlling the illumination of the environment, front door lock control, long-term follow up of the activities with possible notifications and alarms to an external system, and the use of spoken dialogue interaction to control parts of the system. The project was built upon earlier research that acknowledged how the devices were placed within an environment, how the combinations of these devices were practically managed, and how these devices worked as an ensemble, as demonstrated in iStuff (Ballagas et al., 2003); iCAP (Sohn and Dey, 2003); CAPpella (Dey et al., 2004); the soft-appliance vision (Chin et al., 2009) and the work of Rodden et al. (2004), Hagras et. al. (2004) and Kawsar et al. (2008).

Figure 19.
The Home Control System concept.

8.1.2
Life Story Creation service for seniors

The first research set up for the immediate design was identified from the leisure activities of the elderly. The Life Story Creation case study (presented in Article II) focused on developing an easy DIY system for creating personal retrospections. The final prototype was a Web 2.0 service application dedicated to the content creation and sharing of work (see Figure 20). The HCI studies concentrated on the acceptance and experience factors of the system and the design implications for constructing the application. The work employed the notions of Plomp et al. (2009), who accentuated the importance of the communication between community members. The immediate research objectives related to how a person managed the ecology: how they could join up and set up the community and how they managed and shared the content.

Figure 20.
Life Story Creation application with a reconstructed personal retrospection.

Figure 21.
DIY Interior Design Service co-design session.

8.1.3
Do-it-yourself interior design services

The case study for constructing DIY interior design services (presented in Article III) aimed at studying how to use new technologies and applications – such as social media services, 3D and augmented reality (AR) features, and location awareness – in the field of advertising, and find new revenue models for media. The remote design study was arranged with interior designers and design bloggers, who were the anticipated critical users of the interior design service system (see Figure 21). The reason for introducing AR to the service was that the technology, combining the real and virtual, was expected to provide a practical visualisation method suitable for interior design tasks, and the means to enhance user perception (Siltanen, 2012). The user research aimed mainly at understanding the needs and requirements for the system. This was achieved by co-designing interior design service concepts.

8.1.4
Music Creation Tool for the disabled

The second research set up for immediate design was identified from the music therapy environment for people with mild or moderate intellectual learning disabilities[34]. The aim of the prototype was to allow the disabled people to play music in a therapy context,

33 Finnish Strategic Centre for Science, Technology and Innovation in the field of ICT.

34 Diagnosis ICD-10.

with the longer-term objective of creating an environment for the sharing of work. The Music Creation Tool (presented in Article IV) consisted of software and smart instruments. The inspiration for the design was derived from the birth of the digital DIY movement from the late 80s; in those first DIY experiments, as well as with the prototype construction, it was important that there were no requirements for the people to learn specialised skills when playing the instruments. In the quest for supporting this idea in the music therapy context, the development process concentrated on finding interactive technologies that were easily available and motivating to use (see Figure 22).

Figure 22.
Video observations of the Music Creation Tool.

8.2 METHODS AND PRACTICES

Abowd and Mynatt (2000) were among the first to notice that task-centric evaluation techniques are inadequate for studying emerging technologies, remarking that it has been extremely difficult to apply any usual evaluation techniques when the context is an informal everyday computing situation. They specified the difficulty with an example of a domestic environment, explaining that although an authentic deployment could occur in the environment, and the users begin to develop habits for using the services, there was still the question of how to apply most appropriate methods (ibid.). Hyysalo (2010) stated that the existing arsenals for investigating user needs in technology development could be grouped into three broad and historically layered families: quantitatively oriented preference elicitation methods, qualitative methods and design-oriented methods (p. 95). The third family includes the radical design-oriented variants of the qualitative paradigm, which explicitly state that the questions of reliability and of the user data are in many senses secondary to the inspirational value and recourses they provide for designers (ibid.). Hyysalo stated that design-oriented methods may produce sufficiently valid information, while the reliability of the data is grounded on the qualitative assessment and experience of the investigators. Leonard (1999) claimed that in technology research the traditional elicitation methods are more adequate when both the technological possibilities and the users are well known, but their adequacy decreases when less is known either about what the technology is going to be or about who is going to use it. Apparently, this is the case when developing flexible and configurable DIY IoT technologies and introducing them to divergent set of users. In such cases, Leonard suggests employing more “emphatic” qualitative and design-oriented methods for constructing suitable information. Forlizzi and Battarbee (2005) advocated the employment of design-oriented methods for designing interactive systems, especially for situations in which it is critical to understand the social and collaborative aspects of interaction and user experience.

Consequently, the methods for studying the DIY IoT ecologies were chosen to favour design-oriented and co-design approaches (see Table 1). The methods were supplemented with ethnography and user-centred methods, when applicable, and more quantitatively oriented usability research for studying some of the final proof-of-concept prototypes. The co-design processes to facilitate user research of the DIY ecologies fell under the methodological frame of participatory design (Schuler and Namioka, 1993; Greenbaum and Kyng, 1991). In participatory design the role of a researcher is to construct scaffolds that support people’s creativity and allow innovative and generative thinking. Mattelmäki and Sleesvijk Visser (2011) understood that co-design is simultaneously a process and the planning: adjusting tools and facilitation is built on a mind-set of collaboration (p. 11). Thus one of the critical HCI objectives for the research was the defining of suitable practices and methods for user participation in the context of DIY IoT, in a way that would support the experience design research. The consequent objective was to verify that co-design methods could provide suitable means for studying both immediate and remote design concepts of the EASE approach in the IoT research domain. In Table 1 the methods used are arranged in four categories: early qualitative and elicitation methods, complementary design-oriented methods, co-design methods and methods for analysing the results.

8.3 MAIN FINDINGS

In addition to defining suitable practices and methods for immediate and remote design, the main contribution of design-oriented HCI research was in providing design implications for the construction of the proof-of-concept prototypes. The main findings introduced in this dissertation summary, however, limit themselves to three key contributions specifically nominated as being the responsibility of the author; the proof-of-concept prototype construction, which was the mutual effort of the research team, is explained more specifically in Articles I–IV. The first main finding of design-oriented research was the defining of specific human ecologies and the characteristics of participants in the research setups. Overall, the effort was a response to the request issued by Kuznetsov and Paulos (2010) that HCI researchers should engage more with DIY practitioners, whom they view as an emerging group of builders, tinkerers and experts creating novel objects and interfaces that can be imported back into HCI work. The second contribution was the study of DIY experiences in the IoT context; these have given particular focus to defining the experiences related to creating, configuring and sharing activities. Experience design research also contributed in defining new experiences that emerged when DIY IoT technologies were introduced to the communities. The third contribution was the description of the design conventions that may be employed for constructing DIY IoT, particularly when the focus of HCI research is experience design. These design conventions form the basis of the framework for creating science fiction prototypes as experience design outcome of research, which will be introduced in the final part of the dissertation.

METHOD	USED FOR	PROJECT	AUTHOR'S CONTRI-BUTION
	EARLY QUALITATIVE AND ELICITATION METHODS		
Shadowing	Shadowing was used to identify opportunities for design and for quick understanding of the particular design context.	1, 2	
Contextual inquiry	Contextual inquiry was used for observing the tasks and practices of the new and unfamiliar domains.	2, 4	
Design probes	Design probes were used for uncovering the immediate needs and to get behind the driving motivations and values.	4	
Semi-structured acceptance interviews	The early acceptance and values of the technology were evaluated with a semi-structured focus group interview within the user ecologies.	2	x
PRELIMINARY ONLINE SURVEY		3	x
	COMPLEMENTARY DESIGN-ORIENTED METHODS		
Scenario evaluation	Short scenarios, in the form of user- and task-oriented use cases, were used for describing the nominated context of uses.	1, 3	x
Visualisations	Visualisations were used for presenting new application and services, and the interaction possibilities.	2, 3	x
Benchmarked applications	Existing applications were benchmarked for comparing and assessing them against the designs at hand.	1, 3	x
Interviews	Interviews were used in all likely phases, for ensuring that the facilitator becomes an advocate and partner with the interviewee.	1, 2, 4	x
Observations with video	Observations were used for studying real-life situations and understanding how people have behaved. The video observations confirmed that the external activities are observed, recorded and archived for analysis.	4	x
	CO-DESIGN METHODS		
Focus groups	In focus group interviews the communities discussed the topics that the facilitator has disseminated. In small groups, all are able to bring out their opinions and comment on each other's ideas.	1, 2, 3	x
Sketching	Sketching enabled conversations about compound and hierarchical design issues between the participants, and assisted in understanding the user's mental model of the system and the ecology.	1, 3	x
Paper prototypes	Paper prototypes presented the developed UI in a raw form, and aided in completing a task or scenario.	1	x

METHOD	USED FOR	PROJECT	AUTHOR'S CONTRIBUTION
Explorations in sonic interaction	Sonic affordances were used for studying the exploitation of sonic interaction, and discovering aesthetic and emotional qualities in the context of use.	4	x
Walking interviews	Walking interviews were used for analysing the discovering of “things” in the environment.	1	x
	METHODS FOR ANALYSING THE RESULTS		
Usability studies	ISO 13407 has provided guidance for evaluating designs against requirements with measures of effectiveness, efficiency and user satisfaction.	1	
Interaction analysis lab	The method was used for analysing the recorded video observation material. Observers commented on the context of use by seeing the material, creating a hypothesis about what was happening in the recording, and discussing the context.	4	x
Subjective assessment	Subjective assessment was used by users for analysing the results for the facilitator, in order to explain how they experienced the technology.	2, 3	x

Table 1.
Methods used, in chronological order. In the project column each project is described using numbers: Home Control System=1, Life Story Creation=2, AR Interior Design Services=3 and Music Creation Tool=4.

8.4 HUMAN ECOLOGIES AND THE CHARACTERISTICS OF PARTICIPANTS

When constructing proof-of-concept prototypes for emerging technologies, the initial concern for ecological research was to consider the human ecologies that form around the technologies. According to the EASE approach, users of DIY technologies were expected to be active, show initiative, and share the responsibility for developing their own, personal intelligent ecologies. This led to a deeper study of the various kinds of user characteristics suitable for closer investigations. Literature from diverse fields presented evidence of special sets of users that act as experts and innovators in technology design: the brokers in communities of practice, opinion leaders, change agents, prosumers and lead users (mostly described e.g. by Stewart, 2007). Based on the literature review, the most suitable group of practitioners in the ecological research context, and for the particular research cases, appeared to be the “Pro-Am users”. Leadbeater and Miller (2004) have portrayed Pro-Am users as disruptive innovators that in the DIY context may introduce marginal and experimental projects to others. The Pro-Am users, however, are only a part of the involvement classification category that Leadbeater and Miller introduced for describing the expert levels of the DIY practitioners. At the other end of the category are amateurs and professionals, and further characteristics include devotees, fans, dabblers and spectators, which Roeck et al. (2012) have abstracted as novices to better suit the purpose of categorising expertise for HCI that comprises the level of computational thinking.

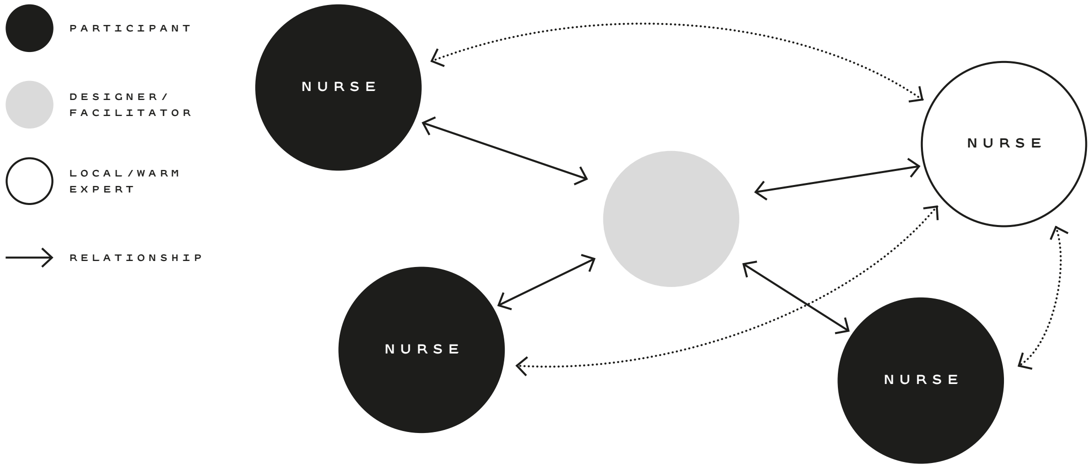

Figure 23.
Participants in the Home Control System co-design.

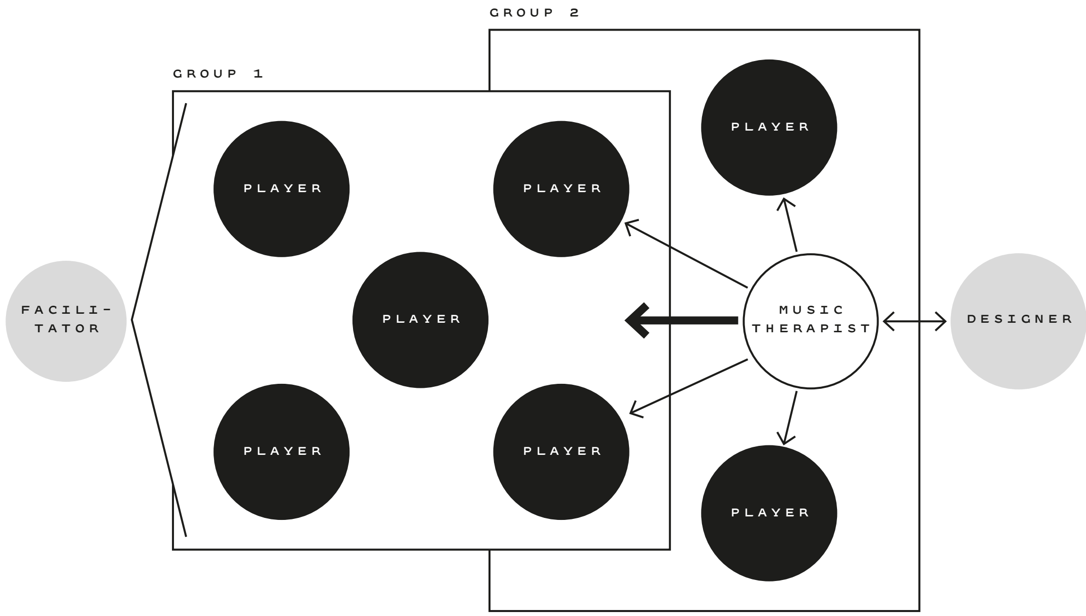

Figure 24.
Participants in Life Story Creation.

Yet characteristics of expertise did not seem to be enough to embrace the full role of DIY participants in the ecological research context. Another criterion for defining the appropriate participants for research was the users' level of involvement. For the case studies, the most interesting involvement properties were found from the local and warm experts. Stewart (2007) coined the term local experts to be used from people "who sustain informal networks and help other individuals and groups adapt and cope with new ICTs". He states that local experts act as bridges or channels, transferring knowledge and examples of use and equipment between particular social settings. He uses the term local to mean not only geographically local, but local in the sense of communication and interaction in physical space and via communications technologies.

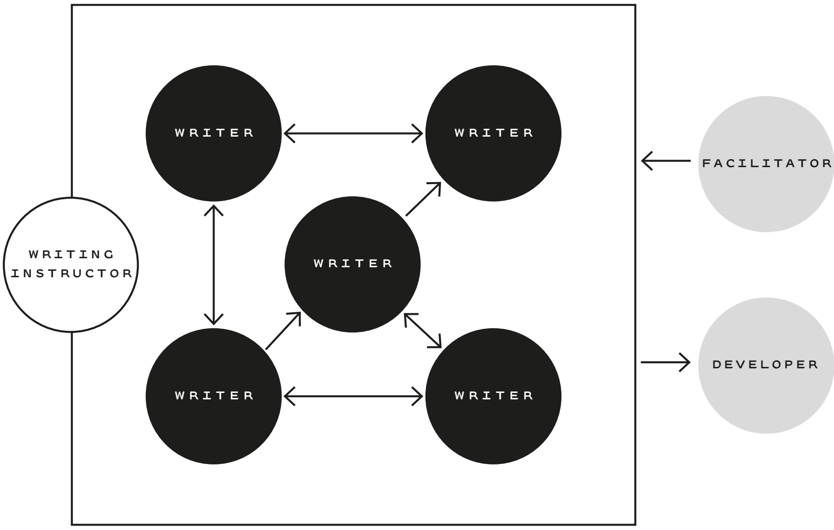

Figure 25.
Participants in the Music Creation Tool co-design.

Bakardjieva and Smith (2001) introduced the term warm experts to refer to people who are technical experts sympathetic to those in need of help and support with ICTs, and possess understanding both of the people they are helping and of the technologies. Bakardjieva (2005) states that warm experts may be technical professionals or just relatively expert to those they help.

Figures 23–25 describe the human ecologies in the case studies and the relationship between the participants and the designer/facilitator. More specific profiling of user ecologies can be found from Appendix C. The Home Control System research engaged nurses in the co-design process and end users in the final evaluation of the system. All nurses were considered Pro-Am users according to the level of computational thinking, but only one of them was considered a local, warm expert mediating the computational expertise within the ecology. All participants in this ecology worked tightly with the designer in the co-design phases. In the Life Story Creation ecology, the teacher of the writing group was considered to be the local, warm Pro-Am expert of the group; however, it turned out that the design of the system benefited more from involvement properties related to the willingness to create and community orientation, which the amateur writers possessed. The amateur writers were thereby selected as the most suitable co-design partners instead of the Pro-Am expert. It should be noted that in this case study the immediate design requirements also necessitated the developer to work in close cooperation with the ecology participants. The music therapist was the nominated co-design partner in the Music Creation Tool ecology: a domain professional, a Pro-Am in computational thinking, and a local, warm expert. The therapist worked tightly with the researcher responsible of the tool construction; otherwise the novice end users were studied through observations.

The AR Interior Design case study was somewhat different in the sense that the main objective was to create user-initiated service ecologies around the interior design concept. The participants were encouraged to identify their role clearly in the system; each defined their role in the service as a designer. Subsequently, the participants were divided into pairs, and each pair was encouraged to produce a sketch of the ecology in a form of a flowchart (see Figure 26). The sketches of the ecologies were expected to include: 1) all necessary

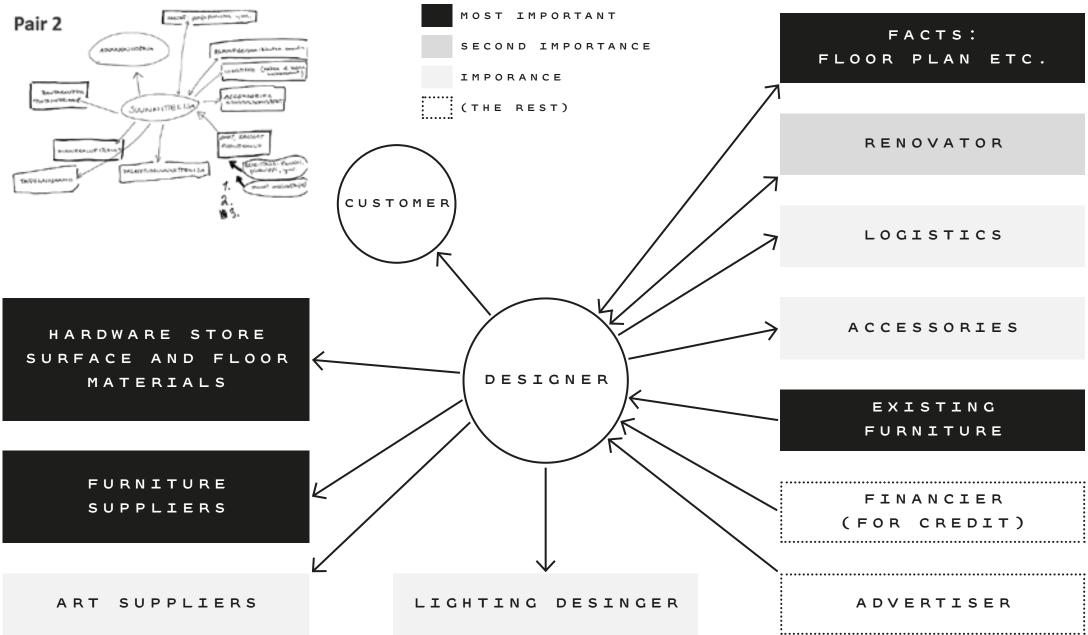

Figure 26.
An example of an ecology sketch
(redrawn from the original sketch, top-right in the fig.)

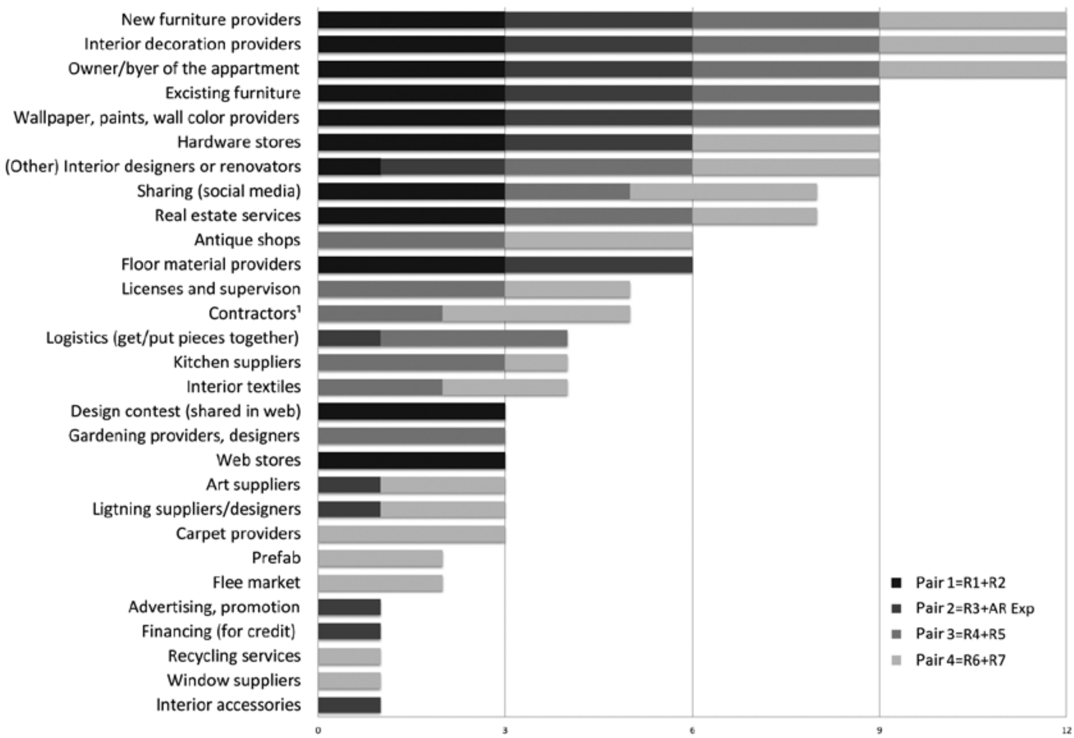

Table 2.
Results of the service ecology sketches. If all pairs (groups 1–4) thought a service most important, it received 12 points. If only one mentioned it, and did not value it highly, the service received only one point.

stakeholders and elements of the system: products, services, technologies; 2) how all stakeholders and elements were connected to the service, and finally 3) the most important stakeholders and elements, using a tree-level scale. Table 2 shows the results by which it was analysed that new furniture and interior decoration providers were the key actors in the service; otherwise the service was seen as a cluster for smaller providers. It should be noted that, even though the participants perceived themselves in the co-design situation as designers, while creating the concepts all mentioned the importance of the customer-relationship.

8.5 THE EXPERIENCES OF DIY IOT

Several DIY-related studies investigated by Leadbeater and Miller (2004) showed that serious leisure improves health and well-being, brings social benefits and a sense of belonging to those involved with the activities. These motivational aspects provided substance for the experience design investigations for the case studies that involved mostly the elderly and disabled. In this particular research context, the feel of control — distinguished e.g. by Edwards and Grinter (2001); Fischer et al. (2004); Callaghan et al. (2009) — was considered as a critical experience that should be supported by the technology. The more specific and relevant experiences for the do-it-yourself context were first studied by an overview of the literature that related to the DIY culture (McKay, 1998; Leadbeater and Miller, 2004; Kuznetsov and Paulos, 2010; Rushkoff, 2010; Gauntlett, 2011) and end-user installation (Humble et al., 2003; Fischer et al., 2004; Beckmann et al., 2004; Chin et al., 2006; Wulf and Paterno, 2006; Kawsar et al., 2008). The critical experiences were then pursued by defining some broad categories of description that could assist when categorising the experiences that emerged within the research setup. Because creativity, craftsmanship and community orientation (e.g. McKay, 1998; Leadbeater and Miller, 2004; Kuznetsov and Paulos, 2010) are central to the do-it-yourself culture, the case studies focused on defining the specific experiences that related to creating, configuring and sharing activities. The creating and configuring activities were considered to be at the core of the investigations, as they defined the furthermost motivation for "doing something by oneself". The sharing activity was seen to relate specially to the motivation within the community orientation. In addition to categorising experiences in the sense in which Dewey (1934) understood "an experience", the other objective for the experience design research was to define the important emerging user experiences evoked by the introduced technologies. These new experiences were considered in the manner that Dewey defines "experience". As the experience design studies also contributed to the design of the proof-of-concept prototypes, it was important to associate the experiences with the context of use. In practice, the experience design studies were carried out by evaluating the configurations and technologies in the context of use with the methods that are described in Table 1, and by eliciting findings that related to the categorised experiences.

At the left of the Table 3 there are broad categories of description for the experiences found from the background literature. The feel of control was considered as a critical experience in DIY-oriented emerging technology research; the experiences relating to it are described as the last six experiences of the table. At the right of the table there is an assessment of whether the experience may be associated with the creating and configuring experience or with the sharing experience.

THE DIY-RELATED EXPERIENCE	CREATING & CONFIGURING IN CASE STUDY	SHARING IN CASE STUDY
Delight of making things by oneself	4	
Pleasure of the everyday creativity	2, 3, 4	
Reward of the process	2, 3	2
Sense of togetherness	2, 4	2
Enjoyment of being noticed and recognised	4	2, 3, 4
Pleasure of the feedback and support	3, 4	3, 4
Sense of inspiration	2	3
Self-esteem	4	2, 3, 4
Arousing emotional experiences in others	1, 4	3
EXPERIENCES RELATING TO THE FEELING OF CONTROL		
Flexibility of the system	1, 4	1, 3
Customisation possibilities	1, 2, 3	2
Personification possibilities	1, 2, 3, 4	1, 3
Local control	1, 2	1, 2, 3
Being able to complete a job more effectively	1, 2, 3	2, 3, 4

Table 3.
In the right column each project is described using numbers:
Home Control System=1, Life Story Creation=2, AR Interior Design Services=3 and Music Creation Tool=4

Shedroff (2001) proposed that after acquiring an understanding of the well-intentioned experiences, the following task is to describe the efforts involved in the way they are translated into the desired media. A description follows of the efforts in designing for the experiences in the proof-of-concept creation phases; the desired media in the research setup is roughly interpreted as DIY IoT technologies.

8.5.1
The creating and configuring experiences

The principal creating and configuring experiences of the Home Control System research related to the device and component connectivity: what kind of setups the users wanted to create and combine from the components provided in the nursing ecology, and what they expected to be ready-made. These experiences were studied according to the type of connections the participants made in the paper prototyping sessions; more specifically, what setups they made for the inhabitants. For example, the nurses created setups that could be associated with the feeling of control; simple configurations to support the inhabitants who could not move from their beds. One of the most influential results of the studies was the utmost limit of the DIY system to which nurses determined that they, or their patients, would create and configure the components. It was clearly stated that the more challenging configurations were expected to be made by someone — the local, warm expert was defined explicitly — for the benefit of the community. This finding highlighted the role of the experts in the ecology, and also the gradual DIY flexibility that was expected from the technical system. From the prototype, the participants required specific, ready-made templates for the constructing activities — often described as an activity, first duplicating and then modifying — in order to create setups within the system's tool. These requirements defined the limitations of flexibility of the proof-of-concept prototype.

The Life Story Creation application was based on templates that the expert amateurs assisted in creating and defining. The templates contained stages that guided the creation process. Within the community, the creation and configuring activities seemed to be an important clue towards connecting the community together and assisting in making the service valued. The experience design investigations were pursued by providing different modes for the creation tasks within the service that would support the differences in purpose. Transfer of these experiences to the application requirements revealed that there should have been even more alternatives for the configuring tasks within the templates.

When the AR Interior Design service was conceptualised together with the interior designers and bloggers, they were at first familiarised with the subject by viewing use cases of the forthcoming service: benchmarked applications and some results of a survey that had been conducted for a wider audience. According to this material, the participants expected the key creation and configuring experiences of the service to relate to the self-actualising part of the construction process: the pleasure of everyday creativity, the reward of the interior-design-creating process itself, being able to complete a design job more effectively, having inspiration, and the freedom of being able to choose from the many alternatives provided by the service. The case's most motivating experience was the appreciation of having some result that had an authentic and personal touch. When translating these experiences into the service system, the participants in their sketches illustrated the technology use in particular situations, and also described the expected barriers to technology use.

The Music Creation Tool needed to be flexible and to provide options according to the various skill levels of the disabled players. The nominated experiences were pursued by observing the players, and by interviewing the music therapist who carried out all the creating and configuring activities of the tool on behalf of the end users. The built-in software components helped the music therapist to create the "half-done music experiences" that in turn gave pleasure to the players. Encouraged by the observations, the development team continued supporting this experience. Because the Music Creation Tool also included tangible instruments, one of the key objectives was to observe how the end users interacted with the modifiable instruments in the therapy situation. When observing the experiences relating to the creation and configuring activities, the concentration was on the motoric skills of the players. The observations revealed that the group would have required even more adaptable instruments: more flexibility and alternatives for the physical components that would have provided enhanced affordances and supported the different skill levels of the players.

8.5.2 The sharing experience

In the Home Control system, although the architecture was created to support the sharing mechanism, in the prototyping reality the configured scenes could not be shared with another entity. The sharing experiences were thus limited to supporting the setups users created by themselves. During the evaluation sessions, the nurses speculated that they would have required different sharing mechanisms for nurses, patients and relatives. When it came to translating these finding into the proof-of-concept prototype, the development team faced difficulties. As it was too laborious to implement the requirements into the prototype, the prototype consisted in the end of one UI that tried to satisfy all the experience-related needs.

Of the three case studies, the Life Story Creation was the only project in which the users actually shared their work during the evaluations. The experience design studies were pursued with the life-story writers, who were appreciative participants in defining what makes a good sharing experience. They provided instructions and comments for each other, or read the life stories of the other writers. They stated that at the core of the sharing experience was the fact that people wanted to help each other and to construct the ecology around their mutual interest. Concerning the translation of the experiences into the desired technical system, the case study demonstrated how the supportive ecology should be built into the application from the very beginning by providing sharing opportunities in the designated technology. The participants were critical of the inadequacy of the mode provided for sharing within the application; there should have been alternatives for sharing the content more intimately, and at the other end for offering the full publication process so that the work could be shared with a wider audience. Also, the interviewees highlighted the anticipated experience that the system should respond to the need to trace back one's personal history and learn about lost family ties. Furthermore, the participants wanted to extend the sharing network to other domains. They provided a considerable amount of substance for what the other domains should be, e.g., a genealogy service, a recipe store, a former classmates archive, various traceable events of relatives and friends, organisational activities, other peer groups, and information about specific places.

In the AR Interior Design service, the sharing experience was pursued with the Pro-Am interior designers, with the foremost aim of supporting the sharing of the outcomes and services. The case study differed from the other presented studies in that the design-oriented research did not aim to construct prototypes, but to co-create service concepts. The anticipated core experiences were related to the reward of the sharing process itself: enjoyment of being noticed and recognised, the pleasure of positive feedback, gaining inspiration from others, ingenuity and self-esteem. The designers invested a considerable amount of effort into designing ecologies around the services, and in the end were able to describe various mechanisms for supporting the sharing activity, varying from competitions to assessments of the provision of good or bad design or service.

In the Music Creation Tool, the sharing experience was tightly combined with the music therapist's task as a mediator in the music therapy context. The music therapist was the only one doing any type of sharing; the observations confirmed that the players did not even share the experience of playing together. However, the observed players seemed to have a subjective enjoyment of the new experiences that were aroused by the tool. When translating these experiences into the technical system, the iteratively constructed prototype appeared to provide sufficient means. The final aim, however, had been to share the musical experiences through social media. The observed music therapy sessions demonstrated that the participants were highly dependent on the well-timed instructions and encouragement of the therapist, and therefore the sharing of the creative work seemed to be extremely difficult[35].

8.5.3
New emerging experiences

In addition to the elicited and confirmed DIY-related experiences, the dissertation introduces two sets of new experiences discovered by the experience design studies. These findings are not necessarily unique, in the sense that the phenomena around most of them have been issued within the emerging technology research context. The relevance of the formulated new experiences in the dissertation, however, is that they have been elicited and extracted on the basis of the evidence relating to the user studies, and can be firmly associated to the Internet of Things research context.

The first set of new experiences related to the physical and digital realms of the ecologies and the piecemeal construction of DIY IoT. The second set of experiences recognised the need for defining a conclusive experience when considering the technological ecology layer. It is acknowledged that the two sets of experiences are in some sense contradictory. The first set of new experiences related to:

- The physical and digital co-existence of the “things” in the environment
- The immersive quality and realism of the augmentation in the reproduction of “things”
- The flexibility in the component modularisation
- The need in experiencing digital “things” with analogue disguise

The second set of new experiences related to:

- Apprehending the digital ecology as a conclusive experience
- Experiencing the ecology through the affordances or the “smart thing” functionalities
- Contentment of the substituting interaction options

The experience of the physical and digital co-existence of the “things” in the environment was confronted during early prototyping in the Home Control System evaluations. In this case, the nurses expressed particular concern about how the existing analogue devices and new smart IoT devices cooperated in the environment. There was consideration, for example, of how the configurable switches could be differentiated from the “normal” light switches. These considerations of the co-existence of the physical and digital things in the environment have been found to be a crucial problem when designing for evolutional construction environments. The problem has been addressed e.g. by Dourish and Bell (2011) and Miorandi et al. (2012), the former by drawing attention towards the messy infrastructures, and the latter in using the term “cyberphysical infrastructure” to describe the interconnection of physical and virtual realms. For the design, the experience of the physical and digital co-existence of “things” thus suggests that attention in the short term should be paid to the interconnecting point of the digital and physical realms. The experiences relating to the dual existence of functioning and non-functioning smart objects will need to be attended to for quite some time ahead, although Miorandi et al. try to raise hopes by assuming that “within the next decade, the Internet will exist as a seamless fabric of classic networks and networked objects”.

In the AR Interior Design service, the connection between the physical and digital environments was made by the AR technology, in which context the duality between physical and digital “things” becomes apparent. This duality has been addressed, for example, by Milgram (1995), who has presented a taxonomy model for the augmented, virtual, and mixed reality, better known as the reality-virtuality continuum (see Appendix A). In the case study, the participants expected to have virtual models of all the existing physical artefacts, furniture and objects, including their personal belongings and antique furniture, in order to place them in the digital realm. By this they expected to have a conclusive experience of the digital environment that

35 This has been studied later in further research by Luhtala et al. (2012).

would satisfied the needs. One of the case study's most critical experiences, however, related to the reproduction of physical objects in the digital realm. This suggested expectation towards what has been described here as the immersive quality and realism of the augmentation in the reproduction of the "things". The participants highlighted the visual quality of the design as an experience relating to immersion, which is particularly important in the interior design planning processes. The experience of the visual quality included how to perceive digital "things", and how realistically they were augmented. The participants also stressed the importance of the rendering quality on the virtual objects with realistic materials and lighting effects.

The experience of the flexibility of the component modularisation in the DIY IoT context may be associated with the modularised embedded computer devices[36] that require only fine-tuning, versus the recombining of individual smaller-scale components that require greater effort in the connection phase but provide more possibilities for personification. During the early research for the Music Creation Tool there were several attempts to provide users with the possibility of combining and integrating singular sensors attached to the musical devices. At the other end there were the ready-made smart devices — game controllers, gamepads, joysticks and motion controlled consoles such as Wii, Guitar Hero and Blobo — that were configured and fine-tuned. The ready-made smart devices were confirmed as more suitable for the particular research setup, although, in general the integration of singular sensors and modularised components are expected to be at the core of DIY IoT systems. Also emerging from the Music Creation Tool evaluations was the need for experiencing digital "things" with analogue disguise. In the case study, the physical combining and configuration of sensors and devices allowed the shape of an instrument to have many different forms; yet surprisingly, in such cases it seemed to matter even more that the artefact appeared familiar and the affordances were recognisable and intuitive. This experience was observed to be extremely important for the particular user group; their preference for the guitar-like appearances of the instruments was in fact confirmed in all evaluation phases.

The conclusive experience of the digital ecology has been one of the long-term research paradigms in intelligent environment research. The experience counters with the aim of reducing the cognitive burden of learning by shrinking the conceptual distance between the actions in the real world and what is programmed in the virtual world (Fischer et al., 2004). The issues related to the question of how to make visible, tangible and perceivable the affordances that the physical environment provides, and preferably turn them into a map of affordances. The crossing point of the physical and digital realms has usually been materialised by the user interface (UI), which offers the interaction possibilities between human, computer and the environment. The interface provides the representation for the user to understand the available components and configurations i.e. experiencing the ecology through the affordances or the "smart thing" functionalities. In the Home Control System, the device-centric solution was accomplished through taking a snapshot of the environment by physically selecting all the environment's active devices. Each snapshot could then be activated and deactivated from the UI. In the Home Control System evaluations, the participants speculated on how the inhabitant could remember what were the triggers of the environment, which controller performed a pre-configured task, and what tasks were related to specific things in the environment. It seemed extremely difficult, however, to address the reduction of the cognitive burden completely using one, all-inclusive UI. The research led to the belief that the conclusive experience should somehow be available in the physical environment.

In the Life Story Creation case, the multimodality of interactions was considered through the possibility of using spoken language dialogue as an alternative interaction method, instead of typewriting. In the Home Control System, the participants were also provided with an alternative of bypassing the UI using spoken language dialogue if the required setups were very simple. Overall, the experience has been labelled here as the contentment of the substituting interaction options. It should be expected that the new interaction techniques, relating to multimodal systems and haptic interfaces, apparently also cultivate a new form of experiences. These techniques have been studied widely within the HCI field, and the studies have demonstrated that when introduced to physical environments they may provide an unlimited source of inspection material for the experience design studies.

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An embedded device commonly refers to electronic computers that have an input, output, and processes. These devices are normally fixed as primary components of a complete device, and should in other words have some hardware and some means of interacting with them (e.g. software) (Chin et al., 2003).

PART 2
:
RESEARCH-ORIENTED DESIGN

Science fiction prototypes as design outcome of research

THE INTRODUCED SCIENCE FICTION stories of this dissertation lean firmly on the science fiction prototyping method introduced by B.D. Johnson (2011a). The dissertation introduces the method to the design discipline, and considers how it may be used as radical, reflecting research-oriented design approach — with an objective to deliver science fiction stories as design outcomes of research, as design artefacts. In essence, the particularities of the science fiction prototypes of the dissertation relate to the manner by how they engage experience design findings profoundly to the process, and how they underline the impact of the aesthetic, positive experiences.

It seems that many of the published science fiction prototypes have nevertheless touched upon the experiences people will have towards the technologies in the future settings. However, most authors do not make any, or at least specific, reference to experience design. The science fiction prototypes that have clearly referred to experience design methodologies may be found from the prototypes of Egerton et al. (2011) and Graham (2011) — but the role of the experience design research has not been systematically described in either of those. In their work, Egerton et al. (2011) briefly presented an expanded consumer experience development, which described how science fiction prototyping process may be applied in traditional product development process. Graham (2011) conversed the business-oriented co-created value production, according to which value cannot be abstractly defined in isolation from the consumption experience. Graham's business-oriented approach to experience design is different than the one presented in this dissertation; however, his ideas have inspired the experience environment construction that will be presented later in the dissertation. Perhaps the best, previous example of an experience-centered prototype is offered by Kovalchuk (2011) who presented interesting experience-related ideas in her very literal prototype, which seemed to employ quite experience-driven technologies.

Another thing that many of the other science fiction prototypes are referring is the HCI work. HCI research has been presented into some extent e.g. in the prototypes made by Clarke and Lear (2010); Jiang (2011); Tassini (2011); Peldszus (2011) and WU and Callaghan (2011). For example, the prototype "Happy eggs" (Jiang, 2011) employed ethnographic research as the backbone of the prototype, however, it focuses mainly on illustrating the scientific genetic research context that was the focus of the ethnographic research. Correspondingly, many other prototypes make a reference to the broader concerns for HCI, but do not explain in detail how these findings are conversed on the prototype creation. An important contribution of this dissertation is therefore to providing of systematic consideration of how to employ the grounding design-oriented HCI research in order to create science fiction prototypes that place the research findings, experiences, meaningfully in the centre. The procedure and findings are used for settling on to a framework for designing experience-based science fiction prototypes.

9.1 EMPLOYING THE EXPERIENCE DESIGN RESULTS

In the context of this dissertation, the broader contextual issue related to the widely discussed topic within HCI of how to design for experiences. The most important topic for the design investigations related to the consideration of how to present "an experience" and "experience" as a repository of experiences — with the "experience as a story" (Schrank, 1990; Forlizzi and Ford, 2000) attitude — in order to provide them with meaning. The decisive aim was to accomplish "the completing experience" that Dewey (1934) has recommended pursuing.

The findings of the experience design studies of the grounding, design-oriented research were the seven new, emerging experiences — deliberated here as "experience" — from the context of DIY construction for the Internet of Things. These seven experiences have been nominated as the foundational themes for the experience-driven science fiction prototypes. The elicited DIY experiences relating to the creating, configuring and sharing activities in the proof-of-concept prototyping phase — considered here as "an experience" — have been reflected in the science fiction prototype construction phase. Furthermore, the prototypes have studied the broader set of positive experiences that have been found important for technological designs (Hassenzahl et al., 2010b), but whose assignment into the design has nevertheless been found very difficult.

The emerging new experiences from design-oriented research have provided the foundational themes for the science fiction prototypes. These new experiences can be associated with the following science fiction prototypes — "IF Alice arrives THEN Wonderhome incites", "Dreamnesting", "Song of Iliad" — of this dissertation:

- The physical and digital co-existence of the "things" in the environment ("IF Alice arrives THEN Wonderhome incites")
- The immersive quality and realism of the augmentation in the reproduction of "things" ("Dreamnesting")
- The flexibility in the component modularisation ("Song of Iliad")
- The need for experiencing digital "things" with analogue disguise ("IF Alice arrives THEN Wonderhome incites")
- Apprehending the digital ecology as a conclusive experience ("IF Alice arrives THEN Wonderhome incites")
- Experiencing the ecology through the affordances or the "smart thing" functionalities ("Dreamnesting")
- Contentment of the substituting interaction options ("Song of Iliad")

In Table 4 there is a list of the experiences that were elicited and confirmed as important for the DIY IoT. The DIY-related experiences, on the left, were first investigated from relevant DIY and end-user installation literature and then confirmed by user studies. In the first, design-oriented research part of the dissertation, Table 3 explained for which case study the particular experience was found to relate[37]. In the centre column, the relevant DIY IoT experiences are tied to the universal psychological needs that Hassenzahl et al. (2010) have associated with the sources of positive experiences: competence, relatedness, popularity, stimulation, meaning, security and autonomy. In the categorisation of the experiences, the feeling of control has special attention, as was also the case in the design-oriented part of research. This was because the approach — according to which people should be in control of their surroundings and collectives of devices (Callaghan et al., 2009) — was nominated as the broader contextual research objective for this dissertation. On the right of the Table 4 are the science fiction prototypes, indicated by numbers: "IF Alice arrives THEN Wonderhome incites" (1), "Dreamnesting" (2), and "Song of Iliad" (3), and a further indication of the prototype for which the particular experience has been designed.

The justification for highlighting the positive experiences in the science fiction prototypes was initiated by Dewey (1934), who considered that "happiness and delight come to be through a fulfilment that reaches to the depths of our being — one that is an adjustment of our whole being with the conditions of existence". Concerning a recent debate relating to the genre of science fiction, Lanier (2013) speculated why the majority of contributions in science fiction present a generally very pessimistic perception of emerging technologies[38]. Lanier has called out for more optimistic insights that he maintains are entirely missing from the genre at present. He goes on to say that when science fiction is bright it helps to clarify what the meaning of the technologies might be when people are highly empowered by the inventions; optimistic science fiction could also demonstrate that there is no need for us to create artificial struggles against our own inventions in order repeatedly to prove ourselves (ibid. p. 128). Lanier has declared that optimism would play an even more special role if the science fiction author were a "technologist". This, he argues, is because the actions of the technologist change events

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It should be noted, however, that the science fiction prototypes do not correspond completely with the nominated case studies. This is because in some science fiction prototypes it has been more important to encourage experiences that were not achieved with the proof-of-concept prototypes.

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More about the optimistic and pessimistic perception of new technologies can be found from Appendix D.

THE DIY-RELATED EXPERIENCE	POSITIVE EXPERIENCE	SFP
Delight of making things by oneself	competence	2, 3
Pleasure of everyday creativity	meaning	2, 3
Reward of the process	meaning	1, 2, 3
Sense of togetherness	relatedness	1, 3
Enjoyment of being noticed and recognised	popularity	2, 3
Pleasure of feedback and support	relatedness, popularity	2, 3
Sense of inspiration	stimulation	2, 3
Self-esteem	stimulation, meaning	1, 2, 3
Arousing emotional experiences in others	relatedness	1
EXPERIENCE RELATING TO THE FEELING OF CONTROL		
Flexibility of the system	autonomy	2, 3
Customisation possibilities	autonomy	1, 2, 3
Personification possibilities	autonomy	1, 2, 3
Local control	autonomy	2, 3
Being able to complete a job more effectively	competence	2

Table 4.
The experience design findings and the positive experiences encouraged in the science fiction prototypes. In the left column are the DIY-related experiences that were found important in the initial experience design studies. In the centre column is the positive experience with which the DIY-related experience may be associated. In the right column are the science fiction prototypes described using numbers: IF Alice arrives THEN Wonderhome incites=1, Dreamnesting=2 and Song of Iliad=3.

directly, not merely indirectly, through discourse. He complains, however, that technologists most often feel no need to talk about the behaviours and needs relating to the technology they are currently inventing, let alone the cultural, spiritual and aesthetic ideas – although this would prove extremely interesting in a public conversation. In conclusion, he justifies this by saying that civility and human improvement are still mainly choices, and reflected against this background, scientists and engineers should present technology in ways that avoid confounding those choices (p. 186).

9.2 AESTHETIC EXPERIENCES

Aesthetic experiences pose another challenge when considering the design for experiences, although they seem to be an important ingredient for the experience design. According to Dewey (1934), the word “aesthetic” refers to experience as appreciative, perceiving, and enjoying. An artefact, object or scene is peculiarly and dominantly aesthetic when the factors that determine an experience are lifted high above the threshold of perception and made manifest for their own sake (ibid.). Dewey perceives the aesthetic quality to round out an experience into completeness and unity exclusively through the emotional. In essence, he considers experiences to be thoroughly emotional: as experience, the perceived artefact, object or scene is emotionally pervaded throughout. Dewey also points out, however, that emotions are commonly understood "as things as simple and compact as are the words by which we name them: joy, sorrow, hope". Yet he maintains that there are no separate things called emotions in experiences; there is no such thing as perception of seeing and hearing plus emotion. Emotions, at least when they are significant, are qualities of a complex experience that moves and changes us (ibid.).

The design for aesthetic experiences pays high regard to the intimate nature of the experiences. According to Dewey, the intimate nature of emotion is manifested furthermost in the experience of "one watching a play on the stage or reading a novel". He considers that all emotions are in fact qualifications of a drama, and change as the drama develops: "(Experience) attends the development of a plot; and a plot requires a stage, a space wherein to develop, and time in which to unfold" (ibid.). Desmet and Hekkert (2007) continue in stating that aesthetic experiences in design should involve the artefact's capacity to delight the sensory modalities. Principally, in the science fiction prototypes of this dissertation the aesthetic experiences have been insinuated by describing the aesthetic qualities of the artefacts and environments that the protagonists of the stories experience with all their senses. However, the senses are only one relatively superficial aspect in the aesthetic experience design.

As a substantial notion towards thoroughly emotional experiences, all the science fiction prototypes of this dissertation have sought to find means to illustrate the aesthetic experiences. The creation process of the aesthetic prototypes leans firmly on the notion by Dewey (1934) who has stated that in an emphatic artistic-aesthetic experience the relation is so close that it controls simultaneously both the doing and the perception. He explains that in order to be artistic, in the final sense, the craftsmanship must be "loving"; it must care deeply for the subject matter upon which the skill is exercised — the expression is emotional and guided by a purpose. The hope is that by engaging aesthetic experiences in the science fiction prototypes they will deliver something that Koskinen et al. (2011) called "aesthetical accountability" towards the design outcome. They state that aesthetical accountability fundamentally concerns the topics that seem inaccessible to science, such as aesthetic pleasure and cultural implications; it is about the ability to articulate ideas through design and evaluate them aesthetically. Koskinen et al. also declared that aesthetical accountability can pertinently be achieved by the narrative and storytelling methods, "for the words translate happenings into experience". In the science fiction prototyping context, it could also be considered that aesthetical accountability allows the author to introduce into the fictional prototypes his or her individual signature, personal fingerprint or sign of loving affinity.

Dewey suggests that to begin to constitute an aesthetic ideal, the experience should absorb into itself memories of the past. Furthermore, he states that the material for presenting the aesthetic experience should be drawn from whatever sources. It could be considered that many of the published science fiction prototypes have instinctively been aiming to this conjuncture when they sought source of inspiration for the work — although this has not been originally specifically defined to be a constituting element in the science fiction prototyping method. Obviously, many of the authors writing the prototypes referenced to acknowledged science fiction literature when they have described of the influences to their work. For example, Birtchnell and Urry (2013) mentioned Neal

Stephenson's "The Diamond Age", Charles Stross' "Rule 34" and Cory Doctorow's "Makers". Schwarz and Liebl (2013) referenced to William Gibson's novel "Spook Country" — and in fact considered it as a science fiction prototype suitable for their analysing purposes. Kera and Tuters (2011) referenced to Margaret Atwood's "The year of the flood"; and a piece of writing by James Joyce. Some other authors also found different literature genres more suitable for source of inspiration: McCullagh (2011) referred to Hans Fallada's novel "Alone in Berlin", McCullagh (2013) to Oscar Wilde's novel "The Picture of Dorian Gray", and Johnson (2011b) to Michael Brook's work "13 Things That Don't Make Sense". Music and fashion seemed to have been another important source of inspiration; McCullagh (2011, 2013) was stimulated by the music of Bruce Springsteen and David Bowie, and Clarke and Lear (2010) presented a historical review of the dark glasses wore by the existentialists Greco, De Beuvoir and Sartre, in order to highlight the aesthetic ideal of their innovation "BioSpeks". Other authors find source of inspiration from spirituality. For example, Loke and Egerton (2010) constituted their prototypes upon the "semangat" guardian spirit of the forest of Belum, whereas WU and Callaghan (2011) were motivated by the oriental Chan Practice — the enlightenment tradition that aims for realising "the ultimate truth".

The reflection and illustration of the aesthetic accountability in the dissertation prototypes was accomplished by drawing inspiration from diverse set of literature and science fiction films, by engaging findings from other research, and by accompanying the prototype with philosophical underpinnings. The philosophical mode to design was proposed by Flanagan (2009), among many others, in the call for bringing origin and scope into design. For the science fiction prototypes of this dissertation, an important philosopher with relevant experience-related contemplations was Yi-Fu Tuan. Tuan conducted an extensive amount of research on place, which he says connotes the privileged access to the states of human mind, thoughts and feelings (Tuan, 1974). The key philosophy in the prototype "IF Alice arrives THEN Wonderhome incites" related to Tuan's concept of "topophilia", which can be defined broadly "to include all of the human being's affective ties with the material environment". Tuan's study of the environmental perceptions, attitudes, and values illustrated that topophilia towards home is more permanent and less easy to express than any other perception. An intriguing opportunity for exploring the concept in the prototype arose when the protagonist Alice's experiences of home were transferred into an intelligent residence "Wonderhome". Another important philosopher in the dissertation prototypes was Gaston Bachelard, particularly the ideas in his principal work entitled "Poetics of space" (1964). Bachelard thoughts on home, house and space have been explored in the prototype "Dreamnesting", for example by illustrating the motivations for protagonist Abby immersing herself in the interior design tasks of her new house.

9.3 EMPLOYING THE SCIENCE FICTION PROTOTYPING METHOD FOR BUILDING AN EXPERIENCE ENVIRONMENT

For the purpose of creating fictional stories based on earlier research, the science fiction prototype creation process of this dissertation leant firmly on Brian David Johnson's (2011a) science fiction prototyping method. However, the method has been accompanied by some complementing frameworks that highlight the role of experiences and underline the positive undertone in the prototypes.

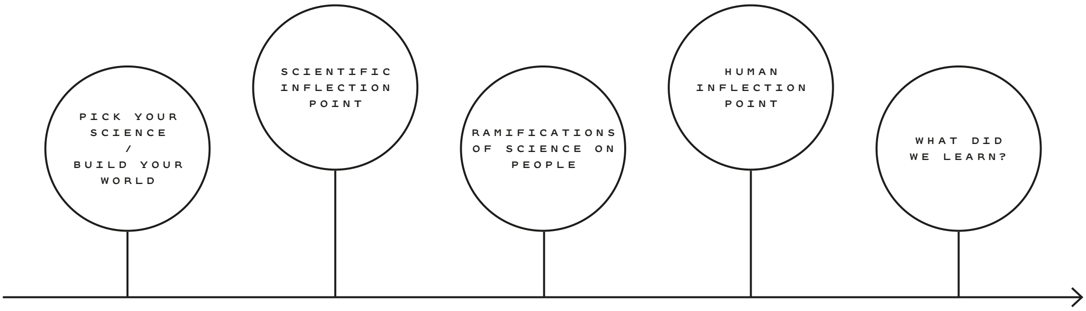

Figure 27.
Brian David Johnson's science fiction prototyping method.
Redrawn from Johnson's (2011a), adapted with permission.

As the first task in the creating process, Johnson suggests determining the technology, science or issue to be explored with the prototype. The *de facto* technologies for all the science fiction prototypes of this dissertation were the Internet of Things technologies, accompanied by intelligent environment, ambient intelligence and ubiquitous computing research opportunities and outcomes when applicable. In the introduced science fiction prototypes, the technologies aimed at capturing more than merely the functional, seizing on the experiences that the IoT technologies were confirmed to provoke in the design-oriented part of research. A more discreet aim of the construction phase was to describe the emerging technologies in a light that made them emotionally and aesthetically pleasing. Also, all the science fiction prototypes accelerated the technological evolution of the IoT technologies by placing the events 5–15 years into the future. The practice was enthused upon by Asimov (1981), who encouraged science fiction writers always to look to world trends in science and technology for plot inspiration[39]. This was expected to be a particularly suitable approach when considering emerging, future-oriented technologies. Koontz (1981; in Johnson, 2011a), however, illustrated the considerable struggles that come to the fore when technology is placed in the near future, by stating: "*Structuring a story background of near future is in some way more difficult than creating an entire alien planet in some impossibly distant age. The writer must conduct extensive research… From that data, the author then extrapolates a possible world of tomorrow, one that might logically rise out of the base of the future*".

The studied technologies provided the necessary premises for the fictional world construction process; the subsequent preparation task in Johnson's framework (2011a) was the introduction of people and locations. For enhancing the construction task with the experience design perspective, the dissertation employed the Gouillart and Ramaswamy (2010) co-creation framework for the process. The first task in their framework was to identify all stakeholders affected by the process, with focus on the experiences of a few key stakeholders. An important notion towards the focusing criteria is presented in the prototype by Kovalchuk (2011) in a sequence in which the protagonist poses an important question, in the context of historical exploration, of "whose experiences should be presented in the interfaces: the protagonist, historians, or past characters". Consequently, at first, the protagonists for the dissertation prototypes were chosen on the basis of the design-oriented research findings, the defined specific human ecologies and the characteristics of participants in the research setups that are presented in Figures 23–25, or according to the requirements of the participants in the case

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"…and in doing so", according to Asimov (1981), "they sometimes get a glimpse of things that later turn out to be near the truth".

studies. The primary criteria for defining the protagonists were based on selecting the most important users that would benefit most from emerging technologies. All three protagonists in the SFPs introduced in this dissertation were considered as amateurs in their DIY-related interest domains, possessing modest computational capabilities. Two of them, Abby in "Dreamnesting" and Iliad in "Song of Iliad", grew to become Pro-Am users of emerging technologies, with an opportunity of advancing towards the professional level. The remark from Laurel (1993) was appointed for cultivating the characters, in which she stated "the empathy experienced with the characters in drama is subject to the same emotional safety net as emotion: we experience the character's emotions as if they were our own". After settling the protagonists, the stakeholders identified subsequently were the immediate characters created to support the protagonist's experiences. Secondly, therefore, all the protagonists had a warm, local expert who familiarised them with the technologies. In "IF Alice arrives THEN Wonderhome incites", the local warm experts were Alice's late husband Frank and her daughter Kay. In "Song of Iliad", the warm expert was music therapist Paula, and in "Dreamnesting", the philosopher Sam. The third group of stakeholders identified were the more advanced intelligent agents that guided the protagonists through their construction objectives. Laurel (1993) noted that when agents are designed, for example, for computer games, they should be presented as responsive and accessible, and certainly by considering the agents more as characters than people. This notion was employed while cultivating the intelligent agents in the prototypes.

The subsequent task in the Gouillart—Ramaswamy framework was to understand and map out interactions among the stakeholders. The design-oriented research again provided abundant information for the task; e.g. the service ecology sketches (see Figure 26) created by the amateur interior designers in the AR Interior Service study were especially useful in understanding stakeholder interactions for the prototype "Dreamnesting". Mapping out the interactions emphasised the roles of the nominated experiences — describing the creating, configuring and sharing activities (see Table 4) — that were explicitly illustrated through the interactions practised by the protagonists and immediate characters when using the technologies. As the last step, Gouillart and Ramaswamy suggested building platforms for implementing ideas for new interactions, and for continuing the dialogue among the stakeholders for generating further ideas. This suggestion, however, was viewed as a call to create new ecologies that inhabit the fictional worlds, for which purpose yet another framework would be needed.

The elements from the Prahalad and Ramaswamy (2004) framework for constructing an experience environment were considered within the prototypes as experience requirements undergone by the protagonist and immediate characters at some point in the storyline. The first task in the Prahalad-Ramaswamy experience environment framework was to offer opportunities for the characters to co-construct their own experiences on demand, in a specific context of space and time. This was achieved in the prototypes by carefully describing what the protagonists were experiencing when they were introduced to the technologies, what they experienced while they were carrying out the creating and configuring tasks, and what was the experience after they had shared their creations. The second task in the experience environment framework involved the engaging of personal meaning to experiences — knowledge, insights, enjoyment, satisfaction and excitement — which were illustrated in the prototypes by demonstrating how the individuals faced the situations and what they derived from the creating, configuring and sharing events. An important part of the prototype construction was accomplished by carrying out the third task of the framework — involvement of the communities — that demonstrated the deepest emotional and intellectual motivations for the protagonists for carrying out the DIY tasks. Employment of the last task of the Prahalad-Ramaswamy construction framework concluded the creation cycle — equating to Johnson's first task — for introducing the new opportunities for the stakeholders afforded by the evolution of emerging technologies.

The two frameworks employed — Gouillart—Ramaswamy and Prahalad—Ramaswamy — intensified Johnson's science fiction prototyping method and provided a position from which to consider the extensive amount of research that had been carried out in the design-oriented research. If examined closely, however, essentially the new frameworks only influenced the first step of the science fiction prototyping method. The subsequent steps of the method concerned introducing the scientific and human inflection points, and exploring the implications and ramifications of the technologies. With regard to beginning designing for action, Laurel (1993) emphasises keeping in mind all that was created in the premises for the fictional world construction process: characters, objects and environments, which are all subsidiary to the central goal of the action creation. Moreover, in the dissertation prototypes the emphasis was on the experience design perspective, which was achieved by exploring the key experiences and positive experiences presented in the Table 5 for all steps in Johnson's method. The first dramaturgical juncture in the action creation process was the scientific inflection point, which Johnson suggested should be considered carefully as it provides the means to explore the implications and ramifications of the technology in the created fictional world. Exploring the implications should be about pushing the plot to extremes — either good or bad — that expose new areas of investigation or exploration in the real world (ibid.). In the dissertation prototypes, the scientific inflection point was demonstrated by introducing the IoT technologies into the daily lives of the characters. According to Johnson, the subsequent human inflection point should complement the dramaturgical juncture by challenging the technology; this provides opportunities for modifying them. The human inflection point in the dissertation prototypes was illustrated when the characters found themselves — through compulsion or intrigue — using, creating, configuring or sharing their creative work by means of the technologies.

Parenthetically, the task of exploring implications and ramifications within the prototypes is in accordance with the notion of Dewey (1934), who stated that "the distinctively aesthetic experience is conversion of resistance and tension, of excitations that in themselves are temptations to diversion, into a movement toward an inclusive and fulfilling close". The narrative in the dissertation prototypes in both inflection points moved unavoidably towards what Aristotle called the catharsis — the rewarding and pleasurable release of emotion (Laurel, 1993). According to Laurel, the catharsis is dependent upon the way that probability and causality has been orchestrated in the construction of the whole; it also depends upon the uninterrupted experience of engagement with the representation (p. 122). Johnson concluded that the final task in the creation process of a science fiction prototype is to explore the solutions, implications and lessons learnt, which in the dissertation prototypes were achieved by reflecting on how the prototypes explored the design-oriented research, what inspiration they drew from literature and science fiction films, what findings they engaged from other research, and what was the role of the philosophical underpinnings. In conclusion, by creating the new experience ecologies thorough the science fiction prototypes, the emphasis was firmly on the subjectivity of the experiences, found to be one of the most difficult properties in experience design, which might yet be considered as the strength of science fiction prototypes: by the means of the method the subjective experiences are brought out, made visible and ultimately, intensified.

9.4
OVERVIEW OF THE DISSERTATION'S SCIENCE FICTION PROTOTYPES

9.4.1
IF Alice arrives THEN Wonderhome incites

The science fiction prototype "IF Alice arrives THEN Wonderhome incites" (in Article VI) (see Figure 27) introduced an intelligent home for the aged that provided motivational and personalised activities, assistance, and memory support for the inhabitants. The prototype was based on two case studies of the dissertation: Home Control System (in Article I) and Life Story Creation (in Article II). The Home Control System study provided substance about the motivations of people configuring, customising and personifying their environments in a do-it-yourself fashion, the inspiring and supporting role of the system, the self-actualising part of the construction process and the preference for multimodal systems, haptic interfaces and spoken language dialogue interaction. The Life Story Creation study provided material mostly for sharing activity, especially for the sharing of private memories.

The experiences

The new experiences that the prototype explored were connected to the physical and digital co-existence of things in the environment; the need for experiencing digital things with analogue disguise and the need for apprehending the digital ecology as a conclusive experience. When weaving the singular key experiences into the storyline of the prototype, the focus was on the positive experiences that could be associated with relatedness, meaning and autonomy. The most important specific experiences in the Home Control System study was found to relate to the arousing of emotional experiences in others, the sense of togetherness and self-esteem, which the prototype also encouraged. The most important experiences in the Life Story Creation case were also related to self-esteem, the sense of togetherness, together with the enjoyment of being noticed. In both these case studies, the experience relating to the feeling of control necessitated focusing of the technology on the personification and customisation opportunities.

Figure 28.
"IF Alice arrives THEN Wonderhome incites"

Setting for the prototype — the new ecology

The setting for the science fiction prototype was “Wonderhome”, an intelligent nursing home providing visible and tangible experiences that the protagonist Alice faced when familiarising herself with the apartment. The setting had an important role in introducing the technology as a conclusive experience for the inhabitants. In the backdrop, the artificial intelligence and autonomous agents ran most of the everyday routines, but there were also many properties in the nursing ecology that required the attention and control of the inhabitants, or warm-hearted nurses and relatives. An important emotional property of the nursing ecology was that the inhabitants did not live completely alone in their apartments; on each floor there were other persons also requiring the personification and customisation experiences. This made perceptible the issue that there must be negotiation of the personification levels in the shared spaces, although eventually all seemed to benefit from the quite radical customisation of the surroundings with, for the elderly, its reminiscent 70s atmosphere. This important detail was adopted from the “counterclockwise” study (by Ellen Langer, 2009), in which elderly men, living for a week in an environment that was designed to represent their youth, were consequently found to take more control over their lives.

Characters for the prototype — the stakeholders

The protagonist of the science fiction prototype was Alice. Her role was essentially determined in the very first considerations and scenarios created within the Home Control System research. In the prototype, Alice faced the challenges provided by her new environment — the nursing home and its ambient technologies — with the help of her daughter, Kay. Their relationship exposed the social connection between an elder parent and adult child, a relationship the technologies endeavoured to support. Another important character was Alice’s late husband Frank, who from beyond his grave had an important role in arousing emotional experiences in Alice, and was in fact responsible for quite a number of the DIY-creation and configurations within the apartment that were made for Alice. The other residents of Wonderhome were Alfred, Sam and Fran, whose roles were to demonstrate the needs and motivations for personifying the environment and camouflaging the technical services. The diagnoses of the side characters were roughly adapted from the Oliver Sacks novel “The Man who Mistook his Wife for a Hat, and Other Clinical Tales” (1985). The prototype also introduced, as a side character, an electronic butler, the white rabbit avatar that was an autonomous, personal agent operating on Alice’s behalf in the virtual world, and who mainly helped Alice to cope with her life and her new environment.

Emerging technologies

The multiuse Wonderhome was augmented with referenced ubiquitous computing and Internet of Things technologies for everyday activities, such as presented e.g. by Kidd, et al. (1999), Brumitt et al. (2000), Hagras et al. (2004) and Roelands et al. (2011): sensitive floors, sensing and person tracking technologies, vision techniques and voice recognition, spatial audio cues, wearable computers and unobtrusive centralised computing services. The system for finding frequently lost objects detected missing objects, for example Fran’s silvery shoes, and was running conceivably by means of small radio-frequency tags and a long-range indoor positioning system. The technical layer of the Wonderhome ecology also included smart memo boards — large touchscreens — that were placed strategically throughout the nursing home, and used for presenting the smart and context-aware services for the inhabitants. In the Home Control system, evaluations of the prominence of the spoken language dialogue had become evident, and were hence chosen as the prototype's key interaction mechanism for triggering actions and subtly securing the private information.

The most significant new technologies of the prototype related to the storing, retrieval and sharing of personal recollections. The BeQuest drawer-chest, rendered operational through Cloud of Things technologies, and the hologram forest, which organised the information of the Cloud of Thoughts, exemplified innovations that could be applicable in future for organising and augmenting private data, information, knowledge and memories. The aesthetic idea for the BeQuest drawer-chest came from a personal heritage cupboard, and had further inspiration from a novel by Henri Bosco (1956). The prototype deliberately neglected to specify in detail the technology behind the "looking-glass reader" of drawer-chest and the "labelling" of objects, as the presently available magnetic and optical data storage technologies in the case could easily be replaced, for example, by future holographic data storage technologies (Sainov and Stoykova, 2012). The "looking-glass" would then play a more important role in creating and reading through the volumetric image. The hologram forest introduced a novel data visualisation technique for presenting the ambiguous, personal digital data stored in the cloud. Another novelty was the haptic feedback and use of gaze-contingent techniques for browsing the volumetric projection.

The scientific and human inflection points

The first scientific inflection point in the prototype occurred when Alice was introduced to her new apartment in Wonderhome. Essentially, the inflection point revealed the emotional stress aroused in confronting the new technologies, and how that stress may be reduced. Henceforth, three new DIY IoT innovations were introduced, each providing sub-scientific inflection points for the prototype. The first scientific inflection point was a dollhouse that served as an interactive artefact for subtle communication. The second innovation was the BeQuest drawer-chest, a computational artefact on top of which their life stories could be built, complemented creatively with rhymes and chords. The third scientific inflection point was the hologram forest, inspired by Mark Weiser's (1991) assertion, "Machines that fit the human environment instead of forcing humans to enter theirs will make using a computer as refreshing as taking a walk in the woods". The hologram forest was a personal map of all the digital data and things traceable in Alice's life. The human inflection points took place each time Alice pursued her ultimate goal of revealing Frank's harassing secret with the help of the new technologies. The final human inflection point was when Alice found the trigger to the secret that only she and Frank shared. An important part of the process was that, to discover the secret, Alice was not using any technology — e.g. browsing the hologram forest or probing the personal belongings stored in the BeQuest drawer-chest — but using an important shared remembrance.

The reflection

The science fiction prototype "IF Alice arrives THEN Wonderhome incites" elaborated the experience design findings of the two grounding research studies of this dissertation, placing them in a new experience environment, and continued by exploring interesting findings of other research. It further described the new interaction mechanisms afforded by future technologies and novel research opportunities for the Internet of Things and Cloud of Things. The core testimony of the prototype was that, in the ubiquitous world, language has enormous significance, defining how people interact with the technology, how devices communicate between themselves, and how lifelong information could be retained and retrieved.

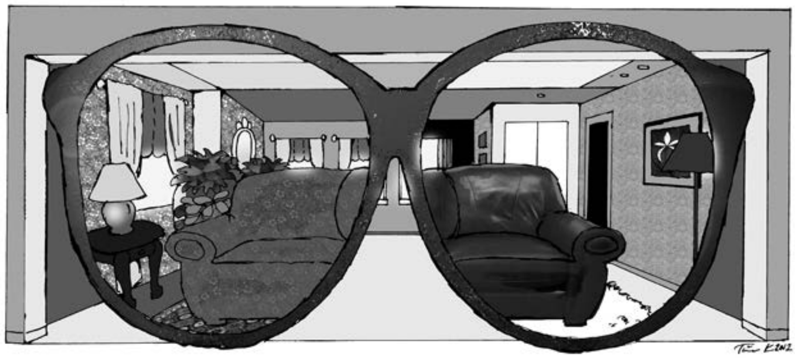

Figure 29.
Space interface and smart glasses from "Dreamnesting".

9.4.2
Dreamnesting

The science fiction prototype "Dreamnesting" (in Article VII) presented a new service enterprise that engaged a user deeply in the co-creation experience and introduced a technology platform for the interior design task: augmented reality (AR) technology in an intelligent service environment complemented with the sharing mechanisms for Web 3.0. The trademark of the Dreamnesting enterprise was "to encourage interior design dreams" (see Figure 28). The prototype was based on the case study for developing an AR Interior Design service (in Article III), which aimed at creating novel interior design service concepts that were intended to be used virtually by exploiting 3D modelling and AR technologies. The creation process for the science fiction prototype was more ambitious and challenging than with the two other prototypes presented in this dissertation – since to gain understanding of the economic ecology and opportunities for the new revenue share, the article conversed on relevant theoretical building blocks that were derived from economic and business theories, namely the approaches from service design, co-design, co-creation, economic studies and customer experience. The process was certainly rewarding, as the literature review consequently provided important material to be exploited when creating the experience environments for the prototypes.

The experiences

From the new experiences elicited from the design-oriented research, the prototype focused on the means of experiencing the ecology through the affordances or "smart thing" functionalities, which in this case also emphasised the aesthetic qualities of the experience. The prototype also conversed with another new elicited experience of the design-oriented research: the obstinate visual and immersive qualities and realism of the augmentation in the reproduction of "things", which was found to be important when transferring physical "things" to the digital world. Based on the grounding research, the most important singular experiences were found to relate to the delight of making things by oneself, the pleasure of the everyday creativity, and the sense of inspiration. These experiences formed the foundation for the new service ecology. The expectations from the new technology suggested aiming towards all aspects of experiencing the feeling of control: designing flexibility of the system, providing opportunities for customisation and personification, designing opportunities for local control, and assuring that the DIY-designer was able to complete a job more effectively. The science fiction prototype mainly communicated the positive experiences that could be associated with: meaning, simulation, autonomy and competence.

Setting for the prototype – the new ecology

The prototype construction focused sharply on the new ecology creation that presented itself as the fictional firm "Dreamnesting". The firm considered the overall structure of the enterprise: the accessibility of the operational parts of the ecology – products and services – and their relation to each other, the defining of "efficient boundaries" – service supply and demand – for the enterprise, and, most importantly, the human assets that apparently formed the principal assets of Dreamnesting. The prototype focused namely on the human assets that were gained in learning by doing; the contribution of individuals to the firm's supply that could be on-demand – as most of the browsing of supply took place in the virtual realm. The prototype emphasised the fact that the firm needed to invest a considerable amount of effort towards the individuals that contributed to the firm's on-demand service supply.

Characters for the prototype – the stakeholders

The participants in the AR Interior Design service study explicitly determined the characters for the prototype: their needs, the most critical time of use for the service, the ecology setting and the supply. According to their judgement, the Pro-Am users for the service were a young couple that had just bought an apartment, and were waiting for a month or two for permission to move in. The protagonist of the story, Abby, thus had a legitimate central role in the prototype, and Elvin, her fiancée, supported her character. A fundamental immediate character in the prototype was philosopher Sam, who provided the employee's perspective as a manager. His role was important, for it was Sam's initiative gradually to turn Abby's pastime hobby into an employment in "Dreamnesting". The protagonist of the previously introduced prototype, Alice, also appeared as a side character who sold her home to the young couple as she was moving into a nursing home. Another important side character in the prototype was Cybil, the autonomous, personal agent representing a collection of artificial intelligence technologies, and who operated on Abby's behalf in the intelligent service system.

Emerging technologies

The technological research context in the prototype was augmented reality (AR) interior design services mediated by Web 3.0. In the original study it was presumed that the users would augment digital images and operate the system by using a PC or a mobile device, but the science fiction prototype accelerated the technological evolution further by placing the events in an intelligent design environment, in which the services were shared by means of Web 3.0. The AR Interior Design service study had nevertheless raised three important topics to be issued by the nominated AR technologies: the realistic lighting, the number and variety of furniture models available including 3D reconstruction of existing furniture, and the smart database search for browsing the models. These requirements were considered more carefully in the prototype, as the photorealistic rendering, for example, was thought computationally much too demanding during the time of the case study. The prototype also illustrated a large object library that supported Abby's creativity, together with (far too) advanced AI search functionalities. The application field, interior design, tempted to place the events in a real – haptic and tangible – environment, i.e. to envisage that the space was the interface. The speculated advantages of the intelligent interior design environment were mostly fiction, but suitable for exploring the prospects of the embedded, aesthetic intelligence that could be perceived with all senses.

The scientific and human inflection points

The first scientific inflection point occurred when Abby was introduced to Cybil, the artificial intelligence that gradually assisted her with the design tasks and illustrated the supply of the service, together with the white space: “her empty canvas on which to paint the dream nest”. For the most part, the prototype illustrated the implications and ramifications of the technologies; how Abby was able to create interior designs that were at first based on the creative work of other service providers, and then after being inspired by the creative designs of others, how she gradually began creating something herself. The implication for the human inflection point began when Abby experienced a need for the customisation and personification opportunities afforded by the service, as she had the need to create some designs from scratch. The human inflection point occurred when Abby preferred to do most of the design work herself; this involved a considerable investment of her time, but ultimately led to a situation in which she was able to sell her creative work to others.

The reflection

The enterprise in the science fiction prototype, Dreamnesting, was not an organisation but an organism, as elucidated by Coase (1937) when defining the nature of a firm. The structure of the ecology comprised an all-inclusive network made up of autonomous networks in which each member was connected with the centre. This was illustrated by demonstrating how the employees — first Sam and then Abby — carried out the design work and executed the services. Prahalad and Ramaswamy (2004) explained that to create an optimal customer experience, managers must understand and intervene selectively in the individual consumer events, even as they manage the overall operation. In the prototype this was illustrated by how the managers, Sam — with assistance from Cybil — received real-time, event-centric data regarding Abby's consumer experiences. The prototype reflection concluded with the most appropriate words from Bachelard (1964): *“Thought and experience are not the only things that sanction human values. The values that belong to daydreaming mark humanity in its depths*”. This philosophy has its mark in the aesthetic accountability of the prototype. In the context, the daydreaming was considered to apply to all the activities: interior design, service design, dreaming about co-created business models and future service ecologies, and most of all, to using science-fiction prototyping as a means for demonstrating future experiences.

9.4.3 Song of Iliad

The science fiction prototype “Song of Iliad” (in Article VIII) was based on the Music Creation Tool case study that focused on the experiences of emerging technologies in the context of music therapy, and that was studied with people who had intellectual learning disabilities. The actual prototype consisted of software and physical guitar controllers, which allowed the music therapist to personalise interactions between physical and digital instrument components. The important experience that the science fiction prototype aimed to preserve was the ability to produce prepared musical compositions — the “half-done music experiences” — without extensive training in learning to play. Concepts that the original prototype was unable to support were training for a performance, performing on stage, and the publishing and sharing of music, all topics that the study participants nevertheless expressed as being important. The science fiction prototype focused on these issues more closely. In essence, the science fiction prototype illustrated a musical service concept twining around a magical music box that unfurled its secrets slowly through the music (see Figure 29). The prototype presented an example of how emerging technologies could be harnessed for the benefit of the experience design, by illustrating highly aesthetic, configurable and personal musical instruments and services.

The experiences

The important new experiences highlighted by the prototype were related to the flexibility in component modularisation, and, on a smaller scale, to the contentment of the substituting interaction options. The experience design emphasised the most important singular experiences elicited from the original case study that could be associated to relatedness, popularity and autonomy. The highlighted experiences of the prototype related particularly to the reward of the DIY process: the sense of togetherness and the pleasure of the feedback and support provided by the community. What was mostly expected from the new technology supporting of the feeling of control were opportunities for flexibility, customisation and personification.

Figure 30.
Ghost-like volumetric projection in the Song of Iliad.

Setting for the prototype — the new ecology

The science fiction prototype described a future musical "performance space" in which children around the globe created music together, formed a band and performed for others. The performance space was basically an example of an operative Internet-of-Things concept in which the virtual world of information technology integrated seamlessly with the real world of things. Although the music therapy research group introduced the popular and widespread music ecology to the protagonist, it became obvious that anyone interested could join the network. The performance space had a publication and broadcasting channel, "His Mastermind's Voice", and together these two virtual platforms formed the new ecology.

Characters for the prototype — the stakeholders

In the "Song of Iliad", the protagonist was a disabled twelve-year-old boy, Iliad, who was isolated and greatly in need of friends. The music therapy research group introduced him to three new acquaintances — Aki, Victor and Nina — with whom he formed a band, the Green Spectacles. Although his friends appeared in Iliad's attic in the form of ghost-like volumetric projections, the experiences they shared felt very real. The side character diagnoses were roughly adapted from the classic novel, Wizard of Oz (Baum, 1900), which introduced a scarecrow that wanted a brain, a tin woodman that wanted a heart, and a cowardly lion that needed to be brave. The artificial intelligence in the prototype was Ellen Blaise, who was Iliad's virtual wizard and evaluator; it should be noted that in the prototype Ellen Blaise had a human counterpart in the physical world. Ellen's role was to introduce the service to Iliad step by step, when it seemed most appropriate, and eventually to fulfil his greatest wish.

Emerging technologies

The Music therapy research group provided disabled children with the physical building blocks, dismountable instrument parts, and self-made applications that together formed a combination of sensors and actuators, communication technologies, automatic identification technologies and, conceivably, real-time locating systems. All smart objects in the prototype had a digital presence, created by using integrated sensors and actuators and by allowing other devices and objects to communicate with each other through the digital network. This permitted the players eventually to share their creative music pieces through the cloud site called "His Mastermind's Voice". The designs and the aesthetics of the innovations — highly personated products and services — were an important part of the prototype. The mysterious music box — a high-technology smart product with tangible buttons and secret compartments — could be seen to provide all potentials for initiating the child's creative imagination. The ghost-like genies — volumetric projections — representing the other players reinforced the magical atmosphere generated by the music box, while the chameleon ring — the context-aware communication device — was something one would proudly carry around as a token of membership of a secret society.

The scientific and human inflection points

The scientific inflection point occurred at the moment Iliad opened the mysterious music box and heard its purring sound. The implications and ramifications of the technologies were introduced while Iliad begun to builds his instruments, record music and make friends with the help of the system. The prototype communicated the relationship of the four friends; how each was introduced to the system one by one; how they eventually played together, and how the recording and performing were carried out with the help of the music ecology. The human inflection point was when Iliad merged his private and secret poem with the music piece he had composed when he first entered the service, and together with his new friends they created a masterpiece that became a success on the popular cloud site.

The reflection

The science fiction prototype broadened the perspective of the current technological achievements to embrace experience-, aesthetic- and emotion-driven design, by acknowledging that experiences are at the core of emerging, highly personified IoT products and services. Kuniavsky (2010) accentuated the role of the new innovation ecosystems, which he believes may well provide suitable purposes for the Internet of Things, in which "the gratification doesn't come from measuring things, but from finding means to use them". According to Kuniavsky, the new innovation ecosystems may be created upon ubiquitous network connectivity, cloud-based services, cheap assembly of electronics, social design, open collaboration tools and low-volume sales channels, for all of which this prototype draws a reference in a tangible and concrete manner. In essence, the prototype described the long-term use of currently non-existent technology, and considered the motivational aspects of the DIY approach, in order to provide realistic designs to suit the purposes of the IoT technologies.

9.5 SCIENCE FICTION PROTOTYPE AS EXPERIENCE DESIGN OUTCOME OF RESEARCH

When Johnson introduced the science fiction prototyping method, he imagined there would be many ways of using it, and for many different purposes. He himself mainly used the method extremely iteratively, and specified that the method works best as a phase in the continuing development process. Overall, the majority of the published science fiction prototypes have focused on considering the wider socio-technical concepts and their consequences to the society, such as freewill (Egerton et al. 2011), transhumanism (Hales, 2011), technological singularity (Callaghan, 2010) reality distortion through AR and VR applications (Clarke and Lear, 2010) and consequences of the 3-D printing (Birtchnell and Urry, 2013). In this dissertation the approach has been very different, in the sense that the science fiction stories are presented as design outcome of great amount of validated design-oriented research work i.e. they are presented as research-oriented design artefacts. Primarily, the dissertation science fiction prototypes can be considered as the experience design outcomes of the ecological, experience design research for the Internet of Things — as argued throughout the dissertation. This was achieved by weaving the studied, critical experiences, and the interactions and relationships between people and technologies to the fabric of the new experience ecologies.

However, somewhat similar approaches on the ways authors engaged previous work to the science fiction prototype creation can be found e.g. from the prototypes of McCullagh (2010, 2011); Graham (2011, 2013); Callaghan (2010); Bostanci and Clark (2011) and Scholz et al. (2011). McCullagh, for example, similarly engages his work in his prototypes that present the research of brain-computer interfaces and the Internet of Things. His motivation for the prototype creation is the disappointment towards the many technical obstacles that still needs to be overcome. The main difference in his visions of future compared to the dissertation prototypes is that they are biased towards the criticism of the social consequences towards the technologies, and, apparently, it seems that the protagonist is more or less the writer's alter ego than the anticipated users of the wellness and assisted living research that was the primary target of his research. Graham's (2011, 2013) work is similar in the way he engages his previous work to the prototype creation, including the context of research and how he considered experiences important aspect of the prototypes. For example, in his prototype “Interaction Space” (2011) Graham deliberates the low barriers of the Web 2.0 for people to engage and be creative, and presents a consumer as the central figure of the prototype. His background, however, is in economic and business sciences, and consequently, he has built the prototypes upon his work on business models and new value chains. The manner in which Bostanci and Clark (2011) engaged their work, in the context of AR research, to construct an immersive gaming experience for their prototype, may also be seen as somewhat similar than the approach presented in this dissertation, however, their approach is more technology-oriented and does not involve HCI research. There can also be found some similarities in the way Scholz et al. (2011) engaged previous research in order to illustrate their sentimental fiction, in which they reflected their work on studying wireless sensor networks. However, the fundamental construction of the story is quite different, as in their prototype the protagonist looks back on the technologies that are currently being under investigation, and considers mainly the benefits that they caused for the society on a larger scale. In general, when considering the way authors' have engaged previous work to the prototype creation, it seems that no one can outpace Callaghan's contribution. His prototype “Tales from a Pod” (2010) describes how artificial intelligence and virtual environment might change the nature of future education; the prototype imagines a future time when the technological singularity has been reached, and machine intelligence and interaction is equal or surpasses that of people. In the introduction Callaghan refers to his past work including hundreds of published papers on intelligent environment research, embedded intelligent agents, virtual environments and -games, educational technology and social-technical aspects — and by drawing the connection he provides an important contribution to the created prototype. However, Callaghan uses his enormous personal research proficiency to serve as the storytelling backbone, whereas this dissertation humbly demonstrates the specific emerging technologies, in specific experience design contexts, in order to draw more straightforward congruence to the particular research settings.

Another difference between the other published science fiction prototypes and the prototypes of this dissertation has been that the method is used specifically as a mean to mediate the positive experiences of the technologies. This objective found justification from Lanier (2013) who notified that the majority of the contributions in science fiction genre have presented very pessimistic perception of the new technologies. This may be verified also by evaluating the other science fiction prototypes, of which principally concentrate on illustrating the negative consequences or experiences of the technologies or even illustrate dystopias. For example, in Johnson's (2011b) prototype the AI develops emotions, starts killing the inhabitants of a distant plant, experiences shame and ends up in self-destruction. Clarke and Lear (2010) present a Dystopia in which the ruling class employs the total immersion of virtual reality technology and drone workers adapt to augmented reality that is merely imposed upon them. In his prototype Graham (2010) presents two dystopian worlds by placing the storyline into decimated fertility world and by illustrating an education process that aim to create an elite intellectual class. McBride (2011) speculate the limitations of current computing systems in the prototype "Meltdown". According to him, the current computing systems are brittle and in need of much maintenance, they provide easy spread of errors and have a uniform lack of resistance to viruses — and as this state of affairs has been placed in a hospital environment, the elements for tragedy seem unavoidable. WU and Callaghan (2011) present a world in which the technology has become so exciting that the reality and virtuality become confused in an intoxicating mix of sensory experiences, which causes a madness known as "obsessive-compulsive technophilia disorder (OCTD)". In his prototype McCullagh (2013) explores the potential negative consequences of the technology to the ageing population. In the prototype "End of Hearing" Kultys (2011) presents a critical perception of the impact that novel technologies will have on human hearing. Some other authors describe the technology as insufficient, broken, lost or used against what was intended as in the prototypes of Clarke and Lear (2010); Loke and Egerton (2010) and Tassini (2011).

Accordingly, what has been essentially the main difference between the other published science fiction prototypes and the ones presented in this dissertation, is the content. Perhaps this may even lead to a conclusion that the content of the dissertation prototypes are not so much science fiction, but closer to speculative fiction[40]. The dissertation, however, has settled in to use the term science fiction in the context, because the prototypes have so clearly adapted the in-built means of science fiction prototyping method for illustrating the revolutionary changes in people's lives that have been facilitated by the novel technologies. Also the

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The definitions of speculative literature are debatable. For example, Margaret Attwood has classed her later work as speculative fiction by arguing that "science fiction seeks only to entertain, whereas speculative fiction attempts to make the reader rethink his or her own world based on the experiences described in the novel" and "things that really could happen, but just had not completely happened when the authors wrote the books." Retrieved 12:20, October 24, 2013, on: http://www.wired.com/2013/09/geeks-guide-margaret-atwood/

technological domain — the emerging technology and the Internet of Things research — has provided appropriate context to be speculated specifically through the lens of science fiction. Consequently, the final argument of the dissertation is that the positive experience-driven prototypes of this dissertation should be seen primarily as design artefacts. If these artefacts are reflected upon Erkan Bostanci's process description of the creative science cycle in Figure 14, the aim has not been to keep the cycle going on forever, but ending up in the artefact creation. It is emphasised here that the literal science fiction prototypes of this dissertation should be considered as artefacts *per se*, although it is acknowledged that they may be supplemented with images or other artwork that more commonly fulfil the criteria for artefacts. It should be noted that the visual imaginary does seem to reinforce the impact of the science fiction prototypes if they are considered as design artefacts. This kind of visual prototyping use are presented in the dissertation prototypes VI and VII, as well as in many other SF prototypes. For example, Johnson (2011a) described of the different variations in the use of visual material when he has described of the method and encouraged to use the visual imagery by his own example. Also in the prototype "The spiritual machine" Wu and Callaghan (2011) included an advertisement of the iSkin technology to enforce their prototype innovation, and Peldszus (2011) included an innovation called "the surprise payload rack" in her prototype, which was in the form of a user manual that aided for the isolation and monotony during the space missions. Another matter is that the visual prototypes may be considered as science fiction prototypes *per se*. This has been illustrated, for example, by Schwarz and Liebl (2013), who have presented the "fictional products" by the British art/design collective "Human Beans", which included the work made by artists Chris Vanstone and Mickael Charbonnel. By the fictional artefacts they refer to a situation in which the artefact speaks about the clandestine desires and hidden anxieties that are not visible but can be imagined. Perhaps, the most advanced visual artefact creation yet has been presented in the Tomorrow project anthology (2013) in which six artists — Chris Carl, Paul Howe, Bobby Zokaites, David Shannon-Lier, Haylee Bolinger and Thad Trubakoff — presented their artwork creations as science fiction prototypes.

9.6 FRAMEWORK FOR CREATING SCIENCE FICTION PROTOTYPES AS EXPERIENCE DESIGN OUTCOME OF RESEARCH

The concluding framework has aimed at answering the research question that reflects the overall pragmatic HCI research question of emerging technology research: how to design science fiction prototypes that place people meaningfully in the centre of designs? The framework has aimed at crystallising the steps taken for constructing science fiction prototypes that are grounded upon ecological experience design research in the emerging technology context, with an emphasis on the co-design approach. The framework may also be considered as a conclusive design strategy for creating science fiction prototypes as experience design outcome of research.

The framework was divided into four phases: the early ecological studies, the co-design phase, the proof-of-concept prototyping phase, and the science fiction prototyping phase. All are considered essential for creating experience design-driven science fiction prototypes. The framework was built upon the method set used for the case studies in the design-oriented research part of the dissertation (presented in Table 1). The two first phases of the framework — the early ecological studies and the co-design phase — were initially created by summarising the steps that were employed for the design of the AR Interior

Design service. Consequently, the framework was then improved by studying the conventions of the other case studies, and by including the proof-of-concept prototyping phase in the framework. As confirmed by all the case studies, the early ecological studies, and co-creating the concept with the contribution of important participants, assisted in defining the emerging technology service concept and important criteria for the technologies. It should be noted that the framework described a somewhat all-embracing situation for delivering science fiction prototypes from research; this, however, may be considered rather a weighty process if used in full as a design strategy.

The science fiction prototyping phase adapted the science fiction prototyping method of Johnson (2011a) and extended it with other frameworks in order to support the experience design approach. The Guillard —Ramaswamy (2010) framework, which they originally introduced for the co-created experiences, served as a means for organising research findings. The first step in Johnson's method, the setting up of the world, engaged the explicit framework of Prahalad and Ramaswamy (2004) for the task. They originally introduced the framework for constructing an experience environment with the intent of offering opportunities for people to co-construct their personal experiences on demand. An important part of their framework was the new opportunities afforded by the evolution of emerging technologies, which the science fiction prototyping method also emphasised as its first step. Setting up the world also involved consideration of the aesthetic experiences, embraced as a central theme in the dissertation prototypes. The concluding four steps of the framework are the steps introduced in Johnson's science fiction prototyping method.

Underlining of the importance of the experience design investigations, and the means of engaging them for the research, was introduced in all relevant phases. If considered merely from the experience design perspective, the early ecological studies and the co-design phase focused on defining what is a good "an experience". The proof-of-concept prototyping phase aimed at further defining the broader "experience" emerging from the context of use. The science fiction prototype concentrated on building a narrative, and aimed at describing experiences through the "experience as a story" manner of approach.

9.7 THE CONTRIBUTION TO THE DESIGN FIELD

By introducing the science fiction prototyping method, accompanied by the emerging technology research, the dissertation aimed to contribute to the design field by delivering concrete examples of the research through a design approach (Zimmerman et al., 2010). The dissertation research also presented solid evidence of the two design approaches distinguished within HCI: design-oriented research and research-oriented design (Fallman, 2007). An iterative design process apparently still involves the designer in all of the three processes of analysis, synthesis, and evaluation as Fallman (2003) has elucidated. Adding iteration to conservative design methods is necessary because of the apparent problem designers face when trying to use them; that one does not really know the problem until one starts working on its solution (ibid).

Consequently, the two sets of articles demonstrated, in a concrete manner, two of the models through which art and research may interact: research interpreting art and art interpreting research (Keinonen, 2006). It should be noted, that when Keinonen considered the models of art and research interfacing and interacting within academic activity, he was not totally satisfied with the models presented. He pursued the definition of a common denominator — a "fifth element" — linking art and research in a way that meant each could

EARLY ECOLOGICAL STUDIES

- Define the emerging technology, science or issue for research — determine the specific context of use
- Study the ecologies, e.g., by the means of ethnographic research or contextual inquiry
- Identify the stakeholders; the different levels of users; their identities, characteristics and positions in the communities

- Collate information about the specific concept, e.g. by the means of design probes, by benchmarking applications or with the help of surveys and interviews

- Outline the information
  - Define more specifically the emerging technology concept
  - Define the experiences that are relevant for the context, e.g. by means of a literary review
  - Define the key stakeholders to work with in the co-design phase

CO-DESIGN PHASE

- Present the information for the co-design participants
- Definition of the emerging technology concept
- Predefined information; scenarios and visualisations
- Early results of the benchmarked applications, surveys or interviews
- Co-evaluate their relevance for the participants

- Co-design conceptual models of the service, e.g. by means of sketching, creating paper prototypes and mock-ups, or walking interviews in location

- Consider the service with a focus on experiences
  - Present the investigations relating to experiences
  - Co-evaluate their relevance
  - Co-evaluate the conceptual models according to design criteria that are based on the relevance

be interpreted without reference to the other. For the model representation, Keinonen considered there might be a third field (Fx), which overlaps with both Field of Art (Fa) and Field of Research (Fr). He characterised the field Fx as including values that are common for both art and research — such as creativity, experience and novelty. He considered design as providing possibilities for such a field, “a transmitting space between different fields”, and drew a reference on this to Herbert Simon (1969), who proposed the idea of “the science of design” that could enable communication across the arts, sciences and technology. Keinonen nevertheless stressed that design itself is much too ambiguous as a term, and fragmented as a field, to provide the conclusive answer to the characteristics of the fifth element.

Within this dissertation, the field Fx was understood as the focused research context: the emerging technology concept — the Internet of Things (novelty); the phenomena — the do-it-yourself culture (creativity); and the focus of research — the experience design (experience). The dissertation specified the “fifth element” in this context to be science fiction prototyping; more explicitly representing the design outcomes of the experience design research.

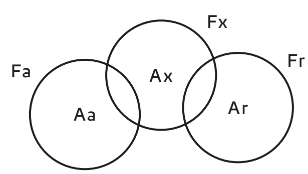

Figure 31.
Overlapping fields of Field of Art (Fa), Field of Research (Fr) and the field Fx. Redrawn form Keinonen (2006), adapted with permission.

PROOF-OF-CONCEPT PROTOTYPING PHASE

- Analyse the material: redefine what makes a good experience

- Translate the elicited experiences into the desired media
- Build the prototypes
- Evaluate the prototypes according to the redefined experience design criteria
- Define new emerging experiences in the context of use, described as “the flight of stairs”, i.e. “the constant stream happening in the consciousness”

SCIENCE FICTION PROTOTYPING PHASE

- Consider the elements that constitute the aesthetic accountability of the prototype

- Organise the research findings and define key actors
  - Use the new emerging experiences as foundational themes for the science fiction prototype
  - Re-identify the key stakeholders affected by the process with a focus on their experiences; define the protagonist and immediate characters
  - Map out the interactions among stakeholders, e.g. with the help of the co-designed conceptual models

- Set up the world; build an experience environment for implementing the ideas
  - Explore the new opportunities afforded by the emerging technologies
  - Offer opportunities for the protagonist to co-construct subjective experiences on demand, in a specific context of space and time
  - Add personal meaning — knowledge, insights, enjoyment, satisfaction and excitement — that the protagonist derives from the event
  - Engage the protagonist emotionally and intellectually, e.g. by the involvement of immediate characters and communities
  - Consider the aesthetic experiences, e.g. by drawing inspiration from literature and science fiction films, by engaging findings from other research, or by imbuing the prototype with philosophical underpinnings

- Use these ingredients to create the science fiction prototype according to Johnson’s method
  - Introduce the scientific inflection point
  - Explore the implications and ramifications of the science for the world
  - Introduce the human inflection point with the technology, e.g. by modifications, fixing of the problem, or introducing new areas for experimentation
  - Explore the implications, solution or lessons learnt with a reflection

The science fiction prototyping method was used for capturing the essence of design, as Simon has defined it: “*Design is devising courses of action aimed at changing current situations into preferred ones*”. The dissertation prototypes were constructed around the extensive amount of knowledge from the contemporary research, which may be considered as the *current situation*. Presenting the science fiction prototypes as design outcomes aimed at exhibiting how the current situations were turned into preferred situations. The science fiction prototypes can thus be considered as the resulting artefacts that Zimmerman et al. (2010) proposed to seek using the research through design approach. In addition, this dissertation firmly correlates with the observation made by Kuutti (2009) according to which design should be called, instead of an ”applied science”, as “involved science”. He has justified the shift on the insight that the more appropriate perception of design should be based on the fact that new knowledge is established within the design activity. Conclusively, the created artefacts of the dissertation may have the qualities as a proposition for a preferred state, or as a placeholder that opens a new space for design, allowing other designers to make artefacts that then better define the relevant phenomena in the new space as stated by Zimmerman et al. (2010) (p. 311). This conclusion is accompanied by a reference to Dewey (1934), who stated that a “drama or novel is *not* the final sentence — even if the characters are disposed of as living happily ever after”.

10 Discussion

10.1 VALIDITY AND GENERALISATION

Gibbons et al. (1994) remarked decisively that although the production of knowledge must be constantly controlled and systemised, the experimental approach more familiar to design processes should not prevent it from being equally recognised as science. Dourish (2006) concurred by considering that the validity and generalisation of research should be associated with the characteristics of the discipline. This dissertation has provided a contribution to human-computer interaction that studies emerging technology research using the research through design (RtD) approach, which Zimmerman et al. (2010) proposed as a lens for observing the design processes. They emphasised the informality of the approach; the process should be considered foremost as an inquiry practice that revolves around the making of a product, service, environment, or system. They also emphasised that the knowledge gained may often be quite implicit, residing almost entirely within the resulting artefact, and went on to state that the research community has yet to develop criteria for specifying suitable approaches for evaluating the quality of contributions.

Moreover, the novelty of the disciplines marks the validation and generalisation of the design research. This dissertation introduced research that has been conducted in an emergent technological domain, the Internet of Things, with diverse disciplines influencing the research. Dourish (2006) stated that as new intellectual disciplines begin to develop, new genre conventions also emerge that shape both research designs and research outputs. Especially in interdisciplinary areas, he continues, the early work in the field tends to be highly divergent in method and approach, as practitioners — individuals, and collectively as a field — attempt to find ways of combining perspectives, conceptual frameworks, and methods. The finding of an appropriate balance between theory and practice, determining of broadly agreed-upon metrics for success, and developing of common vocabularies for the problems and phenomena of study are therefore all means by which, over time, common consensus about research will be developed (ibid.). In the Internet of Things ecological research context, the complexity, dynamic nature, and different layers of the design have resulted in a situation in which it is quite impossible to apply verified, purely scientific methods to research. This notion has been recognised in the EASE approach, in which the objective for validation has been stated to be reliant on the developing of research and design means and methods in a way that connects theory with practice (Kaasinen and Norros, 2007). According to this approach, it must be acknowledged in the verification process e.g. how relevant was the knowledge for the stakeholders; yet, however, it might equally be acknowledged that there are no simple, unambiguous criteria for the verification. Similarly, the experience design has recognised the challenges related to the validating and generalising of the results (Kuutti, 2010).

When considering the first, design-oriented research part of the dissertation, it was acknowledged that the new knowledge produced in the design-oriented HCI research was based on the local understanding of particular studies that describes the particular context of use, but cannot be applied uncritically to other cases. According to Dourish (2006), this has often been the case in HCI research: challenges are resolved on a bespoke, case-by-case basis, in which the development teams are small and homogenous enough to convey the necessary ideas and design implications by themselves. Koskinen et al. (2011) add that in field studies researchers often produce “local” understanding that describes the context, but which cannot be applied to other, even similar, cases, and the results may also be considered something temporary rather than long-standing. All these limitations applied to the design-oriented research in the presented case studies of this dissertation: here research focused on demonstrating specific immediate design and remote design ecology samples by employing case-specific, design-oriented methods in the research. Nevertheless, the “case-specificness” of an ecological study may also be considered more a strength than a weakness. As demonstrated in the case studies, the genuinely co-constructed ecology was achievable through various methods, ranging from more traditional user-centred approaches to more active user participation. The experimentally driven, participative research methods, particularly appropriate for the Internet of Things research context, were validated by using suitable methods for analysing the results as presented in Table 1. It is nevertheless acknowledged that a longitudinal study might have better verified how the technologies would have been adapted and used, and particularly, how they would have evolved within the DIY ecologies; even further, it would have revealed the evolution and co-evolution of technologies as new individuals and groups begin to adapt them. In this, however, it is important to acknowledge the limitations of the research: the design-oriented research studies were mainly aimed at constructing technological proof-of concepts and prototypes.

Apparently there is much to do when it comes to the validation of the science fiction prototypes. Nevertheless, there has already been various efforts that have considered the validation, mostly by employing of the workshop -type of approach. Birtchnell and Urry (2013), for example, presented several stories in a workshop, in which case the prototypes were used as a basis for data collection, designed to identify future social and commercial variables. They placed four different stories by their position on two axes of uncertainty: people's engagement with the emerging technology, 3D-printing, and the degree of its corporatisation. The first axis measured the affordability of the technology, the capacity for users to learn and master everyday functions, and for people to develop social practices around the technology as it become customary. The second axis concerned the degree to which large corporations dominate the development of -printing or whether groups and individuals within civil society are more prominent. Kultys (2011) also organised feedback sessions for his prototypes, in which he presented four (written) stories, narrative objects and sort films that communicated the content of the prototypes. In the gallery, at in the Shoreditch Town Hall gallery, in London, there was a possibility to share beliefs and expectations by responding to the stories in writing and drawing. Based on the material, Kultys further improved the prototypes. Perhaps the most notable and creative attempt to evaluate a science fiction prototype has been presented by Egerton et al. (2011). They introduced an open-source virtual world as an extension to Johnson's prototypes — a place called iWorld in which it was possible to explore the concept of free-will in artificial intelligence. Egerton et al. established the server architecture; execution engine and controller repository in order to allow people to speculate the system communication between the main actors of the prototype, Simon and Jimmy. The evaluation of the controller design was based on blind review process that allocated the technical merit score of the contributions.

Regarding validation of the science fiction prototypes as the design outcome of research, the dissertation leans on other arguments presented by Erickson (1995), Bell et al. (2013) and Dewey (1934). Erickson (1995) made the criticism that in fact virtually any kind of information has some uncertainty embedded in it; it is likely that most of the design-oriented research findings will only be true of certain individuals, in certain situations, under certain circumstances — as was well demonstrated in the design-oriented part of the dissertation — regardless of abundant efforts towards predictability and the rigour exercised in controlling the research setup. Erickson claimed that presenting such information as "design principles" or "findings" will often elicit arguments about validity and generality from a sceptical party. Additionally, Bell et al. (2013) highlighted the remarks from Van Vught (1987), who criticised the popularity of inductive approaches, where generalisations from past experience are applied to the future by assuming that the future will be similar to the past. Van Vught also found a problem in this inductive approach, which in the in the field of evolutionary psychology cannot logically justify the difficulties of the "problem of tomorrow". Consequently, the science fiction prototypes of this dissertation lean on the applicable validity claim of Erickson (1995), who emphasised that stories and storytelling have appropriate informality that is well-suited to the lack of certainty characterising much of the design-related knowledge. He explained that the impact of stories seems to sidetrack the debates about methodology, because people inherently understand that stories are inaccurate and likely to bend the truth for rhetorical ends, so that discussion tends to be of the social, moral and ethical issues raised by the stories rather than their obvious shortcomings. Erickson added that stories also provide concrete examples to which people from vastly different backgrounds may relate, and thereby stories that accrete around a design project provide a common ground, a body of knowledge, which can be questioned and supplemented. Dewey (1934) emphasised the importance of pursuing a genuine participation, what could be called, in the context of this dissertation, the co-created experience between the author of the short story and the person who reads it. Bell et al. (2013) described this as the creative connectivity between the reader and the text. This implies that the meaning — in this case, of the visionary prototypes — is not inherent within the text itself, but is crafted in part by the reader (ibid.). Dewey has found it important in this process that the experience is constructed, not only by collective information concerning the conditions under which it was produced (p. 348), but that there should also be an attempt to make it part of (readers') attitudes. His view is that *"We install ourselves in the modes of apprehending nature that at first is strange to us. …we undertake the integration, and, by bringing it to pass, our own experience is reoriented"*. By highlighting the persuasive attitude, Dewey expects the barriers to be dissolved, and limiting prejudices to melt away. He expects the insensible melting to be far more efficacious than the change effected by reasoning, because it enters directly into the attitude. Furthermore, he considers the ultimate consequence to be that an expansion of experience absorbing the values into itself because of life-attitudes — other than those resulting from our own human environment — may dissolve the effect of discontinuity (p. 350), which may indeed be considered as the most problematic obstruction of the contemporary experience design.

With regard to validating the future-oriented science fiction prototypes as artefacts in the field of design, Fallman (2007) emphasised that the culture of design, in general, has mainly been based on intuition, taste, and personal experience. He considered this to be quite the opposite to what would be expected from such research cultures where, ideally at least, decisions cannot come out of the researcher's own judgement, intuition and taste. Koskinen et al. (2011) showed that the conceited justification for relying on the designers' insight in artefact creation may simply lie in the fact that "they are trained in the arts of capturing fleeting moments and structures that others may find ephemeral, imaginative, and unstable for research". Moreover, designers are also acknowledged to be competent in reframing ideas rather than solving known problems (ibid.). Consequently, it may be summed up that in this dissertation the design outcomes of research, the science fiction prototypes, were profoundly inspired by theory, but have gone far beyond it: they may well be seen as embodiments of the third wave of HCI aimed at capturing the essence of culture, emotion and experiences, and they have also put effort into the aesthetics by employing the various aspects of design. If the science fiction prototypes are considered as part of the art-focused breakdown that Bødker (2006) suggested introducing to the third wave of HCI, the act of generalisation also needs to be entirely re-interpreted. That would nevertheless take more effort than has been achievable within the limitations of one dissertation.

10.2 JUSTIFICATION FOR THE DO-IT-YOURSELF INTERNET OF THINGS TECHNOLOGIES

Roelands et al. (2011) stated that the main challenge in making a technology-driven DIY society possible — by enabling the masses to become creative, and orienting user creation in the Internet of Things context — is to make people capable of creating meaningful objects in the context of today's object complexity. In this dissertation, and in many previous studies, such as those by Humble et al. (2003), Dey et al. (2004) and Chin et al. (2006, 2009), emphasis was on the attempts to facilitate users with advanced, do-it-yourself technologies. Bell and Dourish (2007) proposed earlier that ubiquitous research should pay considerably more attention to technology as a site of social and cultural production; that is, as an aspect of how the social and cultural work are performed, rather than as something which will inevitably transform social practice. This dissertation has revealed how, on a minor scale, the technologies have been introduced to the local sites and ecologies in which people have adapted and transformed the technologies into social practices. Generally, the configuration, connecting and modifying activities were found to have a significant role in people's relation to more user-controllable, technology-driven DIY in the Internet of Things research context.

With regard to the do-it-yourself culture itself, Leadbeater and Miller (2004) reasoned that the major influence on its expansion is on the demographic and underlying social factors that are currently continuously changing. They listed a set of reasons why the research should focus more on the active DIY communities: the extending life span of the population, growing levels of education, the spread of social mobility as people develop distinctive lifestyles, changes in occupational patterns — the need to develop a second career — and consumers spending more on leisure and services. They went even as far as to predict that professional-amateur communities will be the new R&D labs of the future digital economies. They further argued that it should be mainly the responsibility of the public service institutions to equip users with tools and education for doing things by themselves, as well as providing safe spaces and environments in which they can network and learn (ibid, p. 59). The research presented in this dissertation aimed at this conjuncture by supporting the participation of those unlikely at first to join the do-it-yourself construction processes, namely the elderly and disabled. The hope is that there will be more studies relating to the active participation of amateur communities, and the makers culture in general, with a number of different interests and approaches issued by the design and other relevant fields. At the moment, the implications for further studies based on the research seem so numerous as to be uncountable.

10.3 JUSTIFICATION FOR SCIENCE FICTION PROTOTYPING

Johnson (2009a) elucidated the idea of a prototype by saying "(any) prototype is a story or a fictional depiction of a product — prototype is not the actual thing that we want to build; it is an example, a rough approximation of the thing we hope to build one day". Shedorff (2009), in turn, stated that any design, at large, is a kind of fiction. According to him, every sketch, model, and prototype is an elaborate fiction on the road to something becoming real; but it is still fiction until it actually gets built. Buchenau and Fulton Suri (2000) emphasised the use of low-tech methods — such as science fiction prototyping may well be considered — to inform both the design process and design decisions, and have found those that engage profound value for understanding, exploring and evaluating the design. Zimmerman et al. (2007) supported the view that design artefacts are indeed the currency of communication that helps to understand the most profound and essential nature of the design.

While writing science fiction alongside carrying out the design-oriented research, it was important during the journey to consider the specific reasons for the reflecting part of the process being so important. The following contains the collection of reasons and resolutions — personal insights, combined with findings from the literature that was studied for this dissertation and the judgements that the other authors of the fictional prototypes considered — that postulate the justification for the science fiction prototyping. These are divided according to the three domain areas to which they contributed most.

As design artefacts — specifically, as the design outcomes of emerging technology research — the science fiction prototypes may:

- Illustrate what unfolds from the knowledge gained from previous research
- Provide means to build experience environments as test beds for design
- Exploit the elicited critical experiences as design drivers
- Define the early needs and beliefs that have been associated with the technology
- Answer the difficult issues relating to design
- Provide means for identifying new design opportunities

Regarding Human-Computer Interaction, the science fiction prototyping, as a method, may:

- Follow and extend successful early phase scenarios
- Focus on the experiences and contextual issues
- Provide an easy way to enter complex models
- Study the hidden expectations and values; define the social drivers for the technology
- Act as a temporarily conclusion of the research cycle
- Provide the manner to design for experiences

Regarding emerging technology research, the science fiction prototypes may:

- Introduce the new technologies: for defining — or redefining — what can be done with them
- Enhance the desirability of the technologies
- Enhance the social impact of the technologies
- Consider the issues that are not yet relevant for research; to look beyond the immediate commercialisation
- Bring to the fore the emerging — especially the "socially dangerous" [41] — issues of the technologies

Overall, the science fiction prototyping seem to be useful for:

- Estimating the evolutionary future
- Discussing about the ethics and values relating to emerging technologies
- Helping better discuss the problems of today and problems of the cultural context[42]
- Democratising the decision making
- Coping with value conflicts and resolutions
- Paying regard to the infrastructures and arrangements of the technologies
- Generating discussion; for informing — even for persuading

Furthermore, other authors of the SF prototypes have justified the prototyping activity based on their personal interests

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Mark Weiser (1995) anticipated that ubiquitous computing held qualities of something that he categorised as "socially dangerous technology", and the Internet of Things, as ubiquitous computing's most recent successor, has inherited the notorious labelling. For example, in his declaration of "The technologist's responsibilities and social change", Weiser enumerated two principles for the inventors of the technologies. The first principle was: "Build as safe as you can, and build all the safeguards to personal values you can imagine". The second principle was: "Tell the world at large that you are doing something dangerous". However, there still seem not to be enough means to "describe those specific circumstances in which the inventions might threaten free exercise of interests, nor means to design such provisions that would protect those interests", as Greenfield (2006) has urged highlighted.

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Dourish and Bell (2011), for example, saw that the immediate technological problems — problems of power management, calibration, secure data exchange, user interface design, location sensing, and so forth — are problems for today, while the problems of cultural context are ones that come into play later, once our technological infrastructure already "rolls out into the world".

and premises. Kovalchuk (2011) considered that the tampering and malicious exploiting of the electronic systems is a growing problem, which needs to be addressed when the systems are being developed. Stahl (2013) stated that the lesson to be learned for organisations is that they are well advised to proactively engage in the discussion of what their responsibilities are, how these link to existing responsibilities, how they have to develop and what their own role in shaping these factors is. McBride (2011) considered the main benefit of the method being that "a story provides an opportunity to reflect on the idea without getting bogged down in details of possible technical implementation". Consequently, an idea that is abstract, or otherwise too difficult to articulate can be exposed and reflected on by the means of the method. Jiang (2011) perceived that ultimately, the format of the science fiction provided an opportunity to endow significance and liberation of the 'private', the 'personal', the 'subjective', and the 'emotional', to be both a challenge and supplement to the 'public', the 'political', the 'objective', and the 'factual' account that traditional social study approaches claim to achieve.

The science fiction prototypes of this dissertation were essentially reflections of what emerging technologies have to offer. Their strength lay in the way they were presented: introduced as the design outcomes of research, as interpretations of the results that were a phase in the process and aimed at disclosing the underlying ecology structures. The strength of the science fiction prototypes in the field of experience design lay in their ability to illustrate the nominated experiences by convincing and captivating means, as a continuum of the protagonists' life experiences. Moreover, the fictional prototypes were used for considering emerging technologies and their implications within a broader web of relationships; the relationships that come to the fore when the interaction between people and technologies are accurately described. More discreetly, the science fiction prototypes of this dissertation presented the "naturalisation" of the technologies in the new experience ecologies – before the technology actually exists – and illustrated how emerging technologies become taken for granted in everyday use. By this, the prototypes aimed at bypassing Coleridge's paradoxical law (Mumford, 1964), which dictates that: "The effects of the technology are only visible when it has already spread and stabilised, although the shape of the technology can only be affected before it has stabilised". Hyysalo (2010) remarked that the "impact" of technology, however, begins when the imagination and aspiration begin to be shaped by it, which is often before any "working" technology exists. Dewey (1934) emphasised that overall we have to see science as things will be when the experimental attitude is thoroughly naturalised, in order to judge justly. He stated that factual science collects statistics and makes charts, but actually its predictions are but past history reversed (p. 359). According to Dewey, change in the climate of the imagination is the precursor of the changes that affect more than the details of life.

10.4 IMPLICATIONS FOR FURTHER STUDIES

The dissertation demonstrated several unoccupied territories, which also propose further study focus for design research. The findings in the first part of the dissertation, regarding the new experiences of the emergent technologies, were found to be related to the physical and digital realms of the ecologies, the piecemeal construction of DIY IoT and the need to define a conclusive experience when considering the technological ecology layer. The most intriguing thing about all the discovered new experiences was that while they demonstrated and crystallised particular challenges that were elicited from the research, at the same time each one of them proposed new design avenues for the emerging technologies. As an example, the first new experience was related to the physical and digital co-existence of the "things" in the environment, which serve as a demonstration of the depth and width of these new potential design avenues. The physical and digital co-existence of "things" in the environment may be seen as one of the most apparent design concerns in the context of the Internet of Things research. In essence, the concern lies in the dualism between the physical and virtual realms. If the virtual is interpreted to be part of the social and psychological part of the dualism[43], or roughly interpreted as the outsourced mind, the roots for the philosophical considerations can be found from as far back as the metaphysics originated by Plato, and in more formal considerations by Descartes and Locke. Marvin Minsky (1961), who considered the dualism more in the field of artificial intelligence, has stated in relation to the problem formulation that "Our own self-models have a substantially dual character; there is a part concerned with the physical or mechanical environment – and there is a part concerned with social and psychological matters". He continued: "It is precisely because we have not yet developed a satisfactory mechanical theory of mental activity that we have to keep these areas apart." Minsky added the remark that we could not give up this division even if we wanted to – until we find a unified model to replace it. For the knowledge gained from carrying out the dissertation research, it may be confirmed that this duality still exists today and, in fact, is more saturated than ever. What is important for the design research, for example in these considerations relating to duality, is that the designer must understand and analyse the initial conditions for the design – for example, the structure of the ecosystem – and specify the possibilities and limitations – for example, by weighing the aspects of the physical and virtual scales – before beginning the concrete design phase. The designer may then decide, for example, that suitable approaches from the experience design may be employed for studying the duality of the self-models, even much more profoundly than has been demonstrated by this dissertation. In conclusion, the opportunities for design will become endless when all the new experiences of the emergent technologies – the findings in the first part of the dissertation, with all their opportunities for conventions, operations and interactions within different ecologies – are considered as design challenges.

When considering the manner in which to carry out research in the emerging technology context, and especially in considering the complexity of the multidisciplinary approach, Buxton (1988) stated that there has always been "a kind of love/hate relationship between the arts and science and technology for centuries". To Schön (1983), the gap lay between science and practice, more specifically in the fact that basic and applied sciences are "convergent", whereas practice is "divergent". Buxton believed that there is, however, a very important socio-political benefit that accrues from the collaboration of the two perspectives – the artistic practices and more technology-deterministic science – and considered that both parties have important roles to play in breaking down these barriers. The science fiction prototyping was introduced here as a potential tool for filling the gap between artistic approaches and science, but there are yet many unoccupied territories to be explored by this means in order "to boldly go where no man has gone before". Undeniably, the unoccupied territories will unfold as the technology advances.

Nevertheless, Callaghan et al. (2009) cautioned that as technology advances, and opens up new and exciting possibilities, it simultaneously raises new ethical problems that can be related, for example, to the potential that the technologies will be misused, or used against the individual and society. It cannot be stressed enough that these issues are extremely important for all those

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The dualism that essentially contains the concept of mind and body.

pursuing the future Internet of Things that, among other concerns, entails the ever more widespread deployment of intelligent agents. Cook and Das (2007) remind us that we are currently irreversibly moving towards more autonomous and self-adaptable technologies, mainly because future users will not be using the devices in a way that demands vast amounts of training and specialisation. Callaghan et al. (2009) believe that the future development might be completely polarised between self-adaptive and context-sensitive systems, and open do-it-yourself systems with complete or partial user control. This dissertation contributed to the debate by encouraging people to take more control over their technology-augmented ecologies, and aimed firmly at highlighting the emotional aspects through a profound study of the experiences that have formed around emerging technologies, and subsequently creating science fiction prototypes to explain the results to a wider audience. As demonstrated by the dissertation, emerging technology research contains a considerable number of non-technological issues that are very difficult to embody in the high fidelity prototypes. The dissertation nevertheless only scratches the surface of the many gaps in the field, although the hope is that it provides inspiration for more comprehensive studies, preferably attempting to position the research within the intriguing dualistic corrugation provided by practical artistic and emphatic approaches and more technology-deterministic science.

11 Conclusions

GODET AND ROUBELAT (1996) announce: *"All who claim to foretell or forecast the future are inevitably liars, for the future is not written anywhere – it is still to be built"*. They continue, *"This is fortunate, for without this uncertainty human activity would lose its degree of freedom and its meaning – the hope of a desired future. If the future were totally foreseeable and certain, the present would become unliveable. Certainty is death. Because the future has to be built, it also cannot be conceived as a simple continuation of the past."* Furthermore, Dewey (1934) describes the difficulty of reflecting future with regard to the present: *"The attainment of perspective with reference to the future is a most difficult task. We are given to taking features that are most prominent and most troublesome at a given time as if they were the clues to the* *future*". He goes on to clarify: "*Future consists of possibilities that are felt as a possession of what is now and here. We envisage with pleasure Nirvana and a uniform heavenly bliss only because they are projected upon the background of our present world of stress and conflict*". Dourish and Bell (2014) point to this same conjuncture, and as a consequence find scholarly analysis of any science fiction visions of the future interesting, particularly in the way they reveal things about the present. They consider that the account of "how we shall live" is inherently grounded in the assumptions about the problems and opportunities of the time at which it is written. The dissertation promotes the idea that future-oriented work, such as the design through research for the Internet of Things, should engage a twofold approach in order to reflect the contemporary research pursuing a desired future. Thus an account forecasting the future with the "how we shall live" attitude can be considered applicable for the reflecting conversation between the design-oriented research and the research-oriented design demonstrated within this dissertation.

Regarding the present, if the assumptions about the problems and opportunities of the new technologies are contemplated through the lens of the here and now, it is evident that the process towards the emerging technology domain of the Internet of Things has already begun[44]. The most recent technological vision has taken its conquering steps by infiltrating our lives through the rapid adoption of powerful mobile and tablet devices. The processing, identity, connectivity and sensing capabilities in those devices are similarly available in an increasing number of other computerised devices. The development of the artificial intelligence – presenting itself, for example, through the emergence of real-time context-aware information as databases that can ground present context upon past experiences – has allowed new interactions with computerised systems. The pace of change has been accelerating because of the many technical, social and economic forces driving Internet of Things research globally, and the many powerful companies and institutions investing in research in expectation of new market possibilities opening up for those at the forefront. This has nevertheless already been envisaged, for example by such influential prophets as Mark Weiser, according to whom the evolution in computerised environments progresses in waves, from personal to distributed computing. The dissertation highlights people's roles in the opportunity that ultimately presents itself as a change in perception towards the real, material and physical environment. The ecological research approach demonstrates how people accept, relate and experience emerging technologies in the context of prototype use. However, the evolving changes consequent upon the increasing future use of new smart devices, interaction opportunities and the advances in artificial intelligence cannot even be imagined today. This is a worthy reason for placing the technologies under construction in near future settings, "to explore their implications and ramifications" as Johnson (2011a) suggests, by seeing how the technology will be experienced in imaginary everyday settings.

As difficult as it is to anticipate how the emerging intelligent ecologies will evolve in time, the opportunity is such that it cannot be ignored. French philosopher Gaston Berger (1964) emphasises the importance of the future-oriented attitude. He uses the word "la prospective" to describe this attitude: "*...to look far away... to look breadthwise, to take care of interactions, to look in depth, to find the factors and trends that are really important, to take risks, because far horizons can make us to change our long-term plans, to take care of mankind, because "la prospective" is only interested in human consequences*" (in Godet and Roubelat, 1996). In pursuing Berger's "la prospective" the dissertation contains three parts: the introduction, the contribution of the design-oriented research, and the consequent research-oriented design artefacts.

The rather lengthy introduction makes three contributions. The first obvious contribution is to shed light upon and clarify the terminology of emerging technology research and how Internet of Things research positions itself in relation to its predecessors and the most influential of previous research agendas. A second contribution is to introduce the emerging technology research for the design discipline as an important field for investigation. The aim is founded upon conversations within the postgraduate research seminars at the design department, in which the discussions most often turned to the prospects of studying the new technologies using "designerly" means and methods. The third contribution is a concrete demonstration, by means of the practice-oriented review within the chapter "Human-computer interaction and design", of how over a decade HCI has placed people in the centre of emerging technology development. As a more discreet contribution, the introduction demonstrates how emerging technology research — usually gathered under the roof of computer science — traditionally positions itself somewhat differently to other academic fields. As Bell and Dourish (2006) elucidate, the difference between emerging technology research and most academic disciplines is that whereas the latter are determined in building upon and elaborating a body of past results, the former encompasses a wide range of disparate technological areas brought together through focusing upon a common vision of the future.

The part of Berger's (1964) "la prospective" in which he proposes to "*take care of interactions, to look in depth, to find the factors and trends that are really important*" is demonstrated in the grounding work of the dissertation. The first design-oriented research part of the dissertation looks in depth at the research that studies technology-mediated, do-it-yourself experiences for the Internet of Things. The contribution of the first part is the design-oriented approach for human-computer interaction research, especially the user experience design and the application of co-design approaches in end-user involvement and in the creation of new service ecosystems. The case studies apply the ecological approach to smart environments (EASE) as the contextual research framework, for the approach had suggested that the digital ecologies would have an important role in emerging technology research. In the case studies, the human ecologies are considered as a critical part of more complex technical ecologies. In the do-it-yourself ecologies, the main emphasis is not on the technical developments *per se*, but on empowering people to create the configurations they needed, with the technical support they appreciated. The main contribution is in demonstrating how the actual design processes — exploiting the immediate and remote design of the EASE approach — are carried out in a concrete manner. The design strategy has been to explore the suitable design-oriented methods for studying the technology-mediated ecologies. The dissertation focuses on the user research and co-design of the proof-of-concept prototypes in four specific ecologies, with the focus on the experiences. The critical DIY experiences are at first studied by eliciting them from appropriate DIY literature and then confirming the findings by user studies. The critical experiences focus on the creating, configuring and sharing activities in the ecologies, and new experiences that emerge when the proof-of-concept prototypes are introduced to the ecologies.

The part in Berger's definition of "la prospective" in which he proposes to "*look far away... and take risks*" is highlighted in the consequent design artefacts, the science fiction prototypes. The second research-oriented design part of the dissertation sheds light on possible futures in which the Internet of Things technologies are introduced to fictional experience ecologies. The science fiction prototypes pay regard to the suggestion by Abowd et al. (2002) in which they propose to pay attention to the foremost motivation of Weiser's vision

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— "And here it is!" as H.G. Wells (1899) phrased it.

– the impact that new technologies could have on the human experience. The major contribution of the second part is in introducing the radical, reflecting design outcomes of research in order to illustrate the anticipated experiences towards the new technologies. The contribution demonstrates how the grounding research is employed for science fiction prototype creation. The emphasis is on findings that help to place the technology in the future experience environments and described the long-term use of the technologies. The quest was pursued by firmly concentrating on the important and meaningful experiences and to highlight the role of positive experiences. The dissertation concludes with a framework that describes the comprehensive design strategy for constructing science fiction prototypes as experience design outcome of ecological emerging technology research. In conclusion, the design through research, i.e. both parts of the dissertation, takes a stance on "la prospective" that Berger concludes to be *"only interested in human consequences"*.

As a final word, it may be significant to point out that the relentlessly evolving waves of emerging technology research – and the fact that it is usually carried out behind the closed doors of universities, technological institutions and company R&D departments – might mean that its development and advances are not at all visible to people outside the laboratories. An important theme in this dissertation is introduction of the new technology domain to a wider audience by the reflective means of the science fiction prototypes. However, emerging technologies generally have more profound implications at the broader societal level, and this should be considered as the most important objective when anticipating the future. Callaghan et al. (2009) raise the issue that whilst government legislation and self-regulating computers, for example, might go part of the way towards providing security and assurance for an individual, the ultimate assurance for any person relies upon their understanding of the technology – and especially the inherent threats – and this necessitates the provision of means that allow people to understand, use and trust emerging technologies in order to secure themselves. Accordingly, the main conceptual contribution of this dissertation is to encourage people to take control over their technology-mediated things, environments and networks, and to be inspired by the future-oriented designs. In the end, as H.G. Wells (1945) – "the father of science fiction" – cynically declares: "There is no way out, or round, or through". The matter is simply how we understand and relate to the new turn of events. Conversely, Dewey (1934) takes a more positive stance by poetically "accepting life and experience in all its uncertainty, mystery, doubt, and half-knowledge" and by continuing that "Imagination and art turning that experience upon itself to deepen and intensify its own qualities" (p. 35). In concurring with Dewey's philosophy, the dissertation endorses his view of a "future not ominous but a promise; that surrounds the present as a halo".

References
& appendices

Ark, W. S., & Selker, T. 1999, "A look at human interaction with pervasive computers", IBM Systems Journal, vol. 38, no. 4, pp. 504-507.

Aarts, E. & Marzano, S. (eds.), 2003. The New Everyday – Views on Ambient Intelligence, 010 Publishers, Rotterdam, The Netherlands, pp. 12-17.

Abowd, G.D., Abowd, G.D., Mynatt, E.D., Mynatt, E.D., Rodden, T. & Rodden, T. 2002, "The human experience [of ubiquitous computing]", IEEE Pervasive Computing, vol. 1, no. 1, pp. 48-57.

Abowd, G. & Mynatt, E. 2000, "Charting past, present, and future research in ubiquitous computing", ACM Transactions on Computer-Human Interaction (TOCHI), vol. 7, no. 1, pp. 29-58.

Addlesee, M. D., Jones, A., Livesey, F. & Samaria, F. 1997, "The ORL active floor", IEEE Personal Communications, vol. 4, pp. 35-41.

Ailisto, H., Pohjanheimo, L., Välkkynen, P., Strömmer, E., Tuomisto, T. & Korhonen, I. 2006, "Bridging the physical and virtual worlds by local connectivity-based physical selection", Personal and Ubiquitous Computing, vol. 10, no. 6, pp. 333-344.

Ailisto, H., Lindholm, M., Mäntyjärvi, J., Vildjiounaite, E. & Mäkelä, S. 2005, "Identifying people from gait pattern with accelerometers", Defense and Security, International Society for Optics and Photonics, pp. 7-14.

Ashton, K. 2009, "That 'internet of things' thing", RFiD Journal, vol. 22, pp. 97-114.

Asimov. I. 1981, "Asimov on Science Fiction", New York, Avion, in p. 79.

Augusto, J.C. & Nugent, C.D. 2006, "Smart Homes Can Be Smarter" in Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 1-15.

Augusto, J.C. 2007, "Ambient Intelligence: The Confluence of Ubiquitous/Pervasive Computing and Artificial Intelligence" in Springer, London, pp. 213-234.

Atzori, L., Iera, A. & Morabito, G. 2010, "The Internet of Things: A survey", Computer Networks, vol. 54, no. 15, pp. 2787-2805.

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S. & MacIntyre, B. 2001, "Recent advances in augmented reality", IEEE Computer Society, Los Alamitos.

Bachelard, G. 1964, "Poetics of space", Orion press, New York. (In French: La Poétique de l'Espace, 1958, Presses Universitaires de France.)

Bakardjieva, M. & Smith, R. 2001, "The internet in everyday life: Computer networking from the standpoint of the domestic user", New Media and Society, vol. 3, no. 1, pp. 67-83.

Bakardjieva, M. 2005, "Internet society: the Internet in everyday life", SAGE, London.

Ballagas, R., Ringel, M., Stone, M. & Borchers, J. 2003, "iStuff: A physical user interface toolkit for ubiquitous computing environments", Proceedings of CHI, ACM, pp. 537-544.

Bannon, L. 1986, "From human factors to human actors: the role of psychology and human-computer interaction studies in system design", in Greenbaum, J. and Kyng, M. (eds.) Design at Work: Cooperative Design of Computer Systems, Lawrence Erlbaum Associates, New Jersey, USA, pp. 25-44.

Bate, P. & Robert, G. 2006, "Experience-based design: from redesigning the system around the patient to co-designing services with the patient", Quality & safety in health care, vol. 15, no. 5, pp. 307-310.

Battarbee, K. 2004. "Co-experience: understanding user experiences in social interaction", Academic Dissertation, Publication series of the University of Art and Design, Helsinki.

Baum, F. L. 2000, "The Wonderful Wizard of Oz", Harpers Collins Publishers, New York.

Beckmann, C., Consolvo, S. & LaMarca, A. 2004, "Some assembly required: Supporting end-user sensor installation in domestic ubiquitous computing environments", Lecture Notes in Computer Science, vol. 3205, pp. 107-124.

Bell, F., Fletcher, G., Greenhill, A., Griffiths, M. & McLean, R. 2013, "Science fiction prototypes: Visionary technology narratives between futures", Futures, vol. 50, pp. 5-14.

Bell, G. & Dourish, P. 2007, "Yesterday's tomorrows: notes on ubiquitous computing's dominant vision", Personal and Ubiquitous Computing, vol. 11, no. 2, pp. 133-143.

Bentham, J. 1798, "Proposal for a new and less expensive mode of employing and reforming convicts", quoted e.g. in Semple, J. 1993. "Bentham's prison: a study of the panopticon penitentiary", Oxford, Clarendon Press.

Berger G. 1964. "Phénoménologie du temps et prospective" (in English: Experience and Transcendence), Paris, P.U.F.

Bergman, A., Karlsson, J.C. & Axelsson, J. 2010, "Truth claims and explanatory claims — An ontological typology of futures studies", Futures, vol. 42, no. 8, pp. 857-865.

Biggs M. 2002, "The role of the artefact in art and design research", International journal of design sciences and technology, vol. 10(2), pp. 19-24.

Binder, T., Ehn, P., De Michelis, G., Jacucci, G., Linde, G., and Wagner, I. 2011, "Design things", Cambridge, MA: MIT Press.

Birtchnell, T. & Urry, J. 2013, "3D, SF and the future", Futures, vol. 50, pp. 25-34.

Bleecker, J. 2009, "Design Fiction: A short essay on design, science, fact and fiction", Near Future Laboratory.

Bohn, J., Coroamă, V., Langheinrich, M., Mattern, F. & Rohs, M. 2005, "Social, Economic, and Ethical Implications of Ambient Intelligence and Ubiquitous Computing" in Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 5-29.

Bobick, A.F., Intille, S.S., Davis, J.W., Baird, F., Pinhanez, C.S., Campbell, L.W., Ivanov, Y.A., Schütte, A. & Wilson, A. 1999, "The KidsRoom: A Perceptually-Based Interactive and Immersive Story Environment", Presence, vol. 8, no. 4, pp. 369-393.

Bonino, D. & Corno, F. 2011, “What would you ask to your home if it were intelligent? Exploring user expectations about next-generation homes”, Journal of Ambient Intelligence and Smart Environments, vol. 3, no. 2, pp. 111-126.
Bosco, H., 1956. “Monsieur Carre-Benoît in the Country”, Staples Press Ltd. (In French: Monsieur Carre-Benoît à la campagne, 1947.)
Bostanci, E., & Clark, A. F. 2011, “Living the Past in the Future”, Workshop Proceedings of the 7th International Conference on Intelligent Environments, Ios Press, pp. 167-172.
Brumitt, B., Meyers, B., Krumm, J., Kern, A. & Shafer, S. 2000, “EasyLiving: Technologies for intelligent environments”, Springer-Verlag Berlin, Berlin, pp. 12-29.
Buchenau, M. & Fulton Suri, J. 2000, “Experience prototyping”, Proceedings of DIS, ACM, pp. 424-433.
Buxton, W. 1988, The Role of the Artist in the Laboratory (English translation), in Schopf, C. (Ed.) Meisterwerke der Computer Kunst, Bremen: TMS Verlag, pp. 29-32.
Buxton, B. 2007, “Sketching user experiences: getting the design right and the right design”, Morgan Kaufmann, San Francisco, CA.
Bødker, S., 2006, “When second wave HCI meets third wave challenges”, Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles, ACM.
Callaghan, V., Clarke, G., Colley, M., Hagras, H., Chin, J.S.Y. & Doctor, F. 2004, “Inhabited Intelligent Environments”, BT Technology Journal, vol. 22, no. 3, pp. 233-247.
Callaghan, V, Chin, J.S.Y., Zamudio, V., Clarke, G., Shahi, A. and Gardner, M., 2006, “Domestic Pervasive Information Systems: End-user Programming of Digital Homes”, Chapter 7 on Kourouthanassis, P.E. & Giaglis, G.M. 2007, Pervasive Information Systems, M.E. Sharpe, Inc., ME Sharp Inc., New York.
Callaghan, V., Clarke, G. & Chin, J. 2009, “Some socio-technical aspects of intelligent buildings and pervasive computing research”, Intelligent Buildings International, vol. 1, no. 1, pp. 56-74.
Callaghan, V. 2010, “Tales From a Pod”, Workshop Proceedings of the 6th International Conference on Intelligent Environments, IOS Press, pp. 223-232.
Callaghan, V. 2013, “The Maker Fables”, Workshop Proceedings of the 9th International Conference on Intelligent Environments, IOS Press, pp. 306-313.
Carroll, J.M. 2000, “Making use: scenario-based design of human-computer interactions”, MIT Press, Cambridge, Mass.
Chin, J. S. Y., & Callaghan, V. 2003, “Embedded-Internet devices: a means of realizing the pervasive computing vision”, in IADIS International Conference, Algarve, Portugal, pp. 5-8.
Chin, J.S.Y., Callaghan, V., Clarke G, Hagras H. & Colley, M., 2004, “Pervasive Computing and Urban Development: Issues for the Individual and Society”, UN Second World Urban International Conference on “The Role of Cities in an Information Age”, September 13-17, Barcelona, Spain.
Chin, J., Callaghan, V. & Clarke, G. 2006, “An End User Tool for Customising Personal Spaces in Ubiquitous Computing Environments”, in Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 1080-1089.
Chin, J., Callaghan, V. & Clarke, G. 2009, “Soft-appliances: A vision for user created networked appliances in digital homes”, Journal of Ambient Intelligence and Smart Environments, IOS Press, Netherlands, vol. 1, no. 1, pp. 69-75.
Clarke, A. C. 1945, “Extra-Terrestrial Relays — Can Rocket Stations Give Worldwide Radio Coverage?” Wireless World, October 1945, pp. 305-308.
Clarke, G., Callaghan, V. & Pounds-Cornish, A. 2000, “Intelligent Habitats and The Future: The Interaction of People, Agents and Environmental Artefacts”, 4S/EASST Conference on Technoscience, Citizenship and Culture in the 21st Century, Vienna, pp 26-28.
Clarke, G. & Lear, M. 2010, “We all wear dark glasses now”, Workshop Proceedings of the 6th International Conference on Intelligent Environments, IOS Press, pp. 242-250.
Coase, R. 1937, The Nature of the Firm, Economica, vol. 4 (16), pp. 386—405.

Coen, M.H. 1998, “Design principles for intelligent environments”, Proceedings of the National Conference on Artificial Intelligence, John Wiley & Sons Ltd. pp. 547-554.
Coen, M. 1999, “The future of human-computer interaction, or how I learned to stop worrying and love my intelligent room”, IEEE intelligent systems & their applications, vol. 14, no. 2, pp. 8-10.
Cohen, P.R. & Oviatt, S.L. 1995, “The Role of Voice Input for Human-Machine Communication”, Proceedings of the National Academy of Sciences of the United States of America, vol. 92, no. 22, pp. 9921-9927.
Cook, D. & Das, S. 2004, “Smart Environments: Technology, Protocols and Applications”, Wiley-Interscience, Hoboken.
Cook, D. J. & Das, S. 2007, “How smart are our environments? An updated look at the state of the art”, Pervasive and mobile computing, vol. 3.2, pp. 53-73.
Cook, D., Augusto, J. & Jakkula, V. 2009, “Ambient intelligence: Technologies, applications, and opportunities”, Pervasive and mobile computing, vol. 5, no. 4, pp. 277-298.
Cooperstock, J.R., Fels, S.S., Buxton, W. & Smith, K.C. 1997, “Reactive environments: throwing away your keyboard and mouse”, Commmunications of the ACM.
Cross, N. 2006, “Designerly Ways of Knowing”, Springer Verlag, London.
De Roeck, D., Slegers, K., Criel, J., Godon, M., Claeys, L., Kilpi, K. & Jacobs, A. 2012, “I would DiYSE for it! A manifesto for do-it-yourself internet-of-things creation” in NordiCHI ‘12, ACM Press, pp. 170-179.
Desmet, P. & Hekkert, P. 2007, “Framework of Product Experience”, international journal of design, vol. 1, no. 1, pp. 57-66.
Dewey, J. 1934, “Art as Experience”, New York, Perigee Books.

Dey, A.K., Hamid, R., Beckmann, C., Li, I. & Hsu, D. 2004, "a CAPpella:programming by demonstration of context-aware applications", Proceedings of the SIGCHI conference on Human factors in computing systems, ACM, pp. 33-40.
Do, J-H., Jung, S., Jang, S., Yang, H., Jung, J-W. & Bien, Z., 2006, "Gesture-based interface for home appliance control in smart home", in Smart Homes and Beyond – Proceedings of the 4th International Conference On Smart homes and health Telematics, vol. 19 of Assistive Technology Research Series, IOS Press.
Doctor, F., Hagras, H. & Callaghan, V. 2005, "A fuzzy embedded agent-based approach for realizing ambient intelligence in intelligent inhabited environments", IEEE Transactions on Systems, Man, and Cybernetics – Part A: Systems and Humans, vol. 35, no. 1, pp. 55-65.
Dourish, P. 2001a, "Where the action is: the foundations of embodied interaction", A Bradford Book, London, GB.
Dourish, P. 2001b, "Seeking a foundation for context-aware computing", Human-Computer Interaction, vol. 16, pp. 229-241.
Dourish, P. 2006, "Implications for design", Proceedings of ACM Conference on Human Factors in Computing Systems, pp. 541-550.
Dourish, P. & Bell, G. 2011, "Divining a Digital Future: Mess and Mythology in Ubiquitous Computing", MIT Press.
Dourish, P. & Bell, G. 2014, ""Resistance is futile": reading science fiction alongside ubiquitous computing", Personal and Ubiquitous Computing, vol. 18, no. 4, pp. 769-778.
Ducatel, K., Bogdanowicz, M., Scapolo, F., Leijten, J. & Burgelman, J-C. 2001, "Scenarios for Ambient Intelligent in 2010", EU Information Systems Technology Advisory Group (ISTAG), IPTS- Seville, February 2001.
Edwards, W. K. & Grinter R. E. 2001, "At Home with Ubiquitous Computing: Seven Challenges", Ubicomp 2001: Ubiquitous Computing, Lecture Notes in Computer Science, vol. 2201, Springer-Verlag, Berlin, 256-272.
Egerton, S., Callaghan, V. & Clarke, G. 2008, "Using multiple personas in service robots to improve exploration strategies when mapping new environments", IET Conference Publications.
Egerton, S., Davies, M., Johnson, B. D. & Callaghan, V. 2011, "Jimmy: Searching for Free-Will (A Competition)", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 128-141.
Erickson, T. 1995, "Notes on Design Practice: Stories and Prototypes as Catalysts for Communication", in Scenario-Based Design: Envisioning Work and Technology in System Development (ed. J. Carroll), New York, Wiley, pp. 37-58.
Evangelista, B. 2004, "Trek Tech: 40 years since the Enterprise's inception, some of its science fiction gadgets are part of everyday life", San Francisco Chronicle, San Francisco.
Fallman, D. 2003, "Design-Oriented Human-Computer Interaction", Proceedings of CHI 2003, ACM Press, pp. 225-232.
Fallman, D. 2007, "Why Research-Oriented Design Isn't Design-Oriented Research: On the Tensions Between Design and Research in an Implicit Design Discipline", Knowledge, Technology & Policy, vol. 20, no. 3, pp. 193-200.
Fischer, G., Giaccardi, E., Ye, Y., Sutcliffe, A. & Mehandjiev, N. 2004, "Meta-design: a manifesto for end-user development", Communications of the ACM, vol. 47, no. 9, pp. 33-37.
Flanagan, M., 2009, "Critical play: radical game design", MIT press.
Forlizzi, J. and Battarbee, K., 2005, "Understanding experience in interactive systems", Proceedings of designing interactive systems DIS 2005, ACM, pp. 261-268.
Forlizzi, J. & Ford, S. 2000, "Building blocks of experience: An early framework for interaction designers", Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques, ACM, pp. 419–423.
Gauntlett, D. 2011, "Making is connecting: The Social Meaning of Creativity, from DIY and Knitting to YouTube and Web 2.0", Polity Press.
Gaver, W.W. 1991, "Technology affordances", Proceedings of the SIGCHI conference on Human factors in computing systems, ACM, pp. 79-84.
Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. 1994, "The new production of knowledge: The dynamics of science and research in contemporary societies", Sage.
Gibson, J. J. 1977, "The concept of affordances", Perceiving, acting, and knowing, pp. 67-82.
Gibson, J. J. 1986, "The ecological approach to visual perception", Routledge.
Graham, G. 2011, "Interaction Space", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 145-154.
Graham, G. 2013, "Exploring imaginative futures writing through the fictional prototype 'crime-sourcing'", Futures, vol. 50, pp. 94-100.
Graham, G., Greenhill, A. & Callaghan, V. 2013, "Exploring business visions using creative fictional prototypes", Futures, vol. 50, pp. 11-14.
Greenbaum, J. & Kyng, M. (eds.) 1991, "Design at Work: Cooperative Design of Computer Systems", Lawrence Erlbaum Associates, New Jersey, USA.
Greenfield, A. 2006, "Everyware – The Dawning Age of Ubiquitous Computing", New Riders.
Grian, H. 2011, "The Lonely Companion", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 197.
Godet, M. & Roubelat, F. 1996, "Creating the future: The use and misuse of scenarios", Long range planning, vol. 29, no. 2, pp. 164-171.

Gubbi, J., Buyya, R., Marusic, S. & Palaniswami, M. 2013, "Internet of Things (IoT): A vision, architectural elements, and future directions", Future generation computer systems-the international journal of grid computing and science, vol. 29, no. 7, pp. 1645-1660.
Gouillart, F. & Ramaswamy, V. 2010, "Building the co-creative enterprise", Harvard Business School Publishing Corporation.
Hagras, H., Callaghan, V., Colley, M., Clarke, G., Pounds-Cornish, A. & Duman, H. 2004, "Creating an ambient-intelligence environment using embedded agents", IEEE Intelligent Systems, vol. 19, no. 6, pp. 12-20.
Hakkarainen, L., & Hyysalo, S. 2013, "How Do We Keep the Living Laboratory Alive? Learning and Conflicts in Living Lab Collaboration", Technology Innovation Management Review, Living Labs and Crowdsourcing.
Hales, D. 2011, "The Decadence of Mimetic Science: Against Nature 2.0" Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 312-321.
Harrison, S. & Dourish, P. 1996, "Re-place-ing space: The roles of place and space in collaborative systems", Proceedings of the 1996 ACM conference on Computer supported cooperative work, ACM, pp. 67-76.
Harrison, S., Tatar, D., & Sengers, P. 2007, "The three paradigms of HCI", Session at the SIGCHI Conference on Human Factors in Computing Systems San Jose, California, USA, pp. 1-18.
Hassenzahl, M. & Tractinsky, N. 2006, "User experience-A research agenda", Behaviour & Information Technology, vol. 25, no. 2, pp. 91-97.
Hassenzahl, M. 2010, "Experience design: technology for all the right reasons", Morgan & Claypool, San Rafael, California.
Hassenzahl, M., Diefenbach, S. & Göritz, A. 2010, "Needs, affect, and interactive products – Facets of user experience", Interacting with Computers, vol. 22, no. 5, pp. 353-362.
Heinonen, S. & Hiltunen, E. 2012, "Creative Foresight Space and the Futures Window: Using visual weak signals to enhance anticipation and innovation", Futures, vol. 44, no. 3, pp. 248-256.
Hollan, J., Hutchins, E. & Kirsh, D. 2000, "Distributed cognition: toward a new foundation for human-computer interaction research", ACM Transactions on Computer-Human Interaction (TOCHI), vol. 7, no. 2, pp. 174-196.
Hutchins, E. 1995, "Cognition in the Wild", Cambridge, MA, MIT press.
Humble, J., Crabtree, A., Hemmings, T., Åkesson, K-P, Koleva, B., Rodden, T. & Hansson, P. 2003. "'Playing with your bits': user-composition of ubiquitous domestic environments", Proceedings of the 5th International Conference on Ubiquitous Computing, Seattle, Springer, pp. 256–263.
Husserl, E. 1970, "The crisis of European sciences and transcendental phenomenology: An introduction to phenomenological philosophy", Northwestern University Press.
Hyysalo, S. 2010, "Health technology development and use: from practice-bound imagination to evolving impacts", Routledge, New York.
Hyysalo, S., Juntunen, J. K. & Freeman, S. 2013, "Internet forums and the rise of the inventive energy user", Science and Technology Studies, vol. 26, no. 1, pp. 25-51.
Iacucci, G. & Kuutti, K. 2002, "Everyday Life as a Stage in Creating and Performing Scenarios for Wireless Devices", Personal and Ubiquitous Computing, vol. 6, no. 4, pp. 299-306.
Ihde, D. 1990, "Technology and the lifeworld: From garden to earth" Bloomington, Indiana University Press.
Ikonen, V. & Kaasinen, E. 2008, "Ethical Assessment in the Design of Ambient Assisted Living", in A. I. Karshmer, J. Nehmer, H. Raffler, G. Tröster (eds.) Internat, Begegnungs-und Forschungszentrum für Informatik.
International Telecommunications Union, 2005, "The Internet of Things", 7th edition, ITU Publications, Geneva.
Jiang, X. 2011, "Happy Eggs", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 243-254.

Johnson. B. D. 2009a, "Science Fiction Prototypes. Or: How I Learned to Stop Worrying about the Future and Love Science Fiction", in Intelligent Environments, p. 3-8.
Johnson, B. D. 2009b, "Nebulous Mechanisms", Proceedings of the 5th International Conference on Intelligent Environments, Barcelona, IOS Press, pp. 9-18.
Johnson, B. D. 2011a. "Science Fiction Prototyping: Designing the Future with Science Fiction", Synthesis Lectures on Computer Science, Morgan & Claypool Publishers.
Johnson, B. D. 2011b, "Love and God and Robots: The Science Behind the Science Fiction Prototype" Machinery of LoveGrace", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 99-127.
Johnson, B.D. 2013, "Engineering Uncertainty: The role of uncertainty in the design of complex technological and business systems", Futures, vol. 50, pp. 56-65.
Kaasinen, E., and Norros. L. (Eds.), 2007, "Älykkäiden ympäristöjen suunnittelu. Kohti ekologista systeemiajattelua", Helsinki, Teknologiainfo Teknova Oy. (In English: Ecological approach to the design of intelligent environments).
Kawsar, F., Nakajima, T. & Fujinami, K. 2008, "Deploy spontaneously: Supporting end-users in building and enhancing a smart home", Proceedings of the 6th International Conference on Ubiquitous Computing, New York, NY, ACM, Vol. 344, pp. 282-291.
Keinonen, T. 2006, "Fields and acts of Art and Research", in The Art Of Research, Research Practices in Art and Design, Jyväskylä, Gummerus, pp. 40-60.
Keinonen, T. 2007, "Immediate, product and remote design", International Association of Societies of Design and Research, Hong Kong.

Keinonen, T. 2009, "Immediate and Remote Design of Complex Environments", Design Issues, vol. 25, no. 2, pp. 62-74.
Kettunen, I. 2013, "Mielekkyyden muotoilu – autoetnografia tuotekehityksen alkuvaiheista", Acta universitatis lapponiensis, Lapin yliopistokustannus.
Kera, D., & Tuters, M. 2011, "Social Stomach: Performative Food Prototypes", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 279-289.
Kidd, C., Orr, R., Abowd, G., Atkeson, C., Essa, I., MacIntyre, B., Mynatt, E., Starner, T. & Newstetter, W. 1999, "The Aware Home: A living laboratory for ubiquitous computing research", Springer-Verlag Berlin, Berlin, pp. 191-198.
Koontz D. 1981, "How to Write Best Selling Fiction", Writer's Digest Books.
Koskinen, I., Zimmerman, J., Binder, T., Redstrom, J. & Wensveen, S. 2011, "Design Research Through Practice", Morgan Kaufmann.
Kovalchuk, Y. 2011, "The Ministry of Interfaces (Doors)", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 173-184.
Kovalchuk, Y., Johnson, B.d., Ng, J.w.p., López-Cózar, R., Egerton, S., Callaghan, V., Augusto, J.C., Aghajan, H., Cook, D.j., Gardner, M. & Mikulecký, P. 2011, Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, NL.
Kultys, M. 2011, "The End of Hearing", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 219-230.
Kuniavsky, M. 2010, "Smart things: ubiquitous computing user experience design", Morgan Kaufmann Publishers Inc.
Kuutti, K. 2009, "Artifacts, activities, and design knowledge", in Poggenpohl S. & Sato K. (eds.) Design integrations, Research and collaboration, Bristol, pp. 67-85.
Kuutti, K. 2010, "Where are the ionians of User Experience research?" Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries, ACM, pp. 715-718.
Kuznetsov, S. & Paulos, E. 2010, "Rise of the expert amateur: DIY projects, communities, and cultures" Proceedings of the NordiCHI 2010, ACM Press, pp. 295-304.
Langer, E. J. 2009, "Counterclockwise: Mindful health and the power of possibility", Ballantine Books, New York.
Lanier, J., 2013, "Who Owns the Future?" Simon and Schuster.
Laurel, B. 1993, "Computers as theatre", Addison-Wesley, New York.
Leadbeater, C. & Miller P. 2004, "The Pro-Am Revolution. How enthusiasts are changing our economy and society", Demos, London.
Lee, J. & Hashimoto, H. 2002, "Intelligent Space concept and contents", Advanced Robotics, vol. 16, no. 3, pp. 265-265.
Leonard, D. 1999, "Wellsprings of Knowledge: building and sustaining the sources of innovation", Harvard Business School Press, Boston.
Loke, K. S., & Egerton, S. 2010, "Automated Eye on Nature (AEON) and the Were-Tigers of Belum", Workshop Proceedings of the 6th International Conference on Intelligent Environments, IOS Press, pp. 261-270.
Love, R. 2001, "Robot futures: science fiction and futures studies methodologies in action", Futures, vol. 33, no. 10, pp. 883-889.
Luhtala, M., Turunen, M., Niemeläinen, I., Tuomisto J. & Plomp, J. 2012, "Studying Aesthetics of Interaction in a Musical Interface Design Process Through 'Aesthetic Experience Prism'", in Proceedings of the International Conference on New Interfaces for Musical Expression, University of Michigan, Ann Arbor.
Lundequist, J. & Ullmark, P. 1993, "Conceptual, constituent and consolidatory phases – New concepts for the design of industrial buildings", Appropriate Architecture, Workplace Design in Post-Industrial Society, Industrial Planning and Architecture, Chalmers University of Technology, Gothenburg, and Industrial Planning, The Royal Institute of Technology, Stockholm.
Löwgren, J. 1995, "Applying design methodology to software development", Proceedings of the 1st conference on Designing interactive systems: processes, practices, methods, & techniques, ACM, pp. 87-95.
Mannermaa, M. 1991, "In search of an evolutionary paradigm for futures research", Futures, vol. 23, no. 4, pp. 349-372.
Mattelmäki T. & Sleeswijk Visser, 2011, "Lost in co-x: Interpretations of co-design and co-creation", Proceedings of IASDR2011, the 4th World Conference on Design Research, vol. 31.
Mattila, J. & Väätänen, A. 2006, "UbiPlay: an interactive playground and visual programming tools for children", IDC '06, ACM Press, pp. 129—136.
McBride, N. 2011, "Meltdown", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 209-218.
McCullagh, P. J. 2010, "Voices from the Interface", Workshop Proceedings of the 6th International Conference on Intelligent Environments, IOS Press, pp. 251-260.
McCullagh, P. J. 2011, "Internet of 'mysterious' things", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press.
McCullagh, P. 2013, "Superhighway patrolman", Futures, vol. 50, pp. 101-108.
McKay, G. 1998, "DiY Culture: notes towards an intro", in G. McKay (ed.) DiY Culture, party & protest in nineties Britain, Verso, London, UK.
Mendonça, S., Pina e Cunha, M., Kaivo-oja, J. & Ruff, F. 2004, "Wild cards, weak signals and organisational improvisation", Futures, vol. 36, no. 2, pp. 201-218.
Milgram, P., Takemura, H., Utsumi, A. & Kishino, F. 1995, "Augmented reality: a class of displays on the reality-virtuality continuum", in Proceedings of the SPIE Conference on Telemanipulator and Telepresence Technologies, 282-292.

Miles, I. 1993, "Stranger than fiction. How important is science fiction for futures studies?" Futures, vol. 25, pp. 315–321.
Miller, T. & Zeleznik, R. 1999, "The design of 3D haptic widgets", In proceedings of the 1999 symposium on Interactive 3D graphics, ACM, pp. 97-102.
Minker, W., López-Cózar, R. & McTear, M. 2009, "The role of spoken language dialogue interaction in intelligent environments", Journal of Ambient Intelligence and Smart Environments, vol. 1, no. 1, pp. 31-36.
Minsky, M. 1961, "Steps toward Artificial Intelligence", Proceedings of the IRE, vol. 49, no. 1, pp. 8-30.
Miorandi, D., Sicari, S., De Pellegrini, F. & Chlamtac, I. 2012, "Internet of things: Vision, applications and research challenges", Ad Hoc Networks, vol. 10, no. 7, pp. 1497-1516.
Moore, G.E. 1998, "Cramming More Components Onto Integrated Circuits", Proceedings of the IEEE, vol. 84, no. 1, pp. 82-85. Reprinted from Gordon E. Moore, "Cramming More Components onto Integrated Circuits," Electronics, pp. 114–117, April 19, 1965.
Mumford, L., 1964, "Authoritarian and democratic technics", Technology and Culture, vol. 5, no.1.
Nakashima, H., Aghajan, A. & Augusto, J.C. (eds.) 2010, "Handbook on Ambient Intelligence and Smart Environments", Springer Verlag.
Nardi, B. and O'Day, V., 1999, "Information Ecologies: Using Technology with Heart. Cambridge", MIT Press.
Newman, M.W., Sedivy, J.Z., Neuwirth, C.M., Edwards, W.K., Hong, J.I., Izadi, S., Marcelo, K., Smith, T.F., Sedivy, J. & Newman, M. 2002, "Designing for serendipity: supporting end-user configuration of ubiquitous computing environments", Proceedings of the 4th conference on Designing interactive systems, ACM Press, pp. 147-156.
Nelder, G. 2013, "Auditory Crescendo", Futures, vol. 50, pp. 86-93.
Peldszus, R. 2011, "Surprise Payload Rack: A User Scenario of a Conceptual Novelty Intervention System for Isolated Crews on Extended Space Exploration Missions", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 290-300.
Penley, C., 1997, "NASA/Trek: popular science and sex in America", Verso.
Pine, B.J.I. & Gilmore, J.H. 1999, "The experience economy: work is theatre & every business a stage", Harvard Business School Press, Boston, MA.
Plomp, J. & Tealdi, P. 2004, "Ambient intelligent technologies for wellbeing at home", Proceedings of the 2nd European Union symposium on Ambient intelligence, ACM, pp. 81-82.
Plomp, J., Heinilä, J., Kaasinen, E. & Välkkynen, P. 2009, "Sharing Content and Experiences in Smart Environments", Handbook of Ambient Intelligence and Smart Environments, Springer US, pp. 511-533.
Prahalad, C. K. & Ramaswamy, V. 2004, "The future of competition: co-creating unique value with customers", Harvard Business School Press, Boston (Mass.).
Rittel, H. W. J., and Webber, M. M. 1974, "Wicked problems", Man-made Futures, pp. 272-280.
Rodden, T., Crabtree, A., Hemmings, T., Koleva, B., Humble, J., Åkesson, K. & Hansson, P. 2004, "Between the dazzle of a new building and its eventual corpse: Assembling the ubiquitous home", Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques, ACM, pp. 71-80.
Roelands, M., Claeys, L., Godon, M., Geerts, M., Feki, M.A. & Trappeniers, L. 2011, "Enabling the Masses to Become Creative in Smart Spaces: Orienting User Creation in the Internet of Things in the Context of the ITEA2 DiYSE Project", Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 37-64.
Rogers, Y. 2006, "Moving on from Weiser's vision of calm computing: Engaging UbiComp experiences", UbiComp 2006: Ubiquitous Computing, Springer Berlin Heidelberg, pp. 404-421.
Rukzio, E., Leichtenstern, K., Callaghan, V., Holleis, P., Schmidt, A. & Chin, J. 2006, "An experimental comparison of physical mobile interaction techniques: Touching, pointing and scanning", UbiComp 2006: Ubiquitous Computing, Springer Berlin Heidelberg, pp. 87-104.
Rushkoff, D. 2010, "Program or be Programmed: Ten Commands for a Digital Age", O/R Books.
Russell, S. J. & Norvig, P. 2002, "Artificial intelligence: a modern approach", Second edition, Pearson, Boston.
Sacks, O. W. 1985, "The man who mistook his wife for a hat, and other clinical tales", Summit Books.
Saha, D. & Mukherjee, A. 2003, "Pervasive computing: a paradigm for the 21st century", Computer, vol. 36, no. 3, pp. 25-31.
Sainov V. & Stoykova, E. 2012, "Display Holography—Status and Future", Optical Imaging and Metrology: Advanced Technologies, Wiley-VCH Verlag, Weinheim, Germany.
Salomon, G. (Ed.) 1993, "Distributed cognitions: Psychological and educational considerations", Cambridge University Press, vol. 11, no. 9.
Scholz, M., Ding, Y., Jakimovski, P. & Schmidtke, H. R. 2011, "Half a Century of Renovating", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press, pp. 301-311.
Schrank, R. 1990, "Tell me a story", Charles Scribner & Sons, New York.
Schuler, D. & Namioka, A. (eds.) 1993, "Participatory Design: principles and practices", Hillsdale, NJ: Lawrence Erlbaum Associates.
Schön, D. 1983, "The Reflective Practitioner. How Professionals Think in Action", Basic Books, New York.

Schwarz, J.O. & Liebl, F. 2013, "Cultural products and their implications for business models: Why science fiction needs socio-cultural fiction", Futures, vol. 50, pp. 66-73.
Sengers, P., Boehner, K., David, S. & Kaye, J.J. 2005, "Reflective design", Proceedings of the 4th decennial conference on Critical computing: between sense and sensibility. ACM, pp. 49-58.
Shedroff, N. 2001, "Experience Design", New Riders Publishing, Indianapolis.
Shedroff, N. 2009, "Design is the problem: the future of design must be sustainable", Rosenfeld Media.
Shedroff, N. & Noessel, C. 2012, "Make it So: Interaction Design Lessons from Science Fiction", O'Reilly Media, Inc.
Siltanen S., 2012, "Theory and applications of marker-based augmented reality", VTT Science 3, Espoo, Finland.
Simon, H.A. 1996, "The sciences of the artificial", MIT Press, Cambridge, MA.
Sohn, T. & Dey, A. 2003, "iCAP:an informal tool for interactive prototyping of context-aware applications", Proceedings of ACM Conference on Human Factors in Computing Systems (CHI 2003); ACM Press, pp. 974- 975.
Stahl, B.C. 2013, "Virtual suicide and other ethical issues of emerging information technologies", Futures, vol. 50, pp. 35-43.
Steele, 1992, "Hard again", New York Review of Science Fiction.
Stewart, J. 2007, "Local experts in the domestication of information and communication technologies", Information Communication and Society, vol. 10, no. 4, pp. 547-569.
Sundstrom, E., Bell, P. A., Busby, P. L., & Asmus, C. (eds.) 1996, "Environmental Psychology 1989-1994", Annual review of psychology, vol. 47(1), pp. 485-512.
Taleb, N. 2007, "The black swan: the impact of the highly improbable", Random House, New York, NY.
Tassini, K. 2011, "The Magician's Assistant", Workshop Proceedings of the 7th International Conference on Intelligent Environments, Ios Press, pp. 267-278.
Tennenhouse, D., 2000, "Proactive computing", Communications of the ACM, vol. 43, pp. 43-50.
Thackara, J. 2005, "In the Bubble – Design in Complex World", MIT Press, Cambridge MA.
Thacker, E. 2001, "The science fiction of technoscience: The politics of simulation and a challenge for new media art", Leonardo, vol. 34, no. 2, pp. 155-158
Toma, I., Simperl, E., Filipowska, A., Hench, G. & Domingue, J. 2009, "Semantics-Driven Interoperability on the Future Internet", Semantic Computing, ICSC '09, IEEE International Conference, pp. 551-558.
"The tomorrow project" – Uber Morgen, 2010, Open access electronic article, retrieved 21:07, May 31, 2014 from: http://www.intel.com/content/dam/www/public/us/en/documents/technology-briefs/intel-labs-tomorrow-project-complete-brief.pdf
The tomorrow project anthology – Cautions, dreams & curiosities, 2013, Open access electronic article, retrieved 11:18, June 5, 2014 from: http://isef.tomorrow-projects.com/2013/10/cautions-dreams-curiosities-anthology/
Tuan, Y-F. 1974, "Topophilia: A Study of Environmental Perception, Attitudes, and Values", Englewood Cliffs, NJ: Prentice-Hall.
Turvey, M.T. & Carello, C. 1985, "The equation of information and meaning from the perspectives of situation semantics and Gibson's Ecological Realism", Linguistics and Philosophy, vol. 8, no. 1, pp. 81-90.
van Vught, F.A. 1987, "Pitfalls of forecasting. Fundamental problems for the methodology of forecasting from the philosophy of science", Futures, vol. 19, no. 2, pp. 184-196.
Vicente, K.J. 1999, "Cognitive work analysis: toward safe, productive, and healthy computer-based work", Lawrence Erlbaum Associates, Mahwah, NJ.
Weber, R.H. 2010, "Internet of Things – New security and privacy challenges", Computer Law and Security Review: The International Journal of Technology and Practice, vol. 26, no. 1, pp. 23-30.
Weiser, M. 1991, "The Computer for the Twenty-First Century", Scientific American, 265 (3), pp. 94–104.
Weiser, M. 1993, "Ubiquitous Computing", IEEE Computer "Hot Topics", October 1993.
Weiser, M.1995, "The Technologist's Responsibilities and Social Change", Computer-Mediated Communication Magazine, V2N4. April 1, 1995.
Weiser, M. & Brown, J. S., 1996, "The Coming Age of Calm Technology", Beyond calculation, Springer New York, pp. 75-85.
Wells, H.G., 1899, "When The Sleeper Wakes", Harper & Brothers, London.
Wells, H. G., 1945, "The Mind at the End of its Tether", William Heinemann Ltd, London.
Winner, L., 1986, "Do Artefacts Have Politics?" The Whale and the Reactor, Chicago: University of Chicago Press.
Wolf, T.V., Rode, J.A., Sussman, J. & Kellogg, W.A. 2006, "Dispelling 'design' as the black art of CHI", Proceedings of the SIGCHI conference on Human Factors in computing systems, ACM , pp. 521.
Wright, P. & McCarthy, J.J. 2007, "Technology as Experience", The MIT Press, Cambridge.
Wright, P., Wallace, J. & McCarthy, J. 2008, "Aesthetics and experience-centered design", ACM Transactions on Computer-Human Interaction (TOCHI), vol. 15, no. 4, pp. 1-21.
Wright, P. & McCarthy, J. 2010, "Experience-centered design: designers, users, and communities in dialogue", Morgan & Claypool Publishers, San Rafael, Calif.
WU, H. Y. & Callaghan, V. 2011, "The spiritual machine", Workshop Proceedings of the 7th International Conference on Intelligent Environments, IOS Press pp. 155-166.
Wu, H.Y. 2013, "Imagination workshops: An empirical exploration of SFP for technology-based business innovation", Futures, vol. 50, pp. 44-55.

Wulf, V., Paterno, F. & Lieberman, H. 2006, "End User Development", Kluwer Academic Publishers, Dordrecht, Netherlands.
Zimmerman, J., Forlizzi, J. & Evenson, S. 2007, "Research through design as a method for interaction design research in HCI", Proceedings of the SIGCHI conference on Human factors in computing systems, ACM, pp. 493-502.
Zimmerman, J., Stolterman, E. & Forlizzi, J. 2010, "An analysis and critique of research through design: Towards a formalization of a research approach", Proceedings of the 8th ACM Conference on Designing Interactive Systems, ACM, pp. 310-319.

APPENDIX A
DESIGN ARTEFACTS

The Oxford dictionary[45] defines artefact as:

1. An object made by a human being, typically one of cultural or historical interest: e.g. gold and silver artefacts.
2. Something observed in a scientific investigation or experiment that is not naturally present, but occurs as a result of the preparative or investigative procedure.

Biggs (2002) considers the role of the artefact in communicating advancement, and whether artefacts have the capability to embody knowledge. He makes a comparison with archaeological and the embodiments made by artists. His conclusion is that interpretation of an artifact is a combination of intrinsic and extrinsic factors, and that in order to communicate effectively control must be exercised over the extrinsic factors by providing a context. Biggs further explain that the extrinsic factors of an artifact are commonly achieved through words; this is owing to the utility of words for explicatory purposes rather than because words have primacy over objects in art and design research. He emphasizes that it is therefore the content rather than the form of this context that is important.

Biggs has found that it is the particular combination of artefacts and words/texts that gives efficacy to the communication. Neither artefacts alone nor words/texts alone would be sufficient. What is required is the combination of artefact and a critical exegesis that describes how it advances knowledge, understanding and insight. He concludes that the essential factor is not a particular medium but a particular content, i.e. it must step outside the outcomes of the research and explicate the way in which the research embodies its contribution to the advancement of knowledge, understanding and insight.

APPENDIX B
SOME RELEVANT TECHNOLOGIES REGARDING THIS DISSERTATION

The introduction presents many of the important interaction techniques and mechanisms that have been studied intensely and extensively in HCI research. There are, of course, many other important means for the interaction. The following takes a closer look at two important interaction techniques for this dissertation which are absent from the introduction: spoken dialogue interaction technology, and augmented, virtual, and mixed reality. These are important focuses for the technology research in Articles I and III respectively. In the following these technologies are illustrated with a reference to

45 Retrieved 16:53, 21 May 2014 from: http://www.oxforddictionaries.com/definition/english/

popular science fiction films. For the other interaction techniques suitable references relating to the science fiction films may be found from the work: "Make it So: Interaction Design Lessons from Science Fiction" by Shedroff and Noessel, 2012.

SPOKEN DIALOGUE INTERACTION

Speech has been found to be a fast, efficient and natural way of mediating information between people, and thus anticipated to be an expedient technique for interacting with computers. Greenfield (2006) states that speech-based interaction should be most obviously called upon when invisible computing is constructed[46]. Coen (1998) emphasises the unimodality of the speech-based interaction mechanisms, explaining that the technique does not tie users to a display to verify or correct utterances recognised by the system, nor does it require a keyboard for selecting among possible alternative utterances. Speech-based interaction has also been found expedient because speech may be associated with specific people. Cohen and Oviatt (1994) have found that direct interaction with speech is beneficial especially in cases when the objects and affordances of the environment are visible, are confidently recognisable, and there are not too many of them available. Speech-based interaction has been found an important subject for the research carried out for this dissertation because of its appropriateness for seniors and elderly users.

Minker et al. (2009) assert that human-computer interaction is in essence a matter of interactive and incremental problem solving, with both — the user and the computer — playing active roles in the conversation. The process for designing speech-based interaction usually begins by interpreting the user's utterances within the system, and then continuing by taking into account the context of the on-going dialogue and the task-related knowledge. In the research carried out for this dissertation, speech-based interaction is used as a trigger for bringing about a given state, thus resulting in action and the consequent changing of conditions in the environment.

There are nevertheless limitations to speech-based interaction, relating to the technology, the nature of the speech, and the conventions in the communication between people. The first limitation relates to language that is used when communicating with the technology: how to remember the commands that trigger the actions. The user must also understand the possibilities and limitations of what can be achieved by the interaction: what are the affordances and how they are represented in the environment or user interface. Another limitation relates to the nature of the speech, whether it is temporal and subsequent, i.e. whether it emerges in chronological order. Chin et al. (2009) have found that simple utterances are severely limited for creating programmes that have complex sentence structures. In this case, there will be a need for interactive dialogue to seek clarifications in order to avoid misunderstandings and to provide rich feedback. Another limiting issue that has been raised is a notion of "talking to the air" that is in sharp contrast to learnt conventions in normal situations. Minker et al. (2009) see a particular need to investigate how to improve interaction by endowing the systems with more intelligence, so that people are not only able to retrieve information but to integrate information from multiple sources, and by resolving potential conflicts and problems that may occur if the context of use changes.

Science fiction films provide good reference points for how the interaction works. Spoken dialogue interaction in science fiction films has been used as far back as Metropolis (1927), in which a robot called Maria responds to spoken instructions. The most notable spoken dialogue interaction is perhaps demonstrated in Star Trek[47], in which the "Holodeck", a simulated reality facility or "recreation room", was primarily controlled by voice. Some might also

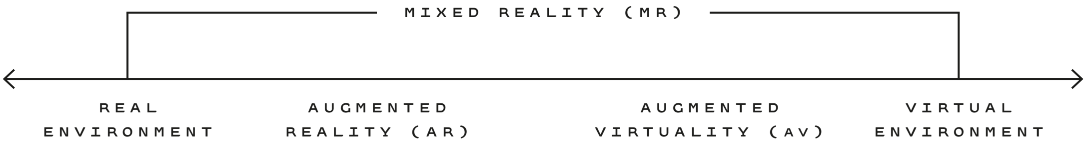

Figure 32.
Paul Milgram's "Reality-Virtuality Continuum" model.
Redrawn from Milgram et al., 1995.

remember a scene in Bladerunner (1982), where detective Decard investigates a set of photographs with the "Esper machine" and uses spoken instructions for browsing the picture. In "I, Robot" (2004), the commands for the smart devices of the home environment are given vocally; the character Dr Susan Calvin in fact becomes quite frustrated because an "antique" stereo fails to understand her spoken commands.

AUGMENTED, VIRTUAL AND MIXED REALITY

Azuma (2001) defines augmented reality as an interactive real-time system that combines real and virtual elements in 3D[48]. Augmented reality technologies are provided in a physical, real-world environment whose elements are augmented — or supplemented — by computer-generated sensory input, such as sound, video, graphics or GPS data (Siltanen, 2012). Augmentation is conventionally in real time and in semantic context with the environmental elements; the technology thus provides a practical visualisation method for purposes where there is a need to enhance the user's perception (ibid.). Augmented reality has been associated with a more general concept called mediated reality, in which a view of reality is modified — possibly even diminished rather than augmented — by a computer. As a result, the technology functions by enhancing the user's perception of the reality. In the context of the dissertation, Web-based AR applications requiring no installation or downloading were found expedient for the service. The functionalities of the system and expectations towards the technology were at the core of the investigations.

An important taxonomy model for extracting the real and virtual technologies is Paul Milgram's (1995) "Reality-Virtuality Continuum" model (see Figure 31). The model describes the main difference between the AR and VR technologies as being that whereas augmented reality (AR) augments the real environment with computer-generated elements, virtual reality (VR) consists solely of virtual elements, all objects in the environment being modelled by the computer. Mixed reality (MR) is a concept that covers all possible combinations of real and virtual elements, from total reality to total virtuality (Milgram et al., 1995).

Augmented reality has been represented successfully in science fiction films, the most distinguished example perhaps being Minority Report (2002). At the beginning of the film, there is a computerised sequence where the protagonist, Anderton, uses gestures to find information from the three-dimensional computerised space. The film later depicts personalised AR advertisements scattered all around the city. In the animation film Wall-E (2008), cleaning robots use a scanner to analyse the amount of dirt on Wall-E before chasing after him. In the same film there are also "Buy 'n' Large" displays of the people on the cruise spaceship that provide a very different world to the one that surrounds

46
Star Trek — The next generation, 1987—1994.

47
When Weiser (1993) illustrated his ubiquitous agenda he stated: "Unlike virtual reality, ubiquitous computing endeavours to integrate information displays into the everyday physical world. Ubiquitous computing considers the nuances of the real world to be wonderful, and aims to augment them." Later a variety of concepts began to flourish that divided or united these "virtual" and "real" realities.

48
Retrieved 16:53, 21 May 2014 from: http://www.oxforddictionaries.com/definition/english/

the crew. Perhaps the first notable film to introduce augmented reality to a wider audience was, however, Terminator 2 (1991), in which at the beginning of the film the terminator uses his built-in computing power to measure people for their clothes. An all-inclusive example of virtual reality is Matrix (1999), although the film describes itself as being about simulated reality. Virtual reality is demonstrated in the film by presenting virtual learning environments, used for example for virtual combat training. Otherwise the film plays cunningly with real and virtual realities in order to distort the idea of the "dream world".

APPENDIX C
PROFILING THE USER ECOLOGIES

Roelands et al. (2011) explain that "DIY communities can be understood by considering carefully the different characteristics people have in the ecologies — depending on their personal background, personal skill or experience". In DIY IoT research, Leadbeater and Miller's (2004) classification categories were adopted to categorise the users' level of expertise. The level of expertise comprised computational and technical thinking, as well as the domain expertise of the people in the nominated ecologies. However, as this seemed insufficient for addressing the full assets people had for influencing the ecologies, the characteristics were further classified according to the users' level of involvement.

LEVEL OF EXPERTISE

Novices, or non-technical users, are people lacking any background in the use of information technology (IT). From the four case studies of this dissertation, the only one that involves novice users is the Music Creation Tool. The end-user participants in the study, people with mild or moderate intellectual learning disabilities, have no computational capabilities and are highly dependent on the computational skills of the music therapist.

Amateurs have little or no experience in application creation, but possess useful domain or technical expertise. In the Home Control System case study, most of the participants — nurses — belong to this category, while also having acquired specialised technical expertise in using an intelligent technology platform (Wiktio W10). The nurses are also experts in the health care profession. The studies confirm that the nurses found themselves deeply involved in the application creation processes by adapting the system and creating templates for others. The participants in Life Story Creation, elderly writers in an activity group, possess an adequate level of computational skills and intimate knowledge relating to their special interest field, the writing of memoirs.

The professional-amateur (Pro-Am) is advanced in technical knowledge and computational thinking. Pro-Ams can be technical experts, even when lacking formal computational training. In the Home Control System study, one of the nurses is regarded as a technical Pro-Am. The nurse teaches the use of the existing technology platform for others and continues to act as an administrator for other nurses, although not appointed to the task. In Music Creation Tool evaluations, the music therapist is an expert in computational thinking, and possesses profound and intimate understanding of the expertise domain. In Life Story Creation, the teacher of the writing group is considered as the Pro-Am who seems the obvious technical person at first for creating service templates for others. In the AR Interior Design case study the interior designers and design bloggers are all Pro-Ams, with qualification in many web-based and 3D interior design tools, and most are also helping others to use the systems.

The case studies make no study of professionals with regard to computational thinking or their being technical experts, since the trained computer scientists in the research group are mostly creating the supporting platforms for the participants. It was considered, however, that once the proof-of-concepts are adapted in use, the domain owners would take the role of professionals to further develop and shape the technologies for their communities.

Overall, the professional-amateurs (Pro-Ams) are found to be the most critical participants for research through their eagerness to provide design requirements for the prototype systems. This is due to their knowing so much about the context of use, and their being so tightly tied to the ecologies. The Life Story Creation case study is the only one in which it is more convenient to study amateurs — especially because a critical objective for study concerns the sharing mechanisms within the community.

PROPERTIES OF THE INVOLVEMENT LEVEL

The other assets for creating, configuring and sharing the DIY projects are explained by the user's level of involvement. The involvement efforts are considered to be described by the number of properties: locality, warmness, willingness to create and community orientation. The qualities emphasised in each different project depend on the context. Of the involvement properties, the local experts are found to be most engaging partners to work with in research projects related to DIY IoT, as they have personal motives for developing their quality of work and working environment, as noted by Stewart (2007). Another interesting group are the warm experts, persons with some degree of emotional ties to the end users of the application they help to design or implement, as defined by Bakardjieva and Smith (2001). Willingness to create and community orientation are only considered to be important involvement efforts in the Life Story Creation study.

Local experts, in the case of the Home Control System, are expected to be more willing to carry on with the system configuration as they have the opportunity to define the configurations and re-configure the system once the emergent situations arise. The nurses are also found to be willing to motivate others — for example, relatives of a patient — by demonstrating how the configurations of the IoT systems are carried out. Although the presence of a professional-amateur, the teacher of a writing group, is important for the Life Story Creation ecology, her role is not crucial for the community. In Music Creation Tool case study, the locality of the music therapist has the upmost importance for the novice users as his constant presence is vital for supporting the community. Interior Design tasks appear to be much more location-sensitive than is the case with the other communities. This is mainly due to the interviewed designers all being part of some smaller ecology in which they share their designs, as well as their knowledge relating to computational design tasks.

Important characteristics for the warm experts seem to be that they involve their personal and professional motivations in the processes. The nurses of the Home Control System case study provide care for a nursing home, as well as for outpatients. Their personal motivation for the design and configuring of the service is high. Their professional motives relate to the increased speed, easing of everyday nursing activities and provision of monitoring and special assistance for outpatients. In the Life Story Creation case study, the teacher of a writing group is the dedicated expert of the field who attends the life story community sessions (even when on maternity leave). In Music Creation Tool evaluations, the music therapist has an extreme level of personal involvement towards the work. The therapist reveals that the professional motivations relate to providing opportunities for individual practising, even outside the music therapy situation, and playing together, even in public situations. In the AR Interior Design case study, although some of the interior designers work as teachers in various educational tasks related to interior design, the amateur design bloggers also appear to take on the role of an instructor in their personal communities.

As mentioned, the willingness to create and community orientation are considered relevant properties only in the Life Story Creation study. The writers in the project have intimate knowledge about their field of expertise, namely genealogy and writing of retrospections. Their willingness to create could, however, be regarded as one of the most important involvement properties. Also, the devotion to their community — the writing group — which has persisted and evolved over several years explains the enthusiasm towards community orientation and "doing things together".

To conclude, when designing do-it-yourself technologies, account must also be taken of the skills people possess, or lack. In these particular case studies, the computational and social capabilities exert a great influence on the success and adaptation of the systems. The skills define the properties for the technical systems: their ease of use and, in contrast, their problems and obstacles. In the Music Creation Tool, the disabilities of the novice users determine how they could participate, the kind of instruments they prefer or could use, and the kind of configurations that should be created for them. The various skills of the novice users are also considered in the Home Control System and AR Interior Design evaluations, although only at the level determined by the Pro-Ams and professionals. In Life Story Creation, considering the skills of the writers accentuates the many different types of writing persons: some are considered discursive writers, while others have a more analytical approach. These skills define the personification needs for the systems; in some prototypes it could be a different kind of encouragement, but some skills demand altogether different tools or even different interfaces for the systems.

As a result, for the design of the systems, the properties of the involvement appear to define how willing the participants are to contribute to the process, as well as defining the mundane qualities of the ecologies and revealing their discreet needs towards emerging technologies.

APPENDIX D
TECHNOLOGICAL DETERMINISM, TECHNOPHILIA AND TECHNOPHOBIA

It should be noted that emerging technology research is most often carried out in an atmosphere filled with extreme technological determinism[49]. Technological determinism may be interpreted by saying that the technology progresses according to its own laws, inherent in what sciences and technology producers manage to develop, and with no outside influence apart from curbing innovation and regulation. Bell and Dourish (2007) remark that technological determinism is already clearly evident in Weiser's early ubiquitous computing visions, in which "the technology has played a liberating role", as they prefer to depict it. Moore's law is another good example of technological determinism in action. According to the technological deterministic interpretation, the people, society and organisations must merely adapt to the fact that the number of transistors per unit area is doubling every year and the consequent small, cheap, smart and higher performance devices permeate the world. Consequently, people will simply have to adjust to this inevitable changes caused by the emerging technologies. According to Winner (1986), technological determinism includes the idea that the best technology always wins; it is solely the technology and its qualities that define what becomes successful. It is acknowledged that the research carried out for this dissertation has been conducted in this

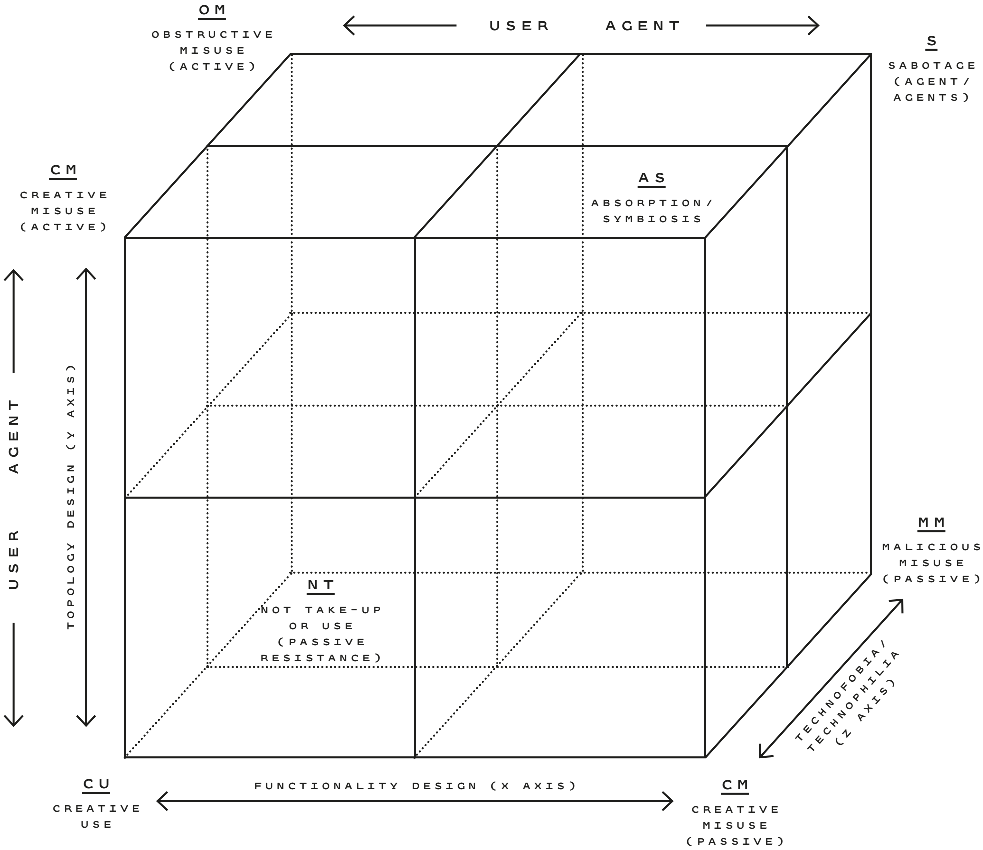

Figure 33.
The socio-technical 3C framework, redrawn from Callaghan et al. (2009), adapted with permission.

atmosphere of extreme technological determinism. The research has been highly technology-driven, which is usually the case with research conducted in R&D departments and government-controlled research centres, and even in academia. However, it should be noted that technological determinism is not the only approach to technological development.

In explaining future-oriented scenarios, Godet and Roubelat (1996) state that the futures they contain might either be shaped to be desired or, on the contrary, feared. It should be equally important to consider what perspective to choose as the approach for science fiction prototypes, especially when the prototypes concern emerging technology research that involves social implications relating to privacy, security, control, ethics and legislation. For this purpose, Chin et al. (2009) and Callaghan et al. (2009) have introduced a socio-technical framework known as the 3C framework. The idea has been to find a way of categorising the main technology and social drivers for intelligent building research (see Figure 32). The framework is aimed at motivating discussion that ranges from exclusive use of intelligent autonomous agents to user-controlled approaches. According to Chin et al., the intensive use of autonomous agents has the advantage of reducing the cognitive load on the user, whereas end-user methods empower the user, giving them a sense of control over what is recorded, when it is recorded and to whom it is communicated. The axes in the framework represent

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Technological determinism is a reductionist theory presuming that a society's technology drives the development of its social structure and cultural values. The term is believed to have been coined by Thorstein Veblen (1857–1929), an American sociologist.

the exclusive use of intelligent autonomous agents against user-controlled approaches, and the rest falls into place to represent some combination of each. The main research on intelligent agents can be categorised as belonging to two underlying approaches; implicit programming (intelligent autonomous agents) and explicit programming (end-user programming). Callaghan et al. present how these possibilities can be represented by using a 2D space bounded by the degree to which intelligent agents or people are in control of both the functionality (X-axis) and the topology (Y-axis) of these systems. When it comes to the *human responses* to these different systems, by introducing another axis (Z-axis or the technophilia/technophobia axis) they indicate the degree to which the person involved is comfortable with this technology and the part they play in it. In this, Callaghan et al. choose a relatively simple measure in which they commonly observe the behaviour of people as they approach these systems. The research work places itself at the lower part of the X-axis, emphasising creative use, but also benefiting from creative misuse (both active and passive).

Chin et al. (2009) justify the use of the 3C framework by explaining that the technology cannot be designed in isolation from social factors. They argue that user acceptance of technology, especially in personal spaces, is linked to perceptions of privacy, which in turn are linked to choices based on the technology's use of agents versus end-user programming. They also argue also that, in social and technological relationships, control and creativity are fundamental human values. The 3C model provides a convenient way of exposing the research issues associated with people living in technologically sophisticated environments. This framework may also be considered very useful when defining the social context for the science fiction prototypes, especially within the emerging technology contexts.

It should be noted that *technophilia* and *technophobia* are not the only terms used to categorise people's relation to technology. Buxton (1988) calls "those intimidated by technology" *cyberphobics* and "those who place all their faith in it" *cyberphillics*. With this division, Buxton highlights the fact that the whole of society is becoming increasingly polarised into these two groups, and anticipates it becoming a very dangerous polarisation. He suggests that this situation can be influenced, firstly through acknowledgement by those who place all their faith in technology of the legitimacy of the fears of the cyberphobic, and secondly through understanding by those intimidated by technology of the positive role that technology can play in society. The 3C framework provides an opportunity for understanding and categorising the legitimacy of fears that have been associated emerging technologies.

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CREATING SCENES FOR AN INTELLIGENT NURSING ENVIRONMENT

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CO-DESIGN AND USER EVALUATIONS OF A HOME CONTROL SYSTEM

ABSTRACT

In this paper we describe the co-design process of a proof-of-concept home control system, and how it was carried out by utilising a user-centred design methodology. The aim was to develop a demonstrator of a home control system that supports elderly people in living more independently in their homes. The focus of the research was on the configuration tool of the environment, which was meant to be exploited in a nursing home. The home control system was intended to be used and configured by non-technologically versed users: mainly the care personnel, but also the inhabitants and their close relatives. The system was co-designed and evaluated at first with nurses, who were considered to be the local experts of the chosen ecosystem. The final web-based proof-of-concept system was evaluated with nurses and end-users.

KEYWORDS

component;
Human-technology interaction (HTI),
human-centred design (HCD),
front end of innovation,
paper-prototyping,
interaction design,
user experience,
usability evaluations

I
INTRODUCTION

The DIYSE-project aimed at enabling ordinary people to easily create, setup and control applications in an Internet-of-Things environment, in this case a smart living environment, allowing them to leverage aware services and smart objects for obtaining highly personalized, social, interactive, flowing experiences at home and in the city.

This research aimed at developing a proof-of-concept creation and configuring tool for an intelligent environment, in the context of a nursing ecosystem. The development process of the home control system utilised a user-centred design methodology covering the front-end of innovation, several iterations, and the final usability evaluations. User-driven co-design and preliminary evaluations of the paper mock-up system took place in an intelligent nursing home, with a group of four nurses who were already accustomed to work in an intelligent nursing environment and use its operating system. Thus our co-design partners, the nurses, had valuable user experience, and in addition, they were considered to be the local experts of the ecosystem. During the first co-design focus group session, the nurses were presented with short scenarios and technological information related to the home control system, according to which they sketched conceptual maps of the tool. Inspired by the results, our research group created paper prototypes of the user interface, which were evaluated by the nurses in turn. After the proof of concept prototype was created, it was evaluated by usability studies. The iterative evaluation process of the system was expected to be challenging, because users were anticipated to conceptualise the system at a different level than developers. The aim was to find the most convenient solution of the home control system and its configuration user interface, which would satisfy all stakeholders.

While creating the home control system, our research group had to define some terms that described the situations and concepts that related to the configuration of an intelligent environment. We came up with the concepts of *scene*, *state* and *snapshot* — terms, which are specified further in this paper.

II
EVALUATION SET-UP

A
Evaluation Criteria and Methods

Our hypothesis was that the conceptualization of a user as an active participant in the front-end design process, instead of as a passive end-user of the final prototype [1], would contribute to the development of more effective, efficient and attractive intelligent environments [2, 3].

The initial home control system evaluations exploited user-driven innovation methods, such as focus groups and scenarios [4, 5, 6]. In a focus group interview a small group, with a similar background, discusses about topics highlighted by the interviewer [7]. The nurses in our focus group were highly experienced and familiar with a technology augmented nursing environment. Short scenarios describe selected usage situations [8] and encourage conversation. In this context, the scenarios presented novel technology provided by the project partners. After evaluating the first scenarios of the system, nurses were familiarised with layout images of existing configuring tools and applications, which they evaluated. Co-design sessions may utilise sketching as a method to involve users in the front end of complex design processes [9]. In this context, sketching enabled conversation about more complex design issues among the participants, and assisted in perceiving users' models of the overall concept [10].

Based on the results from the focus group, the development continued by creating paper mock-ups and layout images of the system's user interface [11]. The mock-ups were evaluated and re-designed with nurses by interviewing each of them individually [4]. The objective was to distinguish the acceptance factors of the tool and gain information for developing the user interface further.

The final user evaluations focused on testing the system user interface (UI) from a usability and acceptability perspective. The usability measures were effectiveness, efficiency and user satisfaction [2]. Methods to study effectiveness are based on qualitative comments by the users emerging in discussions, user interviews and ratings of statements related to the tasks to be performed [12]. Methods to study efficiency pay attention, e.g., to the time consumed in performing tasks and error rates made during the evaluation session. Also qualitative comments and answers to questionnaires were used [4]. The users were asked to rate a few statements relating to user satisfaction after they had used the system by themselves.

B
Criteria for Selecting the Co-design Evaluation Group

The most important criterion to choose the participants for the home control system co-design sessions was the domain expertise [3]: users were expected to have intimate understanding of the domain in which the home control system would be used. Such domain experts are crucial to formulate the needs the application should cater for, and to define the preferred way to interact with the application [13]. In this context, the local, warm domain experts [14] were the health care professionals nursing elderly patients in a nursing home. It was presumed that local experts would be more willing to contribute to the co-design of the home control system, as they had personal motives for developing their quality of work and working environment [14, 15, 16].

C
Evaluation Groups

The preliminary home control system was evaluated in two phases at Villa Jussoila, Rauma, Finland. The first focus group evaluation session was arranged in December 2010, and the second session in May 2011. Four nurses from the care provider entrepreneur, Dement Oy, attended in both evaluation sessions. The nurses provided care at the Villa Jussoila nursing home, as well as for outpatients. The participants were aged 28 – 42, one (1) male and three (3) females in each evaluation session. Two (2) of the participants attended in both sessions. All of the interviewees were accustomed to the Wiktio W10 home care system [17], the existing technology platform in the nursing home. In addition, all participants were regular users of information and communication technology.

The final evaluation group consisted of nine (9) persons, four (4) males and five (5) females. The participants were aged 22-56. Three (3) of the test users were caretakers of elderly or disabled people. The others had a variety of occupations, including teaching, human resource management, ICT and economics. As for ICT related technical skills, three out of nine (3/9) users described themselves as 'highly experienced', four (4/9) users were 'more than basic users' and two (2/9) were 'basic users'.

D
Concepts of State, Scene and Snapshot

While our research group was designing the home control system concepts for the evaluations and the user interface of the tool, we needed to find specific terms to illustrate the settings and situations of an intelligent environment. We tried to come up with descriptive, defining and logical concepts that represented the configuring settings. At first, we defined the term *state*, by which we mean the current status of the intelligent environment concerning an individual device, or the aggregate state of a group of devices. In the user interface level (most often), a *scene* represents the combination of a triggering event, some preconditions and the intended state. The home system aimed at easily configurable scenes, i.e., to provide an easy way to map sensor events to actuator actions. The configuration user interface provides the possibility to obtain the current state of the environment by taking a *snapshot* of it. This snapshot provides a shortcut to create a scene.

III
TECHNOLOGICAL DESCRIPTION

The home control system consisted of a platform and control user interface developed at our institute, VTT; a home gateway (There Gate) and lock control system (Key2phone) provided by our project partners, and commercial Z-Wave light switches and other components connected to the home gateway. The platform featured a Virtuoso database providing a semantic ontology-driven storage and reasoning environment for objects and data in the smart environment. A rule engine utilized the information stored in the database and defined the reactive mapping of sensor and control inputs to output actions. The rules could be edited by means of an interface designed for engineers, but unsuitable for non-technical end-users. Configuring the functionality of the home environment entailed manipulating these rules, and providing an alternative user interface for this purpose was therefore the main objective of the study. The system also included a speech recognition module providing an alternative interaction mode for controlling the environment.

The Key2phone system provided functionality to operate a lock through an adaptive UI on a mobile terminal. The UI automatically pops up, whenever the mobile terminal is in close range of the door lock. The proximity was detected by measuring the strength of the Bluetooth signal at the door lock. Pressing a button in the UI caused the door to open. The door lock sent proximity and door open events to the Key2phone manager software via the cellular network. The events stored in the manager could also be accessed via a dedicated HTTP API. The There Gate gateway connected to wireless Z-Wave sensors and actuators. It provided home control and monitoring functionality through its own UI, but could be accessed via its HTTP API as well.

The available wireless sensors and actuators in the proof of concept were electric switch devices, door/window contact sensors to detect door openings, movement sensors to detect the presence of a person, as well as temperature and hygrometers. This limited the proof-of-concept system to controlling the illumination system of the home only, by monitoring door opening events and proximity (presence) of a person in certain locations.

While the system provided basic data processing functionality, it had to be configured at installation time to properly understand the sensor readings in the location at hand. Therefore installation had to be done by technical experts, using an expert user interface tool for this purpose. Mapping the sensor inputs to (actuator) actions required configuration, which could be done by non-technical end-users utilising a graphical tool. The main objective was making this task and interface so simple that it would not require technical knowledge or programming skills [18].

A
Demo Rooms and Facilities

The home control system was intended to be used also for configuring and creating scenes in a nursing home

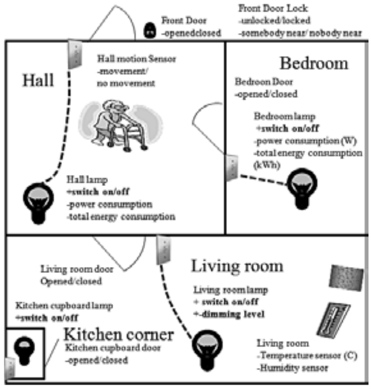


Figure 1.
The home model used in final evaluations. Actuators are marked with a (+) sign, sensors with a (-) sign. Dimmer level behaves as actuator and sensor: it can be controlled to become dimmer or brighter. The dimming level in (%) can be measured. © 2012 IEEE

environment, and therefore the usage situation was evaluated in a real patient's room in intelligent nursing home, Villa Jussoila. The patient room included some smart instrumentation attached to the Wiktio W10 system, such as floor pressure sensors to locate the person. The demo room size was approximate 47 m2, consisting of bedroom, living room and bathroom areas. There were two doors: the front door and a folding door to the bathroom and a window. The lights of the room were: 1 standard lamp, 1 table lamp and 4 ambient lights: by the door, bedroom, toilet and kitchen.

The final user evaluations were carried out in laboratory conditions, for space analysis and performance studies [19]. Conditions were adjusted to simulate a home consisting four rooms: a hall, a living room, a bedroom and a kitchen. The 'home model' of the usability laboratory is presented in Fig. 1. In the evaluations, adjusting the illumination (turning ON and OFF, dimming and brightening) were the main configurable issues. Also a motion sensor was used. The temperature and humidity sensors were not used due to their relatively slow response times.

IV
RESULTS

A
Initial Focus Group Evaluations

1: Scenario evaluation

In the initial evaluation session, the focus group with nurses first evaluated four scenarios, which were based on the technical descriptions of the available technology and on the use cases of the home control system. The scenarios illustrated hypothetical usage situations, which the participants evaluated according to their experience. The presented scenarios were related to lock control, safety & security, activity monitoring, and, scene creation and usage.

Example of a scenario: scene creation and usage:

Lily's mother, Alice, is 82 years old and she has dementia. Alice lives at a nursing home that provides means to personalize devices, for example the illumination system of her room. In Alice's' apartment the illumination is adjusted so that the inhabitant recognizes the time of day: the lights become brighter at dawn when it is time to wake up and fade out when it is time to take a nap or go to bed. (There is a sensor outside, which detects daylight.) The lights in the apartment are OFF when there is no one in the room.

Lily fine-tunes the lighting adjustments of her mother's room. Lily wants the lights to support Alice's normal activities and therefore she configures the lights to adapt to specific situations. For example, when the TV is on, there should be ergonomic, dimmed light behind it, and light in the hall that leads to the bathroom. Lily switches the TV on and touches light behind it with a mobile device. Then she touches light in the hall and adjusts its dimness. When she has finished adjusting the lights, she presses her mobile device's push button. Lily has created and adjusted suitable illumination for the TV-scene.

While evaluating scenarios, the nurses produced valuable, rich and detailed information about each usage situation. From two scenarios; safety & security and activity monitoring, improved ideas emerged reflecting the nurses' experience of using the Wiktio W10 system. A scenario on lock control operation did not receive such enthusiastic response. In the scenario, patient Alice enters her room and controls the lock by her mobile phone. Nurses felt that the scenario was not realistic, as there are so many patients who cannot operate any buttons, or a touch pad of a device. Also it would take too much effort for a nurse to enter the room.

One scenario was more successful, however: the above presented example of scene creation and usage with the configuration tool. The lights of the environment were considered as an important configurable target of any smart environment. The nurses explained that at present, controlling lights was performed manually, and the presented scenario provided a valuable improvement to the situation. Nurses agreed that, in this case, the inhabitants should specify themselves what kind of scenes needed to be created for their apartment. However, in most cases, the nurses recommended that for the wellbeing of a patient suffering from a memory disorder, the scenes should be created by the nurse. Inspired by the scenario, the nurses further elaborated the scene. They all had experience on patients suffering from severe dementia. The patients wake up frequently at night and turn on all the lights, and do not know whether it is day or night. Some patients had come up with creative solutions: most had left the toilet light on for the night, some left the lamp by the door on. By creating an illumination scene, which supported the recognition of the time of day, these patients could benefit from the developed system. All things considered, the night time illumination was selected collectively as the optimal scene for configuration.

2 : Examples of Existing Application Interfaces

After evaluating scenarios, the nurses were shown UI layouts of existing applications used for creating or configuring intelligent environments. After seeing three examples of such systems, the nurses felt that the UI should be graphical and the tool should be used with a portable touch-computer. The example of the UbiPlay Game Creator [20] was stated to be the most appealing example. The advantage of the UbiPlay Game Creator UI was, that it provided clear palettes of symbols and images. Yet the most successful features were the ready-made states or scenes, which could be chained one after another. Such system was stated to be quick to learn and ease the nurses' workload. The participants suggested further, that the users could make their own personal icons and images by, e.g., taking a photograph of the device.

3 : Co-design with Sketching

After learning the information that had been prepared in advance, the focus group participants were requested to co-design the conceptual model of the system by sketching it. The session focused on finding the most essential and critical factors that expert users would expect to find from the system, i.e. the first steps that they would take while creating a scene. The sketched examples illustrated the hierarchical structure of all actions needed when creating a night illumination scene for a dementia patient who wakes up at night (Fig. 2).

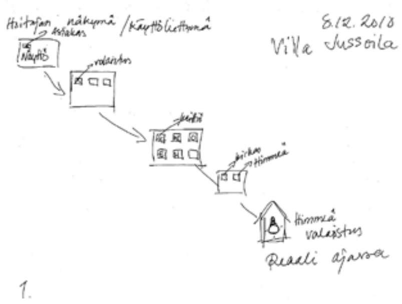


Figure 2.
Nurse's sketch illustrating five steps that are required to perform a configuring task.

The participant who sketched the concept in Fig. 2, explained: "*This sketch describes the user interface for a nurse. First, the nurse selects a patient. Then there are alternative categories such as nursing, water consumption, electricity consumption, illumination etc. We select the illumination. The illumination devices are categorized according to the rooms: living room, toilet, kitchen, bedroom or hallway. We select the bedroom. Then there are alternatives such as dim or bright for the lights - we select the dim option. As a result, a dim light is turned on in the room - also in reality.*" The participant was willing to take all these five steps by using a touchable computer and graphical user interface, because: "*It takes only two to three seconds to create such a scene*". Overall, the users' sketches proved to be a proficient way to find distinctive factors defining the user experience. However, the sketches also proved the variety of different configurations of an environment. It was also noteworthy that most users included some kind of timeline or timer in their sketches.

4: The First Draft of the UI: a Puzzle Metaphor

The last phase of the focus group evaluations was to evaluate the first visualization of the home control tool. At this point, the UI had a puzzle metaphor where all connected pieces had consistent locations and specific colours, as illustrated in Fig 3. In addition, the user could check the operation from a sentence depicting the functionality of the structure. The use case for the layout was taken from the lock control scenario: the nurse's arrival at the inhabitants' door.

The focus group participants found the structure of the user interface difficult to understand, mostly because the presented actions were inconceivable for both nurses and patients. Nurses doubted that they would ever construct a scene that was so time-consuming and prone to errors. Nurses remarked that the visualisation did present a graphical interface, which they earlier stated to prefer; but the presented interface was not user-friendly. Another concern was that the nurses did not want to build the puzzle by creating every single piece or action — they expected the puzzle to be ready-made. Subsequently, the focus group discussed about adding the sentence structure to guide the scene creation (in Finnish, the sentence structure is: subject — verb — object). The focus group anticipated that the users might not need any sentence structure to guide them after they had learned to control the system.

Based on the results, scenarios were developed further for constructing the user interface of the home control system. The puzzle metaphor was ignored, and the set of use cases that presented the control adjustments of the illumination were selected for further development.

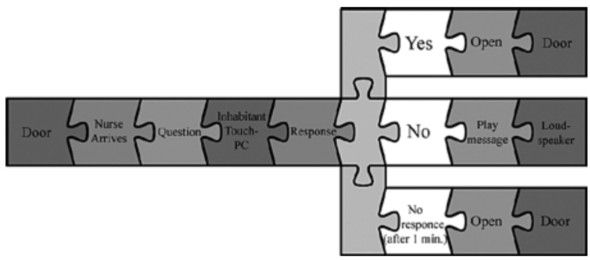


Figure 3.
Puzzle metaphor of the UI: The door — Nurse arrives — Show the question — Inhabitants touch-PC — Response: Yes — Open the door — The door; No — Play the message — The loudspeaker by the door; No response in 1 min — Open — The door (in case of a nurse).

B
Interviews with Paper Prototypes

The objective of the second evaluation phase, six months later, was to obtain insight for the design of the UI, which was, at this point, visualised as a paper prototype. Interviewees were shown layout images of the front page of the application and palettes, and a clip-on paper prototype of the creation tool. In addition, one of the tasks of this evaluation phase was to gather information for the requirements of a speech recognition system.

The scenario 'scene creation & usage', which was introduced in the initial focus group evaluation, was selected to be the starting point of the paper mock-up evaluation. The scenario was about 'customizing the illumination for the homecoming of inhabitant Alice'. In the paper prototype, the user was allowed to control both individual lamps and a group of lamps. There was also another scenario for the speech recognition system: 'scene activation by speech'. The context of these scenarios was explained to participants while creating the scenes with paper mock-ups. According to our previously defined terms, a '*state*' in this case was the state of an individual lamp or the aggregate state of a group of lamps. The illumination *scene* represented combination of the triggering event, some preconditions, and the target state. A *snapshot* was also explained for clarity.

1 : Front Page of the Tool

The interviewees were shown a layout image of the home control tool's front page. At first, the user was expected to select the house (from a group of houses), in this case: nursing home Villa Jussoila, in which the interview took place. Then the user selected the apartment for which s/he wanted to create a scene. Then groups of output devices (actuators) of the apartment were presented in the front page. In the layout image, the output devices were categorized by groups, which were titled: illumination, lock control, ventilation and others. Alternative grouping categories were available as well; grouping could be based e.g. on the room categories: kitchen, bedroom, living room, hall and toilet. Most nurses expressed to prefer categorization by room. For the categorisation by type of device, nurses suggested: illumination, lock control, white goods, HPAC (heating, plumbing, air-conditioning) and television/radio/computer.

Figure 4.
Paper prototype of the scene: homecoming, Alice. Green post-it notes are for illumination, yellow for other devices, orange for controller/s and pink for naming the scene. © 2012 IEEE

2 : Scene Creation

After the front-page selection, a view for scene creation was presented as a clip-on paper prototype (see Fig. 4). The output devices (green post-it notes for illumination, yellow for others) were categorized by the device groups shown in the front page. Only the selected device group was available for configuring at a time. After determining the on/off/dim state of the device, the user selected controller/s (orange) for the device group. Controllers were e.g. sensors, speech recognition or switches that triggered the state. Finally, the user was able to give a name to the whole scene (pink) according to her/his preferences.

As an alternative for presenting the output devices and controllers in an expanding grid, the interviewees were presented a palette type selection method. However, the nurses preferred an expanding grid, because hiding irrelevant devices was regarded a highly usable feature for the UI.

In the scene creation phase, nurses presented the following steps for creating a Homecoming illumination scene for Alice:

- At first, the user gives a name to the scene. Two nurses preferred to call the 'homecoming Alice' scene 'general illumination'.
- The user presses the specific device or light (green post-it notes). When the light is selected, it changes its colour, indicating that it is activated.
- The user defines a value for the device: on / off or a cross, indicating 'don't care'. This option was preferred over e.g. symbols or colours. Presenting a dimmed state was not perceived necessary, as a separate pop-up could deal with the action.
- Finally, the user defines the controllers (orange) that trigger the state. In the paper mock-up, there were options for three controllers: light switches, speech recognition and floor tile sensors. The nurses emphasized that only one controller is required in most cases.

Nurses commented that the illumination of the patient's room, in which the interview took place, required only three different scenes. One nurse labelled the scenes: ambient light 25%/50%/100%, another nurse: morning, day and night. The nurses stated to create scenes for patients in the room with the titles: working lights, mood lights and recreation lights (e.g. for watching TV). One of the nurses pointed out that it should also be easy to deactivate the scenes quickly. The nurse explained that there were frequent situations in which nurses had to bypass or deactivate some functions of the Wiktio W10 system, such as e.g. a stove alarm.

3 : Controllers
Controllers (e.g. the switches) for triggering a state were by no means a simple concept for the interviewees to understand. It was challenging to think e.g. of the light switch and the lamp as two separate objects. When nurses were encouraged to talk-aloud about all the possible controllers in the patient's room, they could only identify the light switches and the remote control. One of the nurses stated that it should be possible to select a controller for the set of devices from the lower right-hand corner of the device view, as that would be the logical location for selecting a triggering controller. All users emphasized that there was not any need to select several controllers for one state; on the contrary, multiple controllers were perceived as extremely exceptional cases. The speech recognition system was expected to be an easy, intriguing and usable method for triggering a scene.

4 : Snapshot
Our research group had proposed a possibility to obtain the state of the environment by taking a snapshot of the temporary conditions. Furthermore, we thought it might be advantageous to activate a device for the UI by physically selecting it, and subsequently apply the desired state of the environment (as explained in scenario: scene creation and usage). This idea was confirmed on a nurse's sketch in the preliminary evaluations. Without exception all interviewed nurses valued the idea. The snapshot feature was expected to help in the adoption of the system's use. The nurses suggested, that the system should work contrariwise as well: it should be possible to control the devices by the laptop. This was stated to be very useful feature for an immobile patient.

5 : Simple and Complex Scene Creation Situations
One of the challenges our research group had identified was the need for the system UI to contain a variety of functions, while remaining flexible and sufficiently easy to use for creating very simple scenes. The nurses anticipated that such a simple scene would be e.g. turning on a light by a voice command. The configuration of such a simple scene should, naturally, be straightforward. The fact that the system UI allows for an inconceivable combination of states (on/off) even for a normal light switch was challenging. Nurses also stated that a logical use of the system should infer that when a particular switch turns a lamp "on" the same switch, with the opposite state, should turn the lamp "off". In our paper prototype, this kind of scene seemed excessively complicated.

It was difficult for the interviewees also to describe more complicated scenes, e.g. multiple conditions for automatically emerging states, such as turning on the light in the hall, when a person approaches the hall *and* it is dark outside. The case of supporting a dementia patient with illumination scenes was highlighted again as an example. One nurse attempted to define the night time illumination by describing: "When the patient gets up from the bed, the table lamp is lit; and as the patient approaches the toilet, the light on the toilet is turned "on" ". This, however, is actually a sequence of two simple scenes. In general, the nurses understood the timer as the conditions.

6 : Scene Creation by Nurses
The nurses agreed that there had to be well-defined purposes for using the home scene creation tool. Acceptable scenes could relate for example supporting patients to feel comfortable in a nursing environment (feel of home), to the energy consumption of the environment and for supporting the diurnal rhythm of the patients. The following scenes are examples of the usage situations suggested by the nurses:

- A nurse configures all morning activities for a patient into one switch: the inhabitant's coffee machine switches on, a dim light and the TV with a morning program turn on. The inhabitant triggers the scene by pressing a switch by the bed, or by saying "Good morning!"
- An energy consumption scene for an inhabitant who wants to sleep in a cooler room. A timer triggers this scene.
- Because the amount of light in winter and summer seasons differs significantly in Finland, ambient

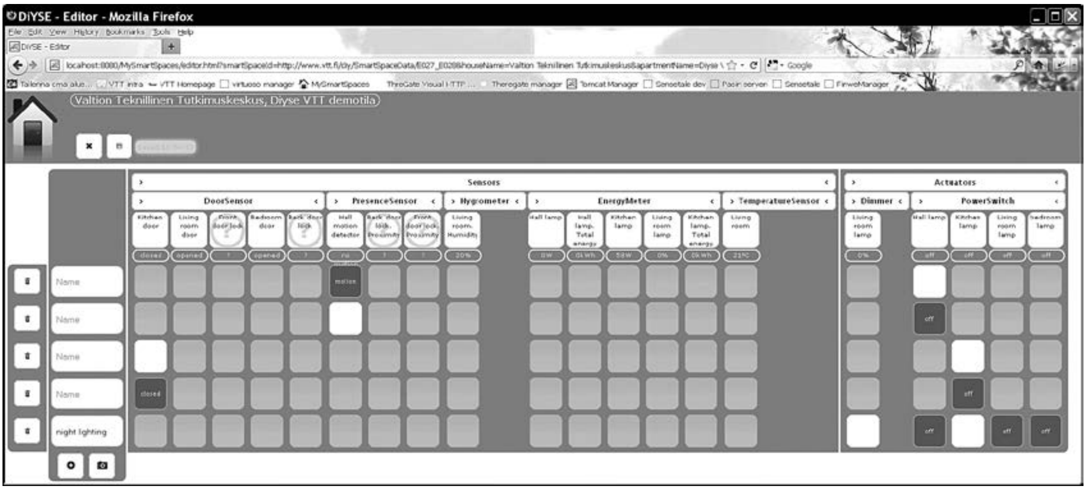


Figure 5.
Final home controller system UI. © 2012 IEEE

lights would be brighter in wintertime. During summer, there might be no lights at all.

- An illumination system connected to moods and feelings, for example to accommodate a romantic dinner. (Customisation of the state by the inhabitant is important in this case.)
- Illumination conditions for cooking. The scene could be triggered for example by a floor sensor when entering the kitchen.

7 : Requirements for the Speech Recognition System

There were extensive discussions about the words and sentences that could be used for triggering a state by the speech recognition system. Nurses talked-aloud [19] all the lights and output devices they perceived in the demo room. There was some concern that a word or a sentence might trigger a state by mistake.

C Final Usability Evaluations

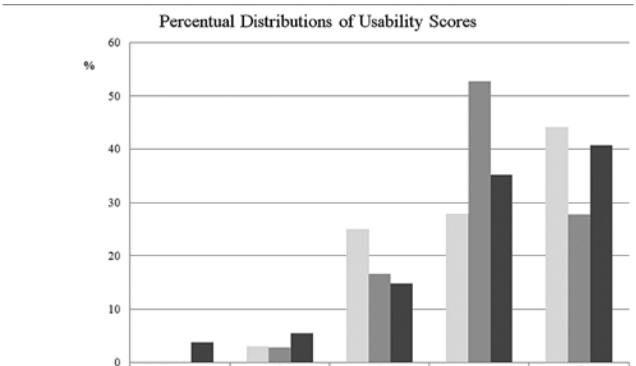
The final usability evaluation session, again six months later, started with a short introduction to the home control system, installed in a laboratory environment. Users were shown the operations, functions and the configuration of the home control system UI (shown in Fig. 5). Also, the predefined rules to be activated by spoken commands, e.g., “mood illumination” or “night illumination” were demonstrated.

For evaluation purposes, the requirements were embedded into a storyline, which was ‘walked through’ by the test users during the evaluation session mentored by the human factors specialists. The purpose of using a storyline was to bring out further scenes about the use and configuration of the home control system. A successful walkthrough of the tasks was expected to provide evidence of the usability of the home control system user interface. The evaluation sessions were conducted as interactive situations between each test user and the mentor. During the walkthrough of the storyline, the users were asked to think aloud while performing the related tasks and the mentor observed and took notes on their activities. During the evaluation session, the users were also asked to score a set of statements related to usability criteria, i.e. effectiveness, efficiency and user satisfaction. These statements were rated on a scale ranging from one (1) “totally disagree” to five (5) “fully agree”. Finally, the users were asked to rank their preferences regarding the given choices of application areas of the home control system.

Figure 6 summarizes the results of the usability evaluations. The figure presents the distribution of the scores on effectiveness, efficiency and user satisfaction. High scores stand for positive attitudes, high acceptance and satisfaction, while low scores indicate opposite viewpoints.

1 : Effectiveness

The evaluation consisted of seven effectiveness related tasks followed by seven statements to be scored. The mean of all given scores for effectiveness



	1	2	3	4	5
Effectiveness	0	3	25	28	44
Efficiency	0	3	17	53	28
User satisfaction	4	6	15	35	41

Figure 6.
Percentual distributions...
Horizontal axis: score values from unfavourable attitude ”1” (=“totally disagree”) to favourable “5”(=”fully agree”) attitude towards usability related statements in the evaluation.

was 4.1 (on a scale of 1-5) and the standard deviation was 0.9 (Fig. 6, red column). The shape of the effectiveness distribution and the mean of all score values dealing with this usability criteria suggest good performance towards reaching the goals by using the UI of the home control system. The small amount of scores one and two (1 and 2) suggest, that using the system with the developed UI was effective in performing the requested tasks during the evaluation.

2 : Efficiency

Efficiency (the green column in Fig. 6) was measuring how the user needed to use resources (e.g., time or mental effort) while using the system. Therefore, efficiency is related to UI structure, e.g., buttons and menus, and how fluently they can be used in the system. Four statements related to efficiency were presented to the users for scoring. The mean value and standard deviation (in parenthesis) of all scores were 4.1 (0.7). The shape of the efficiency distribution in Fig. 6 differs from the shapes of the two other distributions. This may reflect the difficulty of seeing or realising the need of pressing the “Save” button after the configuration of a rule. The icon was said to be too small and invisible. Also the “Trash” icons were commented to be of too small size. Furthermore, some users argued that the changing colour (from red to green) of the sensor button (in use / not in use) was not in line with the status colour changes of other sensors, and they felt this confusing.

3 : User Satisfaction

User satisfaction deals with an overall satisfaction towards the system. It measures the extent to which user finds the system acceptable, how pleasant it is to use, how easily it can be learned and how willing the user would be to take such a system into use. A set of six statements related to user satisfaction were presented to be scored. The mean value and standard deviation (in parenthesis) of all scores were 4.0 (1.1). The distribution is shown in Fig. 6. (blue columns).

The user satisfaction score value distribution was slightly more evenly distributed compared to the two earlier distributions presented above. The result shows that smaller score values (1 and 2) were given here more often compared to the effectiveness and efficiency cases. This may be due to the slowness and uncertainty of the speech command system responses. Though the evaluation concentrated on the configuration UI of the system, users could not neglect shortcomings of the speech recognition system.
The speech recognition system lacked a feedback feature to inform the user whether the command was registered by the system.

4 : Application Areas for Home Control System

Finally, the users were asked to rank a few envisioned home control system application purposes according to their preferences by giving a number 1 (=most useful area of use) to 5 (=least useful area of use). The results are presented in Fig. 7, which shows the distribution of score values 1 and score values 2 and a combined

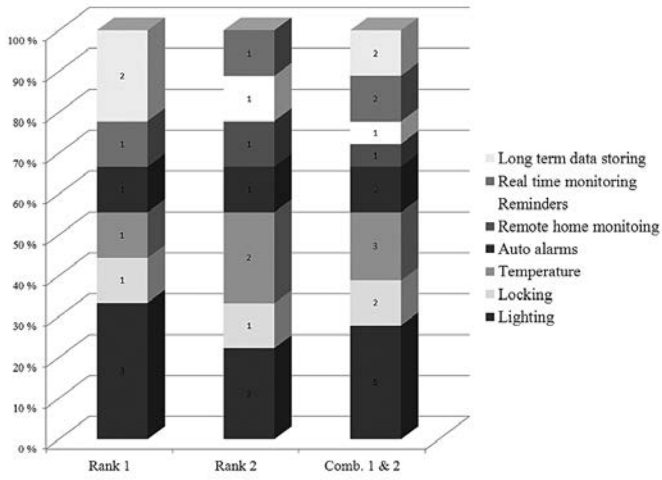


Figure 7.
Prioritising the application areas of the home control system. © 2012 IEEE

column from score values 1 and 2. Besides adjusting the lights, adjusting temperature and locking the home would be areas of interest according to this study. Furthermore, the home control system could be used for sending automatic alarms if something exceptional would take place at home. This necessitates some kind of automatic home monitoring (real time or long term), which were also ranked with relatively high score values (two times each).

V
CONCLUSION

When we began the development of the home control system, our main concern was that the users could not conceptualise the use of the system at the same level as the developers. This was the reason behind the choice of a co-design approach with an experienced focus group. During the initial co-design session and the subsequent interview evaluations, participants discussed about the target user groups and different levels for different users of the system. Participants contemplated that most nurses would not create scenes for inhabitants, if the user interface were as complicated as the first puzzle metaphor UI or the subsequent paper prototype. Interviewees highlighted that someone should first create ready-made templates, and users would only fine-tune those. These findings brought our viewpoints closer to each other as we continued with the development of the proof-of-concept prototype.

The usability evaluations produced suggestions for further development of the system prototype. When looking at the results of the evaluations of the general usability measures (effectiveness, efficiency and user satisfaction), one notices that the average values of all three measures were greater or equal to 4 (on a scale of 1-5) i.e. they were at a high level. This suggests that the UI of the home control system evaluated was well accepted, easy to learn and enabled the users to perform the tasks requested. This finding was supported by the observations during the evaluation sessions.

ACKNOWLEDGMENTS
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1 D. Bonino and Corno. F. What would you ask to your home if it were intelligent? Exploring user expectations about next-generation homes, Journal of Ambient Intelligence and Smart Environments, vol. 3, pp. 111–126, 2011.
2 ISO FDIS 9241-210:2009, Ergonomics of human system in- teraction – Part 210: Human-centred design for interactive systems (formerly known as 13407), International organiza- tion for standardization, ISO.
3 D. Benyon, P. Turner and S. Turner, Designing Interactive Systems – People, Activities, Contexts, Technologies. London, UK: Addison-Weasley, 2005.
4 M. Kuniavsky, Observing User Experience: A Practitioner's Guide to User Research. Elsevier science, San Francisco, 2003.
5 C. Lindsay, From the Shadows: Users as Designers, Producers, Marketers, Distributors, and Technical Support. In N. Oudshoorn & T. Pinch (Eds.), How Users Matter: The Co-Construction of Users and Technologies, Cambridge, MA: The MIT Press, pp. 29-50, 2003.
6 J. Greenbaum and M. Kyng (ed.), Design at Work: Cooperative Design of Computer Systems. Hilssdale, NJ: Lawrence Erlbaum Associates, 1991.
7 D.L. Morgan, The Focus Group Guidebook, Sage Publications Ltd, 1998.
8 P. Lyons, A. T. Cong, H. J. Steinhauer, S. Marsland, J. Dietrich and H. W. Guesgen, Exploring the responsibilities of single-inhabitant Smart Homes with Use Cases, Journal of Ambient Intelligence and Smart Environments, vol. 2, pp. 211–232, 2010.
9 W. Buxton, Sketching User Experiences: Getting the Design Right and the Right Design. Elsevier Inc., San Francisco, 2007.
10 M. Suwa, J.S. Gero and T.A. Purcell, T. A. "The Roles of Sketches in Early Conceptual Design Processes". In proceedings of the Twentieth Annual Meeting of Cognitive Science Society. Madison, WI, 1998.
11 C. Snyder, Paper prototyping: the fast and easy way to design and refine user interfaces. Morgan Kaufmann Publishers, San Fransico, CA, 2003.
12 K. A. Ericsson and H. A. Simon, Protocol Analysis: Verbal reports as data, Cambridge Massachusetts, 1984.
13 M. Bakardjieva, Internet Society: The internet in everyday life. London: Sage, 2005.
14 J. Stewart, Local experts in the domestication of ICTs, Information Communication and Society, 10(4), pp. 547-569, 2007.
15 M. Hassenzahl and N. Tractinsky, User experience – A research agenda, Behaviour and Information Technology, 25(2), 91–97, 2006.
16 M. Bakardjieva and R. Smith, "The internet in everyday life: Computer networking from the standpoint of the domestic user". New Media & Society, 3(1), pp. 67-83, 2001.
17 Wiktio Services: http://www.wiktio.fi/index.php?167
18 K.J. Turner, Flexible managment of smart homes, Journal of Ambient Intelligence and Smart Environments, vol. 3, pp. 83–110, 2011.
19 S. Card, J. Mackinlay and G. Robertson, The design space of input devices. Proc. Conference on Human Factors in Computing Systems, ACM Press, pp. 117-124, 1990.
20 J. Mattila and A.Väätänen, "UbiPlay: an interactive playground and visual programming tools for children". Proc. IDC '06. ACM, pp. 129–136, 2006

TIINA KYMÄLÄINEN

SOMETHING TO REMEMBER ME BY

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CONSTRUCTING A SOCIAL MEDIA SERVICE FOR SENIORS

ABSTRACT

Designing new technology services for the aged is challenging. The most problematic part of research and design is the early expectations and final acceptance towards the introduced technologies. Rendering towards earlier research studies, the expectations and acceptance of new computing technologies have been verified to bias predominantly towards negative experiences. Why is the technology introduced to the seniors? Why yet another technical service should be needed? Why should it be taken into use? Is the technology mean to replace people? (Where are they in the service?) This problem setting set out to hypothesis a design research setup for social service aimed for senior citizens. The early conceptual studies focused in determining meaningful computer-mediated activities that seniors wanted experience and share through social media. The resolution was: to create and share their personal retrospections.

The objective for the 'Life Story Creation' prototype was to develop an easy Web 2.0 service for elderly people to create and share their retrospections, and by the same token, lower their threshold to enter the social media. The design of the service was grounded on extensive research that aimed at identifying long-term opportunities for design by binding value- and experience-centered design approaches to research. To confirm that people were placed at the center of the design — and important values and experiences were delivered to the design — the people benefitting most for the system, elderly citizens, participated to the development throughout the process.

KEYWORDS

Human-computer interaction (HCI),
social media,
value-centred design (VCD),
value-sensitive design (VSD),
user experience (UX)

The explicit aim of the 'Life Story Creation' service was to provide elderly people with social media tools for creating and sharing their memoirs and short recollections. The hypothesis was that the design of such a service should start from understanding people and life around them, and genuinely focus on the reasons why technology should be developed. The objective was confronted by engaging inspiring background theories to the design process: value-centered design (VCD), value-sensitive (VSD) design and user experience (UX) design to the entire lifecycle of the study.

Value-centred design seemed suitable research framework to found the premises of research in the particular context, for the objective in VCD is to focus on the value of the service from the initial identification of opportunities to the installation and operation of the digital service [Cockton 2006]. In technical development processes the material features cannot be ignored, but there are also other features that cannot be ignored, such as the individual, social, historical, and political contexts within which technologies will operate [Flanagan et al. 2008]. Flanagan et al. emphasize that technologies embody values, and values in turn may be embodied in technical systems by design. Winner further asserts that the adoption of a given technical system actually requires the creation and maintenance of a particular set of social conditions as the operating environment of that system [Winner 1986]. This notion sets to believe that the value-centered design would provide more permanent research findings that could be exploited by much larger audience and quite different stakeholders and parties than the single research group who was creating the social media service for the aged. However, during the design research value-sensitive design was adopted as a research framework for the process, as it provides systematic consideration of the values and interests of all stakeholders in relation to the system under consideration [Friedman et al. 2006]. The VSD was considered also to be a close framework as compared to the work processes of HCI, for it distinguishes between usability and human values although supplementing the procedures with ethical import.

Subsequently, the study employed supporting concepts from the experience-centered design approach [Hassenzahl and Tractinsky2003; Forlizzi and Battarbee 2005; Hassenzahl 2010]. According to Hassenzahl and Tractinsky the shift from traditional usability to user experience has been a consequence of the fact that traditional user-centered and usability approaches do not provide sufficient means to measure all the aspects of HCI [Hassenzahl and Tractinsky2003]. Hassenzahl further explains that the subjective approach is often neglected in HCI studies, even though the approach might lead to rich user feedback [Hassenzahl 2010]. Forlizzi and Battarbee have considered user experience to be attractive especially for design research as it covers the wide area of attributes that relate to aesthetics, joy, emotions, and affective aspects of the technology use [Forlizzi and Battarbee 2005]. For the user experience research to case study adapted the propositioning of experience-centered design for emphasizing the power of dialogue and co-production in experience design context [Wright, Wallace and McCarthy 2008]. The emphatic approach of their proposal is part of the broader pragmatist approach to design, which involves the understanding of user and their lived environment through empathy; "Knowing the user in their lived and felt life".

In the context of this article the experiences have generally been seen to form through a social process, which has been studied in order to generate insights for the design of the service. The value-sensitive design provided information to categorize the experiences that were found from the social media service aimed for senior citizens. As a framework for defining the discovered experiences, those were reflected on universal psychological needs that Hassenzahl et al. have stated to be important when designing interactive technologies [Hassenzahl et al. 2010]. The case-specific key experiences were presumed to be in relation to creating and sharing experiences; creating of the personal life stories and sharing them with the help of the service. Plomp et al. have earlier accentuated the importance of the creating and sharing of experiences in social web service (Web. 2.0), which according to them differs significantly from publishing on the web (for example by means of a blog) [Plomp et al. 2010]. According to them, within Web 2.0, users create and import their own content for others to be shared in the public virtual spaces and add value by commenting, recommending or tagging each other's.

Prototyping, as Flanagan et al. have emphasized, is expected to be an essential component in

CONCEPTUAL INVESTIGATION	EMPIRICAL INVESTIGATION	TECHNICAL INVESTIGATION
Acceptance	Selx-expression through Writing	Quality
User defined values	Communication	Technical evaluation
User defined needs	Belonging and community	The Operating Environment
	Privacy	
	Identity, Ownership and Property	
	User defined Value Communities	

Table 1.
Key values for the social media service.

discovering users' beliefs, preferences, and values [Flanagan et al. 2008]. The value-centered and experience-centered design aimed at developing a final prototype that was a Web 2.0 service application. The application prototype focused on the content creation, creating of short retrospections, and the sharing of creative work. The underlying theories were bind to the process for considering the reasons and justifications for developing the technology, but the concrete, evolving design process of the 'Life Story' service was yet expected to confront an unorganized collection of messy design problems. These design problems were expected to be concurred through reflective practice with people whom benefitting most for the system — elderly citizens. The process fell under the methodological frame of participatory design, which generally aims at democratizing design so that the people to be affected by the systems should also be able to participate and influence the design process [Schuler and Namioka 1993]. The research was carried out on, at first, with expert and non-expert senior writers and then, with seniors who were sincerely interested in writing their memoirs; senior participants of a writing activity group.

Consequently, this article describes the construction process of the 'Life Story Creation' service and its application, and defines in detail the system's social operating environment. The contribution of this article is to demonstrate how value- and experience-centered design approaches have been carried out by way of using the design prototypes — the visualizations and application — as drivers for new service innovation.

INVESTIGATIONS AND METHODS

In the evolutionary design process of the 'Life Story Creation' service, the aim was to study people's values, 'needs' and 'wants' and ultimately, the experiences the service prototype implicated. According to value-sensitive design, the design of a service system emerges through iterations upon a process that is more than the sum of its parts [Friedman et al. 2007]. VSD proposes a concrete iterative methodology that integrates conceptual, empirical, and technical investigations to the service system design. The conceptual investigations explore what values are associated with the service. Empirical investigations focus on the individuals, groups, or larger social systems that configure, use, or are otherwise affected by the technology. Empirical investigations are needed to evaluate the success of a particular design. Technical investigations focus on the technology itself.

In the 'Life Story Creation' case study the investigations were interested in exploring the following key values for the social media service (see Table 1): self-expression through writing, communication, belonging and community. In addition, the investigations concentrated on studying: acceptance, privacy, identity, ownership and property, other value communities, quality and the operating environment.

METHOD	USED FOR
	EARLY ELICITATION METHODS
Shadowing	Shadowing was used to identify opportunities for design and quickly understand a particular design context.
Delphi method	A structured communication technique, originally developed as a systematic, interactive early foretelling method with a panel of experts.
Contextual inquiry	Contextual inquiry was used for observing the tasks and practices of new and unfamiliar domains.
	METHODS FOR EMPIRICAL INVESTIGATIONS
Acceptance interviews	The early acceptance and values of the technology were evaluated by a semi-structured focus group interview.
Focus groups	In the focus group interviews the user communities discussed the topics that the facilitator disseminates. The benefit of a small group is that all interviewees are able to bring out their opinions and comment each other's.
Visualizations	Visualizations presented new applications and services. They aided in defining the interaction possibilities.
Semi-structured interviews	Interviews were used to gather all value-centred and experience-centred information. In an interview the mediator becomes an advocate and partner with the interviewee.
Interviews	Interviews were used in all likely phases, for the method of ensures that the mediator becomes an advocate and partner with the interviewee.
Subjective assessment	In subjective assesment the users analyse the results for the evaluator and explain how they feel about the technology. It is constructed around a form of questioning which encourages the users.

Table 2.
Used methods.

The key methods chosen for the empirical investigations of the value sensitive- and experience-centered design are presented in Table 2.

In the initial phase of the Life Story Creation, shadowing, Delphi method and contextual inquiry [described e.g. by Kuniavsky, 2003] were utilized to learn about the life of the senior citizens. The early elicitation methods focused in determining meaningful activities that seniors wanted experience and share through social media with the result that creating and sharing of personal retrospections was considered as the most stimulating activities. The deployment and suitability of these early elicitation methods have been described in detail in a thesis [Laitinen 2010].

This article, however, focuses on eliciting findings for the value sensitive- and experience-centered design at the same time when constructing and modifying the 'Life Story Creation' prototype according to participants' quality requirements. The semi-structured interviews within focus groups were considered to be the main methods to share and gather information that were used in all phases of the creation of the service. Focus group is an interview method in which the groups are formed of people with similar backgrounds [Kruger and Casey 2000]. The interviews brought information about the acceptance of the service, values of the technology, and the requirements for the design. Complementary methods were used as an introduction to the service system. In the early prototyping phase, the participants were

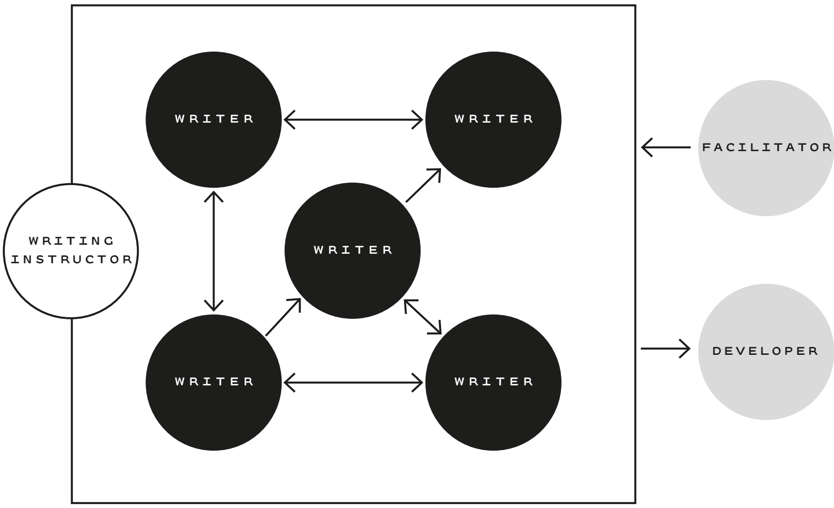

Figure 1.
The setup for the Life Story Creation design ecology.

informed about the objectives with means of user interface (UI) visualizations that were created by the project group [Buxton, 2007]. With concrete visualizations, the participants were encouraged discussing more specifically about the interactions and application requirements.

The subsequent proof-of-concept prototype was the culmination of the design research; it informed about the use, interaction mechanisms and possibilities of the underlying service. The empirical evaluation phase concentrated on the usability aspects of the service from the value- and experience point of view; the benefits and general deficiencies of the prototype, interaction mechanisms, especially issues relating to creating and sharing, and overall design requirements. In the final evaluations of the 'Life Story Creation' application prototype, the subjective assessment [Nielsen 1994] was used as a method for analyzing the results, in which users had a significant role in doing the analysis.

DATA SETS

The early opportunity identification studies were carried out in September 2010 at an institution for senior citizens in Kuopio, Finland. The focus groups consisted of fifteen (15) persons; six (6) males and nine (9) females, with an average age of 70. The participants were seniors living independently, most of whom had rich leisure activities. One group was composed of non-writers (no experience in writing), and three of experienced writers. The non-writers group seemed important to be brought along to research as a group who could be encouraged to write their recollections. All interviewees were familiar with information technology, using mobile phones and computers on a daily or weekly basis. Many of them were also acquainted with social media.

The explicit aim of the initial opportunity identification phase was to study the value expectations of the forthcoming digital service and the objective was to study specifically aspects relating to the collective value; to aim for interactive services that have an impact beyond the sum of any impact on individual users [Cockton 2006]. The implicit aim was to discover and identify the precise key values for the particular social media service.

The second user study of the Life Story Creation was carried out in November 2010 in Tampere, Finland, at a time when an early version of the prototype was ready. The participants were aged 55–69; four (4) females and one (1) male. All were senior citizens – four (4) retired and one (1) self-employed – and all were writers in the same activity group. Each of them was familiar with information technology; they used mobile phones and computers on a daily basis. Most were acquainted in some way with Web 2.0, by using e.g. Facebook, genealogy- and chat applications.

The most important objective for the empirical investigations was the individual worth of the service. In general, the individual values stress the importance

Figure 2.
Visualizations of the 'Life Story Creation' application (by Geniem Oy).
Left: name for the story; Middle: writing of the story, and Right: sharing of the story.

of identity, belonging and growth [Cockton 2006] and in the case study they were considered providing opportunities for design that related to self-expression by creating the retrospections, and communication, belonging and community when sharing them. The conceptual investigations were expected to reveal some of the unfelt needs that related to the service. According to Cockton, the unfelt needs can either be subconscious motivators that an individual may not recognize or understand: needs that are described 'unfelt' because they are not there (yet). The technical investigations concentrated on: usage situations, communication needs, design requirements and the technical feasibility of the prototype.

The most important criterion of choosing the participants to the second phase of the study was the domain expertise of the participants: local experts were expected to have an intimate understanding of the domain in which the service would be used [Stewart 2007]. Such local experts are crucial in formulating the needs a service should cater for, and to define the preferred way of interacting with it. In addition, it was presumed that local experts were more willing to contribute to the time-consuming constructive design process, as they had personal motives for developing their personal expertise and domain. In Figure 1 is the description of the Life Story Creation ecology. The writing instructor of the group seemed, at first, as an ideal partner to work with, but the early evaluations confirmed that the design of the system benefited more from the involvement properties of the participants. The involvement properties relating to the willingness to create and to community orientation, which the amateur writers possessed and which led them to be selected as the most suitable co-design partners to be worked with during the second design phase of the service.

Both phases of the 'Life Story Creation' prototype evaluations created also material for the experience-centered analysis of the value sensitive design, as the participants were considered extremely proficient in defining what makes good creating and sharing experiences as most had collaborated for years within a writing community.

RESULTS

1 Value sensitive opportunity identification findings

At the beginning of the value sensitive opportunity identification research, interviewees were, at first, introduced to the material: visualizations of the application (see Figure 2) that were printed on paper. The visualizations presented a portable tablet device, since the purpose was also to understand the operating environment around the person using the service. Then participants learned about the service concept and were encouraged discussing the acceptance and values of the service.

Conceptual investigation

Acceptance of the service. The interviewed seniors were unanimous over the acceptance and overall usefulness of the 'Life Story Creation' service; according to their judgment the service appeared to be useful and feasible, and it provided a novel solution for sharing memoirs. The service concept was also seen enticing with those who wrote less or not at all, and interviewees speculated that based on the presented material, most of their acquaintance would find the service easy to use and motivating. The application interface (based on the visualizations) was seen as pleasurable in the sense that it provided means for "trying and doing" instead of reading instructions. According to the focus group participants, learning to use the application was expected to bring out the joy of learning new things.

User defined values. The answer to the question "What was seen as the most critical value in the activity of writing memoirs and sharing them?" the outcome was: being able to leave something behind for the children and grandchildren. On the importance of writing down the memoirs an interviewee said:

> "I have been thinking all the more about the knowledge lost, now that my mother is in a nursing home and she has dementia. There is no longer any way to uncover her life experiences. If only had I asked her earlier!"

Some of the interviewees mentioned that the information about everyday life would be the most rewarding aspect when reading another person's memoirs.

User defined needs. Participants described that they faced more and more situations in which they needed to know something about their own past; e.g. about their parents and deceased family members — but no information was available. They pointed out that the need to trace one's personal history and commit it in writing increases often at old age. One of the interviewees described having spent recently considerable time looking for the tombstones and birth certificates of the family ancestors. The participants anticipated that it would be motivating to find out about personal family ties with the help of the service. Another interviewee stated having a large amount of pictorial material concerning past life and relatives that lay about chaotically and that could easily be organized within the service, e.g. with the help of the siblings. As an additional feature, participants requested for an option of combining the memoirs of several persons for constructing family-related information packages within the service.

Empirical investigation

Self-expression through writing. The writing, as a performed action, was seen more like recording and storing recollections than a mean to express oneself. The interviewees developed their own word for the activity[1], short retrospections. The term signified that the writing outcome was not expected to be as thoughtful and complete as a full personal memoir. This was considered to lower the threshold to begin the writing process for those who were not keen writers. The participants continued that the application should be constructed by relying on the expression "the more you do, the more you want to do". In other words, if the writer wants to expand short recollections into a full memoir (the writing process potentially being alluring enough for a short story to grow into an entire novel) one should be able to extend the process to cover even publication. Otherwise, the publication process was not seen to be an essential service, except perhaps for a small group that was seen to be the critical users of the service — people who write much and people who are interested in genealogy.

Communication. Friends were said to be those who could help and refine the retrospections in the creation phase. Trusted friends could help with their comments during the writing process, and also help to revise the written material. All interviewees were confident that they would in turn read their friends' writings and comment on those. Participants stated this would be educational: to learn how other people write. It would not be worthwhile, however, to read a memoir of someone who is only partial acquaintance — although here it was assumed that the interest might correlate with the relevance of the content. For example, the participants emphasized that the interviewed generation would appreciate the opportunity to write about wartime events. This was seen as attracting an even wider audience.

Belonging and community. The audience that would find the shared memoirs most useful was expected to be a small, familiar audience. The spouse was said to be the person most interested in reading the memoirs. When the groups considered the issue of sharing memoirs more specifically, they came to a conclusion that the audience would be only family and relatives, rather than friends, because family was seen to be most concerned about the context. For such community, it might prove to be inspiring to read a piece of writing and add to it, or write one's own version. The reality was, according to the participants, that children might not be interested in the memoirs immediately after they have been shared and published to the social media. However, as one participant clarified: *"Sooner or later the family lineage becomes an interesting topic for everyone."*

Privacy. The option that the recollections could be published through the service, by which anyone could read them, was seen very uncomfortable. It was stated to be crucial that each person should be called in individually; to give feedback to each distinct piece of writing. Some of the participants considered however that too many invitations might turn out to be too stressful. The participants anticipated also that there was an inevitable privacy threat of misuse when any private information was shared in Web. The most concerning matter was that the service might also provide an opportunity for spreading false information, e.g. some persons could use the service intentionally to spread gossips.

Identity, ownership and property. Most interviewees responded to the question "Would you prefer to write alone or with someone else (and with whom)?" by answering "alone". The reason for this was that interacting with someone else during the writing process seemed to have a risk for conflict. A further explanation was that people tended to remember things differently. As a result, the comment field, "Comments from friends and family" (that appeared in one of the visualizations) was considered more useful than an option for co-writing retrospections.

Other value communities for the service. The focus groups considered the prospects of diversifying the selection of topics to extent the created network to other domains. They provided alternative templates for the service of which related to the interviewees' leisure activities. They described that these other domains could be related to: genealogy, recipe library, former classmates, events (of relatives and friends), organizational activities (needlework club, senior citizens' debating club, former classmates) other peer groups and recollections of specific places.

Technical investigation

Quality and technical evaluation. The participants commented that according to the visualizations, the application interface appeared to be clear, and the template provided necessary, helpful instructions. However the participants required a guiding structure that would be useful for people unaccustomed to writing their memoirs. The participants proposed categories for the instruction template; childhood, school, youth, etc. that could be arranged in chronological order. The instructions would help to expand the content and to maintain enthusiasm for producing more information and continuing the writing process – and entice to write more.

The comment field for friends and relatives was stated to be an excellent feature in the service, because one could easily pick useful comments into the text, after considering how suitable they were. As a participant explained: *"[The comments] bring more color to the content and help to remember things"*. Attaching photographs was also seen as advantageous, as all participants *"had so many of them lying around"*. Even just browsing, with friends and relatives, and choosing the best photographs to fit the story was thought to be a pleasurable activity. Photographs were specified to support the memory, but they would be more useful if they included a caption expounding the content.

The operating environment. In the technical investigation the focus was not merely on personal computers. One reason for this was that, at the time when interviewing the seniors, tablet devices were introduced to consumer markets. However, the focus group participants had no long-term experience of touchpads, digital text platforms or any other electronic device that could be thought of in the case, they could not provide information about the use of any other devices. According to the participants, the personal computer was considered to be unsurpassed for the use of the service. It was considered that none of the

1 "Muistelus" (in Finnish), which could be regarded as "very short retrospections".

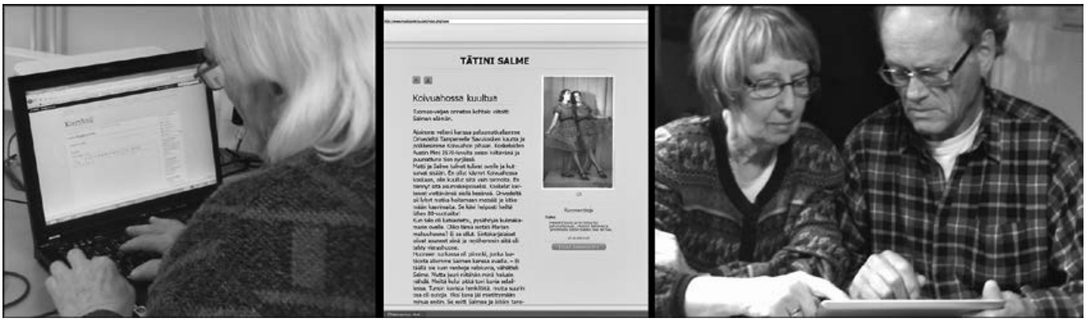

Figure 3.
The 'Life Story Creation' prototype.
Left: writing the Story, Middle: Layout of the application, Right: Sharing of work.

activities of the service would be used by mobile device. The participants mentioned that they would preferably find a particular, comfortable, private place, such as a computer desk or rocking chair, for the usual place for the writing activity.

According to the interviewees, everyone in the generation did not have the ability to use information technology. An acquaintance of an interviewee was a keen writer, but did not own a computer, or the means to use it. In the non-writing group, some interviewees had never learned to typewrite. They explained the difficulty of the service would be the slow writing process. The interviewees were proposed the possibility of using spoken language dialogue instead of typing, as at this point of the study, this was considered a substituting technology. It was assumed that recognition of sentences would be reasonably fluent, but the participants were not provided with an example of the feasibility. Most participants supposed that they would prefer, in any case, to write. Anyone unable to type could co-work with another person (e.g. a spouse). The interviewees suggested that the service could even teach typewriting; yet they were convinced that anyone could learn it if the matter were important.

2 Value-sensitive design findings

The second evaluation phase for the 'Life Story creation' service was carried out at a time when the first version of the application prototype was ready. The design of the prototype included the translation of the gained information from opportunity identification phase and the discovered values. Consequently, the corresponding design features were specified and implemented to a service application prototype. During the introduction, the interviewees were at first demonstrated with how to use the application prototype (see figure 3.) and provided access to the domain where the resources were located. The interviewees were expected to use the system on their personal computers – the application was enabled to work with different browsers – and to share their personal data and stories with others. An important part of the studies was the possibility to share information with other participants and development team. After the two-week testing period, each user was interviewed individually.

Conceptual investigation

The unfelt needs. After the two-weeks testing period, an interviewee commented that there was no difference between the service application and writing to a blog. Another interviewee perceived the service as 'Facebook for senior citizens' and explained that many older people did not want their use Facebook because: "*It is a place for younger people. There are so many games, advertisements and light friendship relations*". These comments suggest that the service should present itself clear and the values it endorses should be distinct and consistent. These unfelt needs relate to the accountability, the conception of the identity or overall courtesy of the service.

The visual appearance of the application was considered old-fashioned, minimalistic and clear; the latter was affirmed to be mostly due to the lack of advertisements. One of the interviewees mentioned that the application would turn more complex and unattractive if it contained the advertisements. These statements relating to the aesthetics of the application can be associated to the value of calmness, which was apparently successful in the prototype, but which could easily be unbalanced when commercializing the service. These statements suggest that the visual harmony and calmness should be considered as important values of the service.

As the third conceptual need relating to the life story creation activity, the interviewees pointed out that people have different kinds of techniques and various levels of writing skills. Some write discursively, while others have more "engineering" kind of approach. The application prototype was considered to be somewhere in-between supporting both types, but the different writing skills could be supported more exclusively. This statement suggests to the need for supporting a spectrum of expertise, as well as supporting of differences in purposes.

Empirical investigation

Self-expression through Writing. The ultimate self-expression goal was almost unanimously seen to be the creation of a finished, i.e. sharable, short life story that anyone interested could read. The interviewees saw that, for an experienced life story -writer, the service was mainly a place to re-write or co-write private retrospections, and that sharing would be most important part of the service. Some participants found it important that the writing of memoirs should lead to a published, printed version of the memoir collection. They expected that if publishing indeed was offered as an alternative goal, some of the forthcoming users could find the writing process much more engaging.

Communication. The application prototype included the writing and reading modes. The communication between writing community members was conceptualized in the prototype as a comment field, visible only in the reading mode. The interviewees found the configuring tasks with the comment field to be equally important with the writing and sharing activities. The overall logic of the comment field was stated to be adequate, but the way it was presented in the prototype was insufficient; it created only weak interaction with other writers although the participants saw potential for better annotation and communication for the co-writing activities. One example of the malfunction was that, at the end of the evaluation period, the interviewees preferred using e-mail to communicate with each other. The participants offered several improvement suggestions for the comment field; for example, it was suggested that the comments should be placed straight into the text at some point of the process. It was remarked that, in that case, the writer could indicate the specification in which part of the text s/he hoped for the suggestions.

Community and other value communities. The interviewees gave thoughtful consideration to the value communities of the service, stating that the kind of writing the service encouraged would be suitable for groups similar to theirs; or any other do-it-yourself- or hobbyist community that wanted to share information, or any group of persons with similar interests (e.g. a philosophy group). Within the application prototype, the relatives were seen to be the most important community of the service. Another important community was childhood friends. It was considered a novelty to able to share memories with relatives, and the service was explicated e.g. to afford the discovering of how differently siblings and relatives remember the past.

Privacy. The participants emphasized strongly that the most important concern relating to privacy was that any unfinished work could not be shared, even by accident. The participants notified that this private threat was apparent in the prototype, as in the application it was not at all obvious that the writing and reading modes were two separate services. The participants reminded also that as the retrospection was shared, each reader needed to be requested personally to join the service.

Identity, Ownership and Property

Before beginning the writing process, users were requested to feed in some personal information to the service. The interviewees pointed out that they were comfortable in sharing some of the information later to a wider audience; according to the interviewees this would help to identify the writers. Domicile, place of birth and year of birth were stated as the most informative data. Relating to the collective privacy values, according to the participants, this kind of information would not be too intimate for sharing, however, the option of not providing any information should always be available. Otherwise, the participants could not point out that there were any contradictory matters relating to the ownership or property of the retrospection: the one starting the process was the editor of the content and responsible of it in all phases of the process.

Technical investigation

Quality and technical evaluation. As individual comments, the interviewees provided many detailed clarifications what an optimal social media service for writing retrospections should contain. Before being able to begin the writing process the writer needed to complete certain phases in the prototype service. The first operation was to give a name for the story. All interviewees wanted to be able to change the name of the retrospection in any phase of the process, and specified that the first, given title was always a working title. Another similar issue came out with the topics for writing a memoir, as there were two alternative modes: automatic topics (childhood, school years, youth and older age) and freely created topics. The automatic topics were the ones proposed by the first focus group. All interviewees began the process with the automatic fields, but soon noticed a need to alter the fields. This need also came up later when evaluating the freely created topics. The participants emphasized that when creating retrospections, generally, all the content, in all phases, should be interchangeable. They justified this by saying that it would be the most important motivation for creating and sharing the retrospections in social media application (instead of aiming for a printed publication). The participants commented that the guidance provided by the automatic topics could be useful when a person was writing for the first time; however, for them it was neither interesting nor appealing to write according to the given topics more than once.

About the design trade-offs, one example concerned the layout, which according to the interviewees involved too much 'scrolling'. The interviewees specified that if the alternative option were to divide the text into several pages, users would probably prefer scrolling (e.g. one of the interviewees had a slow network connection). The participants complimented the simple and clear user interface, but required some customary writing process tools. For example, all interviewees needed to divide the retrospections into paragraphs; the provided subheadings and interleafs in the prototype were not seen as a sufficient solution to this need. The interviewees required also some customary means of forming the text (mentioning: bolding, italics, spacing, hyphenation and indentation). They defined: *"Without these features it is impossible to write a story"*. Marking some part of the text, e.g. by coloring it yellow, could also be useful (e.g. to highlight the parts for which the writer would like to have comments).

The photographs were said to be the best part of the application, although the task of adding images to the application was problematic throughout the two weeks testing period. According to one interviewee: *"Photographs have a significant role in the application. In this case, they are not meant to be illustrative decoration, but they have more profound, informative part."* According to the interviewees, the photographs should nevertheless be positioned in their appropriate places in the text (not in the side column in which they were in the application prototype).

As an overall comment, the participants remarked that the service should have a front page containing all the recent updates of the community that contained all other writers' comments and latest retrospections. According to an interviewee: *"[In the front page] there should be all most recent events, popular stories and updates, and everything that has happened recently"*.

The operating environment. The operating environment in the testing phase was participants' personal computers. As a novel technology, the second phase evaluation group was introduced with a spoken language dialogue interaction technique instead of typewriting. According to interviewees, the voice recognition option would certainly be a function worth implementing in the service. Although the interviewees were not keen in using the technology for creating the retrospections it was thought to be useful for persons who were unable to use the keyboard. However, some interviewees said that the technology could also be used when interviewing people (e.g. relatives) who would not otherwise be able to contribute to the process.

PSYCHOLOGICAL NEED	THE EXPERIENCES	ELEMENTARY EXPERIENCES
	CONCEPTUAL INVESTIGATION	
meaning	Reward of the process	create, configure
meaning	A structured communication technique, originally developed as a systematic, interactive early foretelling method with a panel of experts.	create
	EMPIRICAL INVESTIGATION	
relatedness	Sense of togetherness	configure, share
popularity	Enjoyment of being noticed and recognized	share
relatedness, popularity	Pleasure of feedback and support	configure
simulation	Sense of inspiration	create, configure
simulation, competence	Self-esteem	create, share
security	Intentional misuse	share
security	Not sharing of unfinished work	share
	TECHNICAL INVESTIGATIONS	
autonomy, competence	Customization possibilities	create
autonomy	Personification	create
autonomy, security	Local control	create, configure, share
competence	Being able to complete a job more effectively	create

Table 3.
The categorization of the experiences found from the value sensitive research.

3 The experience-centered research

The experience-centered studies were considered to be the analysis of the value sensitive studies: the value sensitive research provided material, which in the experience-centered investigations was formed as a list of experiences that any social media service for sharing recollections should aim.

In Table 3, in the left column, the relevant experiences are tied to the universal psychological needs that Hassenzahl et al. have associated the sources of experiences to psychological needs that are important when designing interactive technologies [Hassenzahl et al. 2010]. These psychological needs are: competence, relatedness, popularity, stimulation, meaning, security and autonomy. In the center of the table are the experiences that have been elicited from the value-sensitive identification opportunities and design research. The broad categories of description for the experiences have been established on relevant literature [Leadbeater and Miller 2004; Fischer et al. 2004; Kuznetsov and Paulos, 2010; Gauntlett, 2011] and confirmed by user studies. The elementary experiences for a social media Web 2.0 service for senior citizens were expected to be involved with two main experiences: creating and sharing, but the evaluations confirmed the third experience was equally important: configuring (within the community). In the right of the table is the interpretation for which of these three main categories the experience finding related to.

According to the conceptual investigations of both research phases, the most important experiences were related to the meaning that the service provided: pleasure of the everyday creativity and the reward of the process. In the 'Life Story Creation' case study the particular experiences related to:

Reward of the process:

- Need to leave something behind for the children (as: "sooner or later the family lineage becomes an interesting topic for everyone")
- Inform about (past) everyday life
- Need to trace one's personal history

Pleasure of the everyday creativity:

- The storing of recollections
- Browsing old photographs
- Motivation, stimulating creativity (enticing those who wrote less or not at all)
- Supporting of a spectrum of expertise: supporting different writing skills

Empirical investigations confirmed that important experiences related to relatedness, popularity, simulation and security, which in this particular case study were related to:

- Sense of togetherness; belonging to a community
- Enjoyment of being noticed and recognized: sharing of work and publication
- Pleasure of the feedback and support:
  - Friends help, refine and revise
  - Discovering of how differently siblings and relatives remember the past
- Sense of inspiration (as suggested: "the more you do, the more you want to do")
- Self-esteem relating e.g. to the need to write about wartime events
- Intentional misuse of the service e.g. to spread gossips
- Need to secure that unfinished work was not shared

Based on the technical investigations, the expectations towards the social media service were expected to focus on personification, customization possibilities, local control and the possibility of being able to complete a job more effectively. These experiences answer to the sense of autonomy and competence for the users. In the 'Life Story Creation' case study the particular experiences related to:

Customization possibilities:

- Need for extendable value communities
- Having all useful components provided (e.g. customary means of forming the text)
- Determining the intimacy level of the sharing

Personification:

- Having support when necessary: helpful instructions, guiding structure
- All the content, in all phases are exchangeable

Local control:

- Decide what to share (e.g. share some of the personal information for all)
- Having the possibility to use (or not to use) the information and comments provided by others

Being able to complete a task more effectively:

- Photographs support the memory
- Comments help to remember things

The technical investigations involved also the consideration of the operation environment. The considerations included the substituting interaction options (in the case, spoken language dialogue). Overall, this operation environment specific experience could be interpreted as having the prospect for a substituting interaction option (which was said to be important according to the value-sensitive studies, but which was not supported by the 'Life Story Creation' prototype).

Discussions

When transferring the find creating experiences to application requirements, there was a strong emphasis to the visual harmony and calmness which the service application aimed to support. There was also a need for aggregating all the information relating to sharing of work and community collaboration, which the application prototype did not support. Within the writing community the configuring experiences; annotation and communicating activities, seemed to be an important clue when assisting in making the service valued and connecting the community together. The experiences were pursued by supporting of different purposes in the creation and sharing tasks, though, according to the evaluations, these efforts were clearly not adequate. The conjecture at the core of the sharing experience seemed to be that people wanted to help each other and construct the ecology around their mutual interest. The sharing activities in the testing phase were carried out mainly by providing instructions and comments. The participants asserted that the modes provided for the sharing activities were not at all sufficient; they expected to have more flexibility for sharing the content intimately, e.g. the proving of personal requests for joining the service or offering of the full publication process so that the work could be shared with a wider audience.

With regard to translating values and experiences into the desired service system, the case study demonstrated how the supportive ecology should be built into the application from the very start, by using design prototypes as drivers for new service innovation. An important contribution of the study was that, by the means of the prototypes, the participants were able to express the unfelt needs that could not have been concluded in any other means. An example of this is the anticipated experience that the system should respond to the need to trace back personal history and learn about lost family ties. Furthermore, the participants expressed a need to extend the sharing network to other domains, and provided a wealth of material on what the activities should cover.

conclusions

This design research produced local understanding that described the context — and thus the study cannot be applied uncritically to other, even similar, cases. Its contribution may be seen as temporary rather than something long-standing, which Geertz remarks to be typical when pursuing local knowledge [Geertz 1983].

According to Cockton, technology push designs where technical innovations may appear to offer opportunities to meet currently unfelt needs [Cockton 2006]. He asserts that, therefore, the purpose of prototyping is to assess whether such new technologies can really deliver anything *worthwhile*. The implication of this article is thus that, as with unfelt needs, people may not be able to articulate what they value now or in the future; only what they have found to be worthwhile and they can express those values by referring to the prototype. In the 'Life Story Creation' prototype, the design — the visualizations and the application — was used as drivers for user-driven innovation. The main research questions were formed around value- and experience-centered design explorations rather than usability aspects — the research concentrated on finding new design opportunities rather than optimizing the service (though this was also achieved on a smaller scale). The evaluations brought out unanticipated values and even design trade-offs; thus, the case study also reflects with the result that Friedman et al. find in their study [Friedman et al. 2006] — it is important to design flexibility into the underlying technical architecture so that it can be responsive to emergent value concerns.

Essentially, the design process of the 'Life Story Creation' service illustrates how illuminating it is to employ value-centered approach to research when the new technology is intended for a specific, predefined ecology. The value-centered approach is especially important if the technology is meant to be used as means for satisfying social needs and experiences. The justification for involving people concerned from the very start of the process has been proposed by Winner [Winner 1986]:

> "the greatest latitude of choice exists the very first time a particular instrument or system, or technique is introduced. Because choices tend to become strongly fixed in material equipment, economic investment, and social habit, the original flexibility vanishes for all practical purposes once the initial commitments are made. In that sense technological innovations are similar to legislative acts or political foundlings that establish a framework for public order that will endure over many generations."

The value sensitive investigations completed in the defining of relevant experiences for the social media service. The main key experiences related to creating, configuring and sharing experiences that were associated in the interpretation with the universal psychological needs of competence, relatedness, popularity, stimulation, meaning, security and autonomy [Hassenzahl et al. 2010]. The detailed categorization of the experience-cantered design findings hopefully may provide assistance for those constructing a social media service for senior citizens. The study engaging seniors for designing unique social service prototype can be seen as an effort to focus on the strategy of postulating contemporary opportunity findings. The experiences could also be read as design proposals for service design. An example of an important present-day design proposal for the creation of the retrospections was said to be the need to write about wartime events. The first focus group participants also provided suggestions for several templates for the service, and another important design proposal was related to providing services to the communities close to the studied one.

The study exposed that there seems to be a particular need for social media services targeted specifically at senior citizens. The design research of the 'Life Story Creation' service was one attempt to answer to that need. The memories of the studied people endure much after the life stories they shared within the means provided by the prototype, but there is a call for more permanent storing of people's life stories and retrospections. Even more so, as the 'Life Story Creation' service was not developed further or published after the research project. If there is an interest for any party to continue the process, one should bear in mind the fact: "when new features emerge, there is always the chance that new versions will bring to light new value choices" [Flanagan 2008]. The similar new service innovations should take to account the remark that an interviewee articulated: *"There are always people's lives and stories involved with this type of writing"*.

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1 Buxton, B. 2010. Sketching User Experiences: Getting the Design Right and the Right Design: Getting the Design Right and the Right Design. Morgan Kaufmann.
2 Cockton, G. 2006. Designing worth is worth designing, Proceedings of NordiCHI Conference, ACM
3 Press, pp. 165-174.
4 Fischer, G., Giaccardi, E., Ye, Y., Sutcliffe, A. G. and Mehandjiev, N. 2004. Meta-design: a manifesto for end-user development, in: Communications of the ACM, 47 (9), 33-37.
5 Flanagan, M., Howe, D.C. and Nissenbaum, H. 2008. Embodying Values in Technology. In. van den Hoven (Ed.) Information Technology and Moral Philosophy, Cambridge University Press, pp. 323-353.
6 Forlizzi, J. and Battarbee, K. 2005. Understanding experience in interactive systems. In Proceedings of designing interactive systems DIS 20114, 1-4 August, Boston, MA (pp. 261-268). New York: ACM.
7 Friedman, B., Kahn, P.H., Borning, A., "Value Sensitive Design and Information Systems", In Zhang, P. and Galletta, D. (eds.), Human-Computer Interaction and Management Information Systems: Foundations, NY: M.E. Sharpe Inc, 2006, pp. 348-372.
8 D. Gauntlett. 2011. Making is connecting: The Social Meaning of Creativity, from DIY and Knitting to YouTube and Web 2.0, Polity Press.
9 Geertz, C. 1983. Local Knowledge. London: Fontana.
10 Hassenzahl M. and Tractinsky N., 2006, User experience – A research agenda, Behavior and Information Technology, 25 (2) 91–97.
11 Hassenzahl, M. 2010. Experience Design, Technology for All the Right Reasons, Morgan and Claypool.
12 Hassenzahl, M., Diefenbach, S., and Göritz, A. 2010. Needs, affect, and interactive products—Facets of user experience. Interacting with computers, 22(5), 353-362.
13 Krueger, R.A. and Casey, M.A. 2000. Focus Groups: A Practical Guide for Applied Research, 3rd ed. Thousand Oaks, CA: Sage Publications.
14 Kuznetsov S. and Paulos E., 2010. Rise of the Expert Amateur: DIY Projects, Communities, and Cultures, in: Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries. ACM, pp. 295-304.
15 Kuniavsky, M. 2003. Observing the User Experience: A Practitioner's Guide to User Research. Elsevier Science. San Francisco.
16 Laitinen, J. 2010. Elämäntarina: Muistelukonsepti ikääntyneille. Final project with thesis, Savonia University of Applied Sciences.
17 Leadbeater, C. and Miller, P. 2004. The Pro-Am Revolution. How enthusiasts are changing our economy and society, London, Demos.
18 Nielsen, J. 1994. Heuristic evaluation. In Nielsen, J. and Mack, R. L. (Eds.), Usability Inspection Methods, John Wiley & Sons, New York, 25-64.
19 Petäkoski-Hult, T., Kurki, M., Järvinen, M., Kuukkanen, H. and Vainikainen, S., 2011. Elderly people in the world of social media, EFRR Congress Perspectives and controversial issues for research in rehabilitation. European Journal of Physical and Rehabilitation Medicine. EFRR. Riva del Garda, IT. Vol. 47, pp. 31 – 32
20 Plomp J. et al. 2010. Sharing content and experiences in smart environments. Handbook of Ambient Intelligence and Smart Environments, Springer US, pp. 511-533.
21 Schuler, D. and Namioka, A. 1993. Participatory Design: Principles and Practices, Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey.
22 Stewart J. 2007. Local experts in the domestication of ICTs, Information Communication and Society, 10(4), pp. 547-569.
23 Winner, L. 1986. Do artifacts have politics? In: Kaplan. D.M. (ed.) Readings in Philosophy of Tech, Pp.289-302.
24 P. Wright, J. Wallace and J. McCarthy. 2008. Aesthetics and experience-centered design, in: ACM Transactions on Computer-Human Interaction (TOCHI) 15.4, 18.

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CO-DESIGNING NOVEL INTERIOR DESIGN SERVICE THAT UTILISES AUGMENTED REALITY

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A CASE STUDY

ABSTRACT

In this paper we describe a co-design process and implementation requirements of an interactive interior design service system. To gain design information for the system we studied two focus groups that were composed of designers, bloggers and serious amateurs in the field of interior design — the estimated critical users of the forthcoming service system. The framework for the co-design study was twofold. The design aim was to study users' innovation capability in the early phase of a complex process by utilising co-sketching as a means of obtaining a user model of the interactive system. The technological aim was to create interior design concepts that exploited augmented reality (AR), 3D models and user-generated content within the system framework. This paper reports the design process and results of the co-design sessions; furthermore, it presents requirements for the system, use cases utilising AR technology, plus consideration and evaluation of the AR functionalities.

KEYWORDS

Interior design,
human-centred design (HCD),
front-end of innovation,
focus group,
sketching,
co-design,
augmented reality,
virtual reality

1
introduction

The case study was part of research that aimed at studying the use of new technologies and applications – social media services, augmented reality (AR) features and location awareness – in the field of advertising, and find new revenue models for media. This paper presents a case study which aimed at understanding the needs and requirements of the design service providers. Research was carried out by co-designing interactive user-centred interior design system concepts that utilised AR features. Co-design focus group sessions were arranged with interior designers and design bloggers – the anticipated critical users of the interior design system.

The participants of the study had taken part in a preliminary online survey, and were therefore all familiar with the background of the system concept. Participants received further information relating to the concept in the focus group sessions, first viewing scenarios that described possible ways of comprising interior 3D and AR services. Participants were then presented with some information from the preliminary online survey, including the key elements and materials thought by most respondents to be critical for the service. This was followed by a short presentation by the facilitators of the AR technology and existing AR applications.

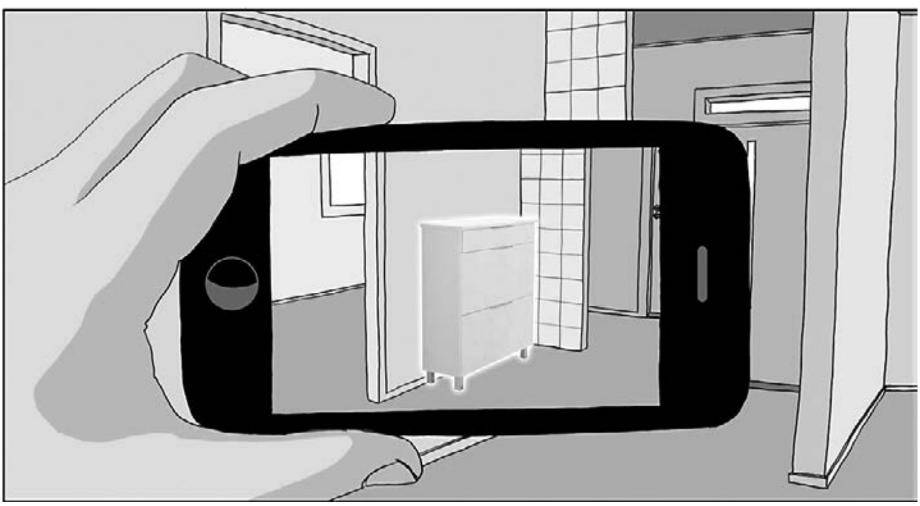
In the co-design phase, the focus group participants co-sketched the system concepts. Sketching proved to be a practical method in this context, as the participants were able to produce dissectible results. Participants provided valuable design information during the discussions – in the form of use cases – concerning the promising ways of utilising AR technology in the service concept.

2
chosen key technology: augmented reality

Augmented reality is defined as an interactive real-time system that combines real and virtual elements in 3D [1]. Virtual reality (VR) consists only of virtual elements. Diminished reality is a system where objects are removed from real environment, and mediated reality refers to a system where real environment is altered virtually [2]. Mixed reality (MR) is a concept that covers all possible combinations of real and virtual elements, from reality to total virtuality [3]. From the user's point of view the functionalities of a system are more important than the technology categorisation. "The basis in all the discussions was an AR system in which real images are augmented with virtual objects. However, in sessions the discussion was open to all forms of combination and alteration of real and virtual elements, including all the above-mentioned technologies – we used the term AR for simplicity, though."

Augmented reality provides a practical visualisation method for purposes where there is a need to enhance the user's perception. Interior design,

Figure 1.
With a mobile AR application the user can see virtual designs in real environment.



in particular, is an application field where the combination of real and virtual benefits the user [4]. Web-based AR applications — in not requiring installation or downloading — are consumer friendly and can be integrated with social media and web stores. Also, recent mobile devices are equipped with reasonable-sized displays and have network connection for accessing the Internet. Based on these facts, we selected a web-based AR interior design service as a starting point for the co-design discussions, and presumed that users could augment digital images and operate the system by using a PC or mobile device.

3 USER-DRIVEN INNOVATION

3.1 Methods

The co-design process falls under the methodological frame of participatory design, which generally aims at democratising design so that the people to be affected by the systems should also be able to participate in and influence the design process [5]. Participants may be involved in the process by means such as focus groups, scenarios and early phase concept design [6–8]; methods which were adapted to this study. Focus group interview is an interview method in which a small group, with similar background, discusses the topics disseminated by the facilitator [6] — in this study, the similarity was the participants' interest in interior design. Because of their experience, the participants were seen as critical users [9] of the future service.

The co-design process was pragmatically conducted by utilising sketching as a co-design method, to provide means for users to produce design outcomes of a complex design service system [10]. The sketching method appeared to be a flexible way of prioritising design issues, and considered suitable for these particular focus group participants. The hypothesis was that sketches would offer support in obtaining a user model of the overall system [11].

3.2 Set-Up of the Co-design Session

The project group had identified a definition statement of the service concept for the focus groups: '*Novel web-based service concepts that exploited 3D and AR technologies, which may be used virtually when creating interior and renovation designs*'. The statement described the system and its core requirements in brief, and was meant to provide focus for the participants' concept ideas. Because the focus group participants were seen as service providers, the emphasis of the co-design session was on the service ecosystem of the concept.

At first, participants were encouraged to identify their role in the service system. It was decided mutually in the sessions that each participant would define her role as an ambiguous *designer*. Participants were then divided into pairs, and each pair encouraged to produce a sketch of the ecosystem in the form of a flowchart. The descriptions were expected to include: 1) all necessary stakeholders and elements of the system (products, services, technologies); 2) how all stakeholders and elements were connected to the ecosystem, and finally 3) which were the most important stakeholders and elements (using a tree-level scale).

The participants were encouraged to think about the application through discussed scenarios, and to exploit the information from the online survey and demonstrated applications. In the sketching phase, participants were provided with sketching tools: paper, pens, cardboards etc. Other materials, such as used e.g. in IDEO's tech box [12]: colour schemes, pieces of wallpaper, images of furniture etc. were available for inspiration and reference purposes.

Following the sketching phase the focus group participants shared their ideas with others. After presentations, participants improved each other's ideas by paying attention to the application definition statement, scenarios, and, most importantly, personal interest.

3.3 Participants

The preliminary online survey data was collected from ordinary consumers (250 respondents) and serious interior design amateurs (36 respondents). The following two focus groups were composed of volunteers from the latter respondents, who were mostly interior designers or serious interior design amateurs: students and bloggers in the field of interior design. The two groups consisting of 3–4 participants, with 1–2 project participants in each group, and one evaluator leading the two-hour co-design session. The first focus group session was arranged in May 2011 at VTT Technical Research Centre of Finland, Espoo, and the second at Alma Mediapartners' facilities at Tampere, Finland. The interviewees were 27–49 years of age, all females.

Figure 2.
Example of a Scenario: Interior design contest for design bloggers.

4
Results

Participants provided detailed information on the qualities of the service during the introduction, while sketching the ecosystems and, finally, when considering the AR features for the service. The following presents the results of the discussions, the ecosystem sketches and the participants' AR use cases with detailed considerations.

4.1
Comments Relating to Scenarios

Pre-made scenarios were first presented, discussed and evaluated in the focus group sessions. The preference of serious interior designers for using very simple design tools in the presented cases was emphasised by the participants, who stressed that usability would be the crucial factor for their interest in using the system. Participants assumed that the real, accurate sizes of the apartment, rooms and furniture were the most critical individual features of the service system. Besides size, the most important qualities for the products, furniture and representative 3D models were stated to be style and colour. It was considered reasonable, however, for colour to be merely suggestive – e.g. fair, mid-dark or dark – to give an impression of the overall design. Participants thought that placing old, existing furniture in the design was even more important than buying new furniture through the service.

It was stated very clearly that a design process often begins by placing existing furniture – an ancestral cupboard or piano, for example – in place, with this piece or artefact defining the overall design plan. However, participants speculated that there might not be any party interested in providing such a service. If the service were to concentrate exclusively on selling new furniture, this would mean all major furniture providers having all their products available in the service system.

Concerning the sharing of design ideas through social media, participants remarked that if they were providing services themselves they would prefer to share their ideas with other interior designers, design enthusiastic people or customers. Designers suspected that general users of the service would also prefer at least semi-professional feedback on their design plans. The participants who were design amateurs were pleased by the idea of the scenario – presenting a home decoration contest (see Fig. 2) – perceiving that the special knowledge and expertise of interior designers and design amateurs could be fully utilised through the contest. Sharing design plans with a wider audience, or with friends and family, were seen as irrelevant.

4.2
Comments Relating to Example AR Applications

Participants subsequently saw three example applications that were benchmarked by the research group. The applications provided 3D and AR functionalities for creating interior designs. Participants were given

Figure 3.
An interior application that utilised AR technology by VividWorks Ltd.

an oral description of the benefits that were the criteria for selecting these specific applications.

Participants provided detailed evaluation of the presented applications. The most important statements related to the visual appearances: the aesthetics. Participants emphasised that the 3D environments and models needed to be attractive and realistic. The realism brought to interior scenes by the showing of lights and shadows and textures in detail, for example, would make them more convincing. It was also seen as advantageous to induce the user/designer to feel that decorating rooms and creating plans was "leisure activity" – that it was fun to spend time in this way and to explore the service. The design competitions for interior designers in the example applications seemed to lack purpose: there were too many of them with no reward. In addition, the most important priority was stated to be the overall costs of the products and services. The existing services, however, only showed prices for single articles.

4.3 Sketches of the Service Ecosystem

After the introduction phase, participants created system concepts in pairs and presented them to each other. Figure 4 presents an example of a concept made by one of the pairs. The pair explained that the ambiguous *designer* and the service tool were identical (as it is the designer who uses the tool). The first task was to feed the background information and facts into the system, e.g. the floor plans. The sketch contained a two-way arrow – at this point the information either exists or has to be created. The main service providers in the cooperation were interior decorating stores (for wallpapers, floor and wall materials) and furnishing companies. The existing furniture was equally important – "*the past life, which does not vanish when a new home comes along*". Service providers were the second priority: the individual designers who offer their services, or could be accessed through the service. A third priority was logistics; those who put all the pieces together and provide complete light decoration services, for example. This was followed by accessories, e.g. lighting providers and art suppliers. The sketch also described the chronology of events.

Table 1 presents the results of the service ecosystem sketches, and the conclusions of the co-sketching session. Participants were encouraged to determine the importance of the factors using a tree-level scale. For the most important factors, participants used numbering, a different colour, or a stronger line, and confirmed and explained the importance of the services after sketching the content. As the table shows, participants thought that the new furniture and interior decoration providers were key factors in the service. The participants perceived themselves in the co-design situation as designers, but while creating concepts all mentioned the importance of the customer relationship. Also, all mentioned the other designers – competitors or designers with different expertise. The participants highlighted some new providers to be included in the service: kitchen-,

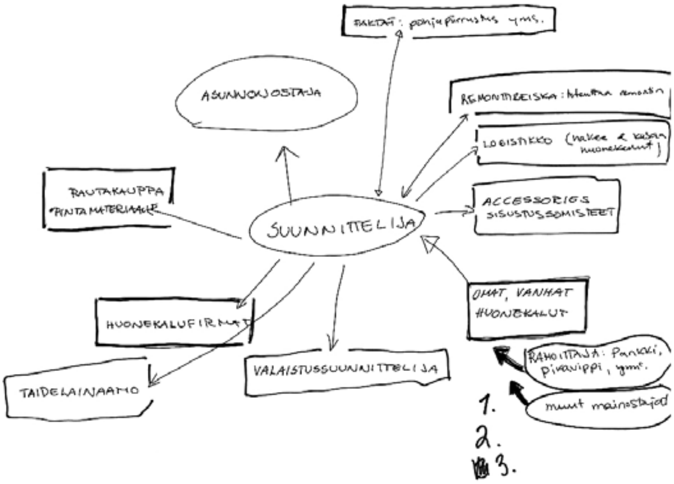


Figure 4.
Example of a sketched service ecosystem.

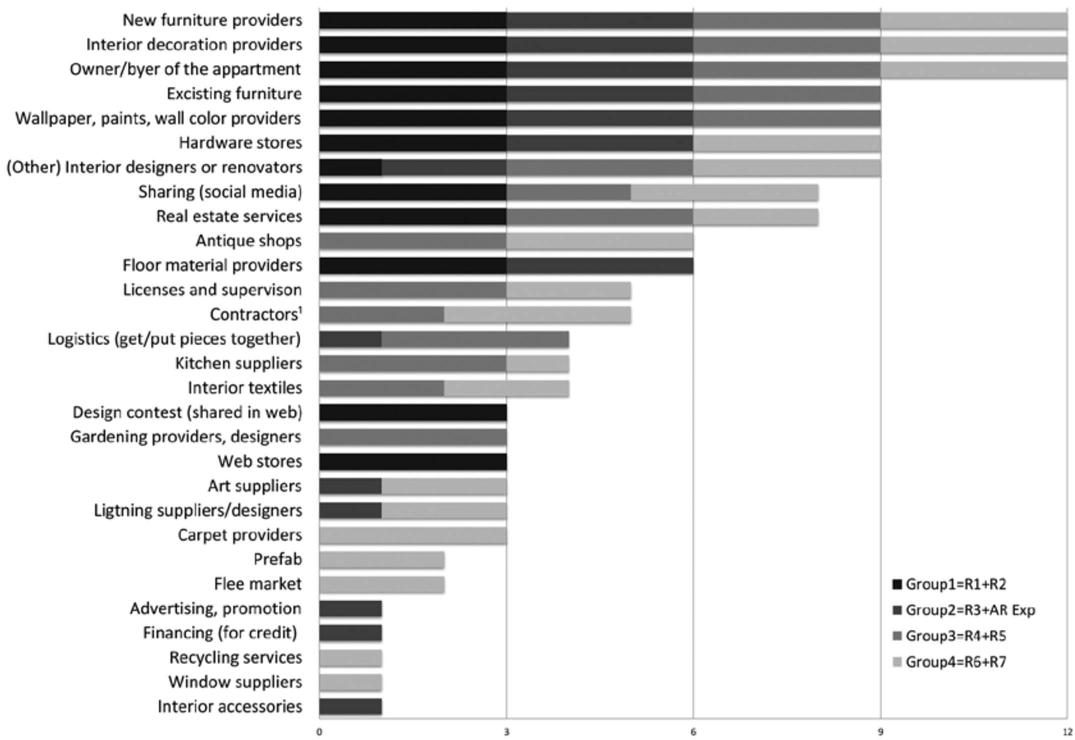


Table 1.
Results of the service ecosystem sketches. If all pairs (groups 1–4) thought a service was most important, the service received 12 points. If only one mentioned it, and did not value it highly, the service received only one point. Contractors = e.g. HPAC-planning, electricity, masons

window- and carpet providers, antique shops, flea markets, art suppliers, gardening-, lighting- and 3D-model designers of existing furniture. From this viewpoint the service was seen as a cluster for smaller providers.

With a service dealing with novel ideas, participants emphasised that the price of furniture, material and accessories would constitute the essential feature of the concept. It was therefore considered important that the total cost of the new furniture and design alterations should be clearly visible. One group remarked that the customer could apply for a loan from a credit provider if it were possible to refer to an estimate provided by the service.

Because the information was qualitative there was some overlapping with the service providers presented in the table. Some participants, for example, mentioned hardware stores, but described them later as interior decoration providers, and placed both of them in their ecosystem sketches. There were also some conflicts relating to participants' statements of preference during the conversations, and how they were implemented in the ecosystem sketches. For example, all participants emphasised the importance of old, existing furniture in the service, but this nonetheless failed to receive the full amount of points in the analysis.

4.4 Ideas for Augmented Reality in Interior Design System

After sketching the service ecosystem concepts, the focus group participants thought more thoroughly about the AR features of the interior design service. Three topics were highlighted above others in the discussions: realistic lighting, number and variety of furniture models available (including 3D reconstruction of existing furniture), and search functionalities.

Based on their experience, participants emphasised how the lighting conditions affected the overall feeling and atmosphere of a space — and how difficult it was to explain for the customers. By using the AR technology, they saw an opportunity to visualise lighting effects: e.g. an ideal system would show the space in realistic lighting in the evening, morning, winter or summer, or according to the position of the windows. This would show the virtual apartment in a more realistic light: *"All dark corners during winter days, and harsh light during spring"*. Besides the ambient lighting, participants pointed out that it would also be useful to be able to model and visualise the lighting effects of different light sources e.g. to demonstrate the accurate size of selected spotlights.

Designers explained further that they constantly experienced situations in which they had no tools to communicate with the customers e.g. about the colours of the walls. One designer described such a situation: *"The effect of black walls are unimaginable for most customers, as white walls are still so common, but the atmosphere could really be altered by simply changing one wall to black."* This situation could be demonstrated quickly with on-site AR or VR technology.

The participants created use cases that could employ the AR technology, presenting a case in which a person was interested in a particular apartment. With this type of use the person could take pictures of the physical apartment and furnish it later virtually, at home, using the AR service.

The participants raised the issue of the visual quality of the design, which is highly important in interior design planning processes. The participants stressed the importance of the rendering quality of virtual objects: the application should be able to produce realistic materials and lighting effects on virtual objects. Participants stated that they would not engage AR features in the service unless the quality correlated sufficiently with the real environment.

Another important issue was that the availability of virtual models should not restrict the inspiration of a design. If the designer has e.g. an antique furniture model in mind, it should be possible to add it to the interior design plan or at least to represent it using an almost equivalent model. The same need applies to existing furniture; the user should be able to add virtual counterparts of the furniture easily into the design. This means that the 3D-object library should be large, and should contain generic objects whose colour, size and materials could easily be changed. Alternatively, designers should easily be able to create their own models e.g. based on images of an item of furniture. The service should also contain smaller objects, such as curtains, plants and flowers, paintings, posters and photo frames. Participants hoped for a sophisticated database search that enables search by colour, style and size. Typical situations were described as e.g. *"I need a chair of this size"* or *"I want a reddish couch"*.

5 REFLECTION: TECHNOLOGICAL FEASIBILITY CONCERNING AR

Concerning the remarks on the AR functionalities, it was said that virtual lights and shadows affect not only the visual quality perceived by the user, but also the realism of the augmentation. In other words, virtual objects seem to hang in the air if they are not attached to the floor with virtual shadows. Virtual lighting, similar to real lighting, embeds the virtual furniture as part of the environment. It is also possible to adjust virtual lights easily, according to real light sources, with user interaction in interior design application [13].

Photorealistic rendering, i.e. the production of photo-like 3D graphics, is computationally demanding, similarly in applications where live video feed is augmented. However, still images are well suited to interior design applications [13], and computation time is therefore not an issue. It is possible to measure the real lighting conditions of the environment, adapt the virtual object to it, and produce adaptive photorealistic AR [14].

The participants expressed a need for a large object library that supports creativity, together with sophisticated search functionalities. The challenge of a model library lies in economics: how to create a business model that supports the creation and sharing of 3D models. We may assume that if an interior design service has a sufficient number of users, the creation of a large number of 3D models would be viable.

6 CONCLUSION

Since the focus group participants' expertise was high, they were able to create several new, aesthetic ideas for the interior design system concepts. AR technology was mostly speculated upon by offering examples of existing AR features, yet the participants were able to provide valuable feedback: AR use cases, and the fact that the evaluations of the feasibilities were based on the experience of interior designers.

The sketching approach for empowering a co-design process proved to be a flexible and productive method of involving users in the innovation conception phase, and for perceiving a user model of an interactive design system. Table 1 — the results of the service ecosystem sketches — presents certain evidence that it is also conceivable to analyse users' models. Moreover, because of the ecosystem descriptions, the highlighted issues were discussed more thoroughly in the focus groups. In exploiting sketching as a means of involving users in the interaction design processes, the key finding was that during the co-design session the sketches remained in the custody of the participants: even if the conversation and new information led opinions and ideas along different courses, participants expressed their judgements by referring to their sketches.

After studying the most important requirements of the critical users for the AR technology, it can be said that most ideas could easily be implemented in an interior design service system. When it comes to participants' needs for modelling existing furniture, however, it may take some time before practical solutions are available; current solutions for 3D reconstruction (i.e. construction of a three-dimensional model of an object from several two-dimensional views) require too much involvement and knowledge from the user. Research is nevertheless moving towards rapid 3D reconstruction on mobile devices [14]. In future interior design services, the user is expected to scan the interior environment effortlessly with a mobile device, and even obtain modelling of an existing item of furniture.

Focus group user evaluations and co-design sessions provided adequately new information for further design and development of interactive interior design services that utilise AR technology. The focus group participants, whom we anticipated to be the critical users of the service, in turn described the users of the service as: interior designers, interior architects, various decorators, model creators, lighting consultants, electrical consultants, small or large furniture companies (or individuals), decoration- and renovation providers.

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1 Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S. and MacIntyre, B. Recent Advances in Augmented Reality. IEEE Computer Graphics and Applications, Vol. 21, No. 6, pp. 34-47 (2001)

2 Mann, S. Mediated Reality with implementations for everyday life. Presence Connect, MIT Press journal PRESENCE: Teleoperators and Virtual EnvironmentsPresence (2002)

3 Milgram, P., Takemura, H., Utsumi, A. and Kishino, F. Augmented Reality: A Class of Displays on the Reality-Virtuality Continuum. In Proceedings of the SPIE Conference on Telemanipulator and Telepresence Technologies, pp. 282-292 (1994)

4 Siltanen S. Theory and applications of marker-based augmented reality. VTT Science 3. Espoo. Finland, in Press (2012)

5 Schuler, D. and Namioka, A. Participatory Design: Principles and Practices, Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey (1993)

6 Morgan, D.L. The Focus Group Guidebook, Sage Publications Ltd. (1998)

7 Carroll, J.M. Making Use: Scenario-Based Design of Human-Computer Interactions. MIT Press, MA, USA (2009)

8 Greenbaum, J. and Kyng, M. (eds) Design at Work: Cooperative Design of Computer Systems. Lawrence Erlbaum Associates, New Jersey, USA (1991)

9 Cassim, J. and Dong, H. 'Critical users in design innovation'. In Clarkson, P.J., Coleman, R., Keates, S., and Lebbon, C. (eds.) Inclusive Design: Design for the Whole Population, Springer-Verlag, London. pp. 532-553 (2003)

10 Buxton, W. Sketching User Experiences: Getting the Design Right and the Right Design. Morgan Kaufmann, San Francisco, USA (2007)

11 Kymäläinen, T. in Saariluoma, P. (ed.), Kujala, T., Kuuva, S., Kymäläinen, T., Leikas, J., Liikkanen, L. and Oulasvirta, A. Ihminen ja teknologia – Hyvän vuorovaikutuksen suunnittelu, Teknologiateollisuus, Helsinki, Finland (in Finnish). Human and Technology (2010)

12 Kelley, T., and Littman, J. The Art of Innovation: Lessons in Creativity from Ideo, America's Leading Design Firm. Doubleday, New York (2001)

13 Siltanen, S. and Woodward, C. Augmented Interiors with Digital Camera Images. Piekarski, W. (ed.) In proc. Seventh Australasian User Interface Conference (AUIC2006); CRPIT. ACS. Vol. 50: 33 (2006)

14 Aittala, M. Inverse lighting and photorealistic rendering for augmented reality. The Visual Computer, Vol. 26, No. 6, pp. 669-678 (2010)

15 Hartl, A., Gruber, L., Arth, C., Hauswiesner, S. and Schmalstieg, D. Rapid reconstruction of small objects on mobile phones. Computer Vision and Pattern Recognition Workshops, IEEE Computer Society Conference, Colorado Springs CO, USA, pp. 20-27 (2011)

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DESIGNING A MUSIC PERFORMANCE SPACE FOR PERSONS WITH INTELLECTUAL LEARNING DISABILITIES

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ABSTRACT

This paper outlines the design and development process of 'DIYSE Music Creation Tool' concept, by presenting key questions, used methodology, music instrument prototype development process and user research activities. The aim of this research is to study how music therapists (or instructors) can utilize novel technologies and study new performing opportunities in the music therapy context, with people who have intellectual learning disabilities.

The research applies an action research approach to develop new music technologies by co-designing with the music therapist's, in order to develop in situ and improve the adoption of novel technologies. The proof-of-concept software utilizes Guitar Hero guitar controllers, and the software allows the music therapist to personalize interaction mappings between the physical and digital instrument components. By means of the guitars, the users are able to participate in various musical activities; they are able to play prepared musical compositions without extensive training, play together and perform for others. User research studies included the evaluation of the tool and research for performance opportunities.

KEYWORDS

music interfaces,
music therapy,
modifiable interfaces,
design tools,
Human-Technology Interaction (HTI),
User-Centred Design (UCD),
design for all (DfA),
prototyping,
performance.

1
INTRODUCTION

The Do It Yourself Smart Experiences (DIYSE) project[1] aims at enabling ordinary people to easily create setup and control applications in their smart living environments as well as in the public Internet-of-Things space, allowing them to leverage aware services and smart objects for obtaining highly personalized, social, interactive, flowing experiences at home and in the city. The development of the 'DIYSE Music Creation Tool' and the user research studies were based on a preliminary study within the DIYSE-project. The study outlined the everyday life of people with intellectual learning disabilities[2] concerning new technologies. Based on this preliminary research, the music therapy context was chosen for the research framework.

Learning to play any traditional musical instrument requires long-term training, and consequently many beginners never succeed in developing the necessary fine-motor skills to play music. This is especially the case with the end-user group of this study; people with intellectual learning disabilities. This user group needs musical interfaces that are extremely easy to understand and to adopt: the paradigm is also found in the studies of Machover [6] and Benvenieste [1]. Therefore, the aim of this study has been to design easy-to-learn interactive music instruments and develop alternative methods for music creation. This paper presents the challenges of interaction design related to the music creation context, describes the prototype development and the user-centred design research processes [5].

2
INTERACTION DESIGN FOR A MUSIC CONTEXT

In the field of interaction design research, there is a demand for new design tools that enable creativity by means of explorative interaction, as opposed to limited executive and mission-based interaction (e.g. [3], [5] & [6]). Petersen et al. have proposed that the aesthetical interaction perspective offers an alternative to traditional interaction ideals [6]. In aesthetic interaction, the user is seen as an improvisator and the interaction between the human and the technology is a situation of play. According to Petersen, aesthetic interaction is found in the concept of intrigue, that is connected to experience, surprise and serendipity in the use of interactive systems (ibid p. 274). In the light of Petersen's theory, when the creativity-supporting music tools are being designed, equal attention should be paid to players' cognitive skills, emotional values and bodily capabilities. A music-playing learning situation should able the player to imagine, create, play, share and reflect musical actions [7]. The playing situation involves an interaction feedback loop between the participants, their instruments and produced sounds. In an ideal state, a playing situation should encourage players to improvise and express themselves through playing and experiencing immersion.

3
METHODS AND TOOLS

3.1
Prototyping

In the pursue of finding means to support the musical activities of persons with intellectual learning disabilities, we begun by simplifying the music creation process and concentrated on finding interactive technologies that were easily available and easy to use. According to the preliminary research, we had learned that the target group end-users had various, and often multiple, disabilities and that they were enthusiastic about music. In the initial research phase, various sensor technologies were experimented and observed with the end-users. The prototyping phase was carried out through an iterative co-design process between the designers and a music therapist. The co-operation with the professional music therapist was an essential part for developing the prototype. For developing the digital user interface we used the Max MSP graphical programming language [12]. Nintendo Wii Remotes [13] and Guitar Hero controllers were chosen for our physical controller framework. Both of the technologies offered good technological support for realizing proof of concept prototypes because of their technological reliability and widely active open source and sharing communities.

1
http://www.dyse.org

2
People who have a mild or moderate intellectual learning disability (Diagnosis ICD-10).

3.2
Music Therapy Context

The use of the ‘DIYSE Music Creation Tool’ was observed and evaluated in a natural music therapy context, in order to gather information about the adoption and usability of the software and the instruments. Rinnekoti Foundation, a service provider for disabled people and partner in the project, provided the facilities for the evaluation and ‘DIYSE Music Creation Tool’: a computer, three guitars and the software, were brought to the music therapy studio. The therapist chose the players based on their capability to benefit from the new means to make music and based on the availability for the whole observation period. The music therapist proposed a performance, and thereby the observation period culminated into a final concert, in which the participants performed the music piece to an audience with the instruments accompanied by an acoustic drum kit. The concert was part of the DIYSE project research consortium meeting (see video link in the appendices section).

3.3
Prototype Evaluations

The ‘DIYSE Music Creation Tool‘ was evaluated in two phases. The first evaluation session was arranged in August 2010, at the Rinnekoti Foundation, Espoo, Finland. The participants were 26—58 years of age. All of the interviewees knew each other beforehand and were accustomed to participate in music therapy sessions. The research methods were observations and semi-structured interviews [5] and there were two objectives for the evaluations. Firstly, the initial goal was to determine technical requirements by utilizing co-design, and thereby the music software was introduced to the music therapist. Secondly, the acceptance and the user experience was evaluated with the players. At the end of the evaluation session, there was a short ‘Sonic Sketching’ workshop that was aimed to encourage participants to innovate surprising and inspiring ideas for novel music instruments.

Figure 1.
‘Music therapy session: learning to play and practicing for a performance.

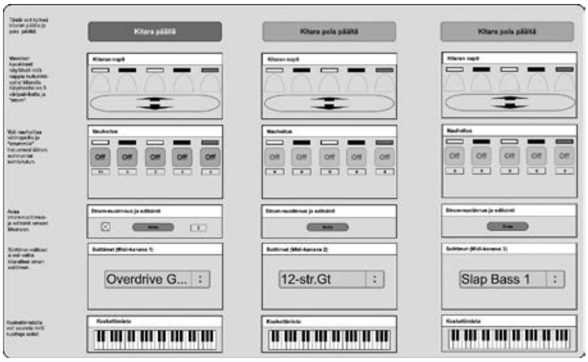

Figure 2.
DIYSE Music Creation Tool’ software’s main window: functionalities for recording, mapping interactions and choosing sounds.

The second evaluation phase was held between October/November 2010, at the Rinnekoti Foundation and the participants were mostly the same as in the first phase. The observation framework was arranged for 1.5 weeks observation period, and the music therapist was responsible for the therapy context within the given framework. The therapist carried out most of the therapy sessions individually. The video observation period lasted ten days, and seven music therapy sessions were video-recorded on that time scale. The recorded video material was analysed based on the ‘interaction analysis lab’ method [3]. In the method, the observers comment about the context of the video material, create a hypothesis about what is occurring in the recording, and discuss about the context [10]. During the analysis, the material was observed according to four topics: supporting creativity, learning, user frustration and independent playing.

4
Results

4.1
Prototype

The software features the following three functionalities: 1. Composing and restoring music tracks in the software. 2. Design of interaction mapping strategies between the guitar's interface elements and played sounds. 3. Choose sounds for the guitar. Figure 3 presents the software's interface layout.

4.1.1
Prototype in Use

The music therapist prepared the therapy sessions by recording song arrangements into the software using a midi keyboard. The music in the first evaluation session was a general 12 bar 'blues' theme. For the second session, the therapist chose a song composed called 'Egyptian Reggae', by Richman Jonathan. The first song was used for practicing purposes and the latter was rehearsed to be performed in the concert. According to the therapist, the chosen genres – the blues and the reggae – were stated to provide a 'good groove' and were therefore suitable for the therapy group. In addition, the songs' musical elements were easy to arrange for the three guitars. The therapist arranged the musical elements as follows: 1. bass guitar, 2. rhythm guitar and 3. solo guitar.

The software assisted to map the arranged sound elements to the three guitars interface elements. The bass guitar was played using the controller's strum switch. The switch triggered single notes from a step-sequencer's timeline in sequential order. The bass guitar was meant to be the easiest instrument to learn as it produced meaningful musical structures through simple switch triggering. The rhythm guitar and the solo guitar were played by pressing the color buttons attached on the controller's neck. The rhythm guitar's idea was to challenge the player to play chords in the right order and time. The solo guitar was designed to support an idea of free playing and expression. Using only harmonic

Figure 3.
Practicing to operate the instruments: music therapist giving instructions – red, green, yellow...

notes, each mapped to the guitar's colored buttons, the audible result was designed to be pleasing as there were no dissonant notes.

4.2
Interviews and Observations

According to the interviews and observations, the most satisfactory attribute of the 'DIYSE Music Creation Tool' was the experience itself; the joy of creating and generating music and the feel of accomplishing something in a short period of time, even if the players lacked the skills to play musical instruments. This sense of easiness was consequence of the fact that some music pieces were composed beforehand and thereby there were "no wrong notes" i.e. if the player pressed the bass guitar's strum, the music floated and sounded pleasant. According to the preliminary observations, it seemed to be important that the instruments resembled real instruments, guitar and bass, for the reason that its affordances are perceivable [2]. For the music therapist, it was important that there were many alternatives to choose from the sound library, relating to music genres, instruments, sounds and tones. The most significant finding was the fact that performing to an audience seemed to be important to this user group. Generally, the threshold to perform and try out new things seemed to be quite low.

4.3
Interaction Analysis Lab

The music therapist used a lot of effort in trying to provide a creative atmosphere, so that the therapy situation would not be just about pressing buttons and learning rhythm. For example, he accompanied the players by playing traditional instruments and encouraged the players to communicate with him through musical expressions such as tempo variations and pauses. In addition, he made occasional polyrhythmic textures in order to increase the complexity level of playing. Many times his efforts disturbed the participants, as finding the rhythm took all their attention. Otherwise, the playing situation was quite static; it appeared that there was not much improvisation or experimental playing during the practise. An incentive to support creativity with the 'DIYSE Music Creation Tool' was the promised performance for an audience.

The observations indicated that the appearances, the shape and sound of the instrument, were important and that the instruments must support the player's identity. For example, one of the players mentioned that because his brother played the guitar in a band, he liked to play it too. However, the guitar-like shape also provided challenges: it was difficult to detect the colour buttons and it was challenging to decide how to hold the instrument, as it seemed to be uncomfortable to hold it 'like a guitar'. Some participants even did not have enough motor coordination to play the instrument like a guitar. This was an important observation, because the way to hold the instrument influences to how the feedback is received. Preferably, the interaction with the instrument should be as intuitive as possible. Observations indicated also that it seems to be more important for the players to press the right button at the right time, than to have a subjective playing experience and feel comfortable in the role of an improviser.

The music therapist himself learnt to prepare the system on the third observation day; connecting the guitars and the computer, uploading the sounds and creating personalized mapping strategies for the players. The most significant observed difficulty of the learning experience, was related to learning the rhythm. If the players could not find the rhythm, it became difficult to perceive a mental map of the overall situation, and the users were disappointed and frustrated. In general, the players of this user group needed a lot of support from the therapist i.e. the level of independency was low. The music therapist guided the participants e.g. by instructing the colour keys of the instrument: "red-green-yellow" (see figure 5). On the third observation day, there was a new player attending to the music therapy sessions. He practiced playing the instruments only once and was therefore an excellent subject to study. At first, he played the bass and was able to learn the first three notes of the rhythm pattern, but learning the whole rhythm structure seemed to be quite demanding for him too. Yet when he finally had learned the rhythm, it seemed to be extremely rewarding.

During the observations, there were specific moments when players seemed to be quite frustrated. For example, in the second observation day one of the players was notably disturbed. His playing of the bass was already fluent and therefore his gaze wondered towards other interests. One of the players stated to be tired of the chosen piece of music, and he wanted to play something else. Frustration was apparent especially when the participant's ability to learn was not properly taken into account. There seemed to be a delicate balance between patronising the player and providing too much information and encouragement for independent playing.

5 DISCUSSION

The 'DIYSE Music Creation Tool' was intended to be a design tool for the music therapist. During the design process, the therapist utilized the system for planning the sessions for his customers, and the end-users utilized the system for playing music and performing. By co-designing the system and using it in a real therapy situation, it was possible to create and develop new music playing experiences for music therapy clients in situ. Creativity was chosen to be a critical issue of the study. Based on the theoretical background and the results attained through the user evaluations, it was perceived that the Guitar Hero controller is not an ideal controller for playing music. The controller's interface elements mainly support point and click interaction style, which is suitable for playing rhythm games as indicated by Machover [5]. Supporting only the rhythm is not nearly enough; rhythm, timbre, pitch and time should all be considered equally important when designing interactive music instruments. In the light of Petersen et al [6], the Guitar Hero controller can be mainly seen from the mechanistic tool perspective, thus having distance to dialogue, media and aesthetic views of interaction. In search of the aesthetic experience, we emphasize experimental aspects of the four music elements presented above. Therefore interaction design of the instrument should encourage the player to explore and playfully appropriate the musical dimensions through the instrument. However, it must be acknowledged that the point and click interaction is one considerable alternative when designing music instruments for persons with learning disabilities. A significant finding of the research was that it is important to minimize the possibilities to fail (or the feeling of failure) by keeping the control of the instrument simple. On the other hand, it is important that the playing situation challenge the player in the five learning phases that Resnic [7] presents: imaging, creating, playing, sharing and reflecting. In future research, we intend to develop instruments that enable explorative human-computer interaction. This allows the players to concentrate on the creative process of music making and creating in a performance space. Performing on stage and training for the performance were stated to be very important. Some of the challenges for future design phases include providing support for two or more players and for the coplaying concept as a whole. Social media could support in developing the music performance space by offering a tool for publishing music and providing a place for recording music or performing. In an ideal situation, digital and physical tools help users to enhance their everyday life; to think, to design and create art, experiment with new technology and technological gadgets and become stakeholders in public projects..

REFERENCES

1 Benvenieste, J. Jouvelot, P., Lecourt, E. and Renaud, M. Designing Wiiprovisation for Mediation in Group Music Therapy with Children Suffering from Behavioral Disorders, IDC 2009, Como Italy.

2 Jordan, B. & Henderson, A., 1995. Interaction analysis: Foundations and practitice, The journal of the learning sciences 4 (1), 39-103.

3 Krippendorf, K. 2006. The semantic turn, a new Foundation for design, Taylor & Francis.

4 Kuniavsky, M., 2003. Observing the user experience: a practitioner's guide to user research, Morgan Kaufmann.

5 Machover, T. 2009. "Beyond Guitar Hero - Towards a New Musical Ecology." RSA Journal (London), January— March 2009.

6 Petersen, M. Iversen, o. Krogh, P and Luvigse, M. Aesthetic Interaction — A pragmatist's Aesthetics of Interactive Systems. DIS2004, Cambridge, Massachusetts, USA.

7 Resnic, M, N/A, All I Really Need to Know (About Creative Thinking) I Learned (By Studying How Children Learn) in Kindergarten, Mitchel Resnick: kindergarten approach to learning, MIT Media Lab, Cambridge.

8 Ylirisku, S., Buur, J., 2007. Designing with video: Focusing the User-centred design process. Springer.

LINKS

9 Max MSP, Web site (read April 26, 2011): http://www.cycling74.com

10 Nintendo Wii Remote, Web site (read April 26, 2011): http://www.nintendo.com/wii/console/controllers

VIDEO

http://www.youtube.com/HTIforWelbeing

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A USER-CENTRIC VIEW OF INTELLIGENT ENVIRONMENTS

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USER EXPECTATIONS, USER EXPERIENCE AND USER ROLE IN BUILDING INTELLIGENT ENVIRONMENTS

ABSTRACT
Our everyday environments are gradually becoming intelligent, facilitated both by technological development and user activities. Although large-scale intelligent environments are still rare in actual everyday use, they have been studied for quite a long time, and several user studies have been carried out. In this paper, we present a user-centric view of intelligent environments based on published research results and our own experiences from user studies with concepts and prototypes. We analyze user acceptance and users' expectations that affect users' willingness to start using intelligent environments and to continue using them. We discuss user experience of interacting with intelligent environments where physical and virtual elements are intertwined. Finally, we touch on the role of users in shaping their own intelligent environments instead of just using ready-made environments. People are not merely "using" the intelligent environments but they live in them, and they experience the environments via embedded services and new interaction tools as well as the physical and social environment. Intelligent environments should provide emotional as well as instrumental value to the people who live in them, and the environments should be trustworthy and controllable both by regular users and occasional visitors. Understanding user expectations and user experience in intelligent environments, and providing users with tools to influence the environments can help to shape the vision of intelligent environments into meaningful, acceptable and appealing service entities for all those who live and act in them.

KEYWORDS
intelligent environments;
ambient intelligence;
user acceptance;
user experience;
interaction;
tangible interaction;
augmented reality;
do-it-yourself

1 Introduction

Intelligent environments have now been envisioned for over 20 years. The original vision of ubiquitous computing—machines that fit to the human environment instead of forcing humans to enter theirs—presented by Mark Weiser [1] has been complemented over the years. The concept of Ambient Intelligence (AmI) was proposed by the ISTAG, European Commissions IST Advisory Group [2]. Ambient Intelligence emphasizes the human viewpoint—user-friendliness, efficient service support, user-empowerment, and support for human interactions. In the scenarios presented in the ISTAG report [2], people were surrounded by intelligent intuitive interfaces embedded in the environment and in different objects. The environment was capable of recognizing and responding to the presence of people in a seamless, unobtrusive and often invisible way. The concept of a smart or intelligent environment emphasizes technical solutions such as pervasive or mobile computing, sensor networks, artificial intelligence, robotics, multimedia computing, middleware solutions, and agent-based software [3]. Those technical solutions acquire and apply knowledge about the environment and the people in it in order to improve their experience in that environment. Thus, intelligent environments target the same kinds of user experiences as does Ambient Intelligence. Aarts [4] saw a focus shift in AmI visions from productivity in business environments to a consumer- and user-centered design approach. A major challenge remaining is to understand and anticipate what people really want and to build solutions that really impact their lives [5]. Aarts and Grotenhuis [5] propose revisions of the original ideas of Ambient Intelligence, emphasizing the need for meaningful solutions that balance mind and body rather than driving people to maximum efficiency.

The development, concretization and adaptation of large-scale and truly intelligent environments has been slow, and intelligent environments are still rare in actual use. Nevertheless, intelligence is gradually entering our environment, especially with the development of mobile technologies, social media and new interaction tools. As a result of people's growing expectations of new technology and the on-going societal development towards an 'experience economy' [6], it has become increasingly important to understand the expectations that people have of intelligent environments. User's expectations reflect anticipated behavior, direct attention and interpretation [7], exist as a norm against which the actual experience is compared [8], and influence the user's perceptions of the product [9], thus having an influence on forming the actual user experience and acceptance of the product. For example, Karapanos *et al.* [10] state that "often, anticipating our experiences with a product becomes even more important, emotional, and memorable than the experiences *per se*". We argue that it is important to understand what people expect of intelligent environments, hence gaining new insights into the design targets, limitations, needs and other considerations that should be taken into account when designing intelligent environments.

Since the first visions, several research and development activities have been pursued. Many of those activities have included user evaluations, resulting in empirical knowledge of potential users' expectations of the different facets of intelligent environments. The design focus on human-technology interaction has been extended from mere usability or identifying human factors to embracing a rich user experience [11], hence emphasizing emotional and experiential aspects in addition to rational and instrumental ones. This has allowed the study of users' expectations in a more comprehensive way, allowing identification of subjective meanings, long-term product attachment and emotional values such as pleasure and playfulness.

In this paper we deal with user expectations on three levels as illustrated in Figure 1. Firstly, in Section 3 we discuss *user acceptance* of intelligent environments (IE): what do people value, what do they consider to be threats, and what other factors affect user acceptance? We review several user studies to analyze issues that affect the willingness of people to adopt intelligent environments. The second level is *user experience* when acting in an actual intelligent environment. Section 4 is devoted to understanding experiential aspects of the interaction. Intelligent environments may include different interaction technologies, but in this paper we focus on interaction tools that intertwine physical and virtual elements; tangible and embodied interaction techniques. These interaction tools are studied as examples of the kinds of user experience targets we can set for actual intelligent environments. The third, emerging level is the users' own role as *co-crafters* of intelligent environments—users are not just using intelligent

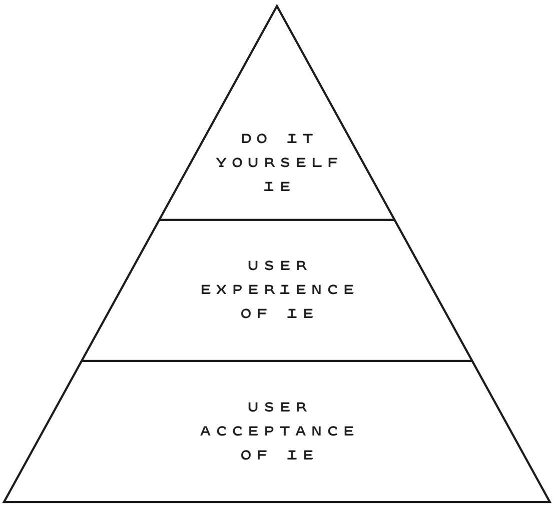

Figure 1.
The viewpoints of user expectations of intelligent environments (IE) in the paper.

environments but are living in them, and at the same time developing the environments themselves. Intelligent environments should allow users to shape the environments gradually as the needs of the users change. In Section 5, we describe our approach to extending the users' role of just using the given intelligent environments to actively design and build their own intelligent environments: do-it-yourself smart environments.

In Sections 3–5 of this paper, the review focus is narrowing from general issues related to all intelligent environments (user acceptance) to specific issues of specific interaction concepts (user experience) to specific issues of individual environments (do-it-yourself (DIY) intelligent environment). The three viewpoints of our study can also be seen as representing different phases of the design process: before starting to design an intelligent environment, the designer needs to understand what could increase or decrease user acceptance. Once starting the design, concrete targets should be set for the user experience that the environment should provide. When the intelligent environment is in use, it should still provide the user with ways of shaping the environment according to user's current needs and ever-changing expectations. Consequently, in the pyramid in Figure 1, the upper level can be seen to be founded on the layers below it; for pleasurable UX to take place requires that acceptance issues are well-implemented, and the DIY approach assumes that the overall UX demonstrates other positive experiences in the human-technology interaction.

Regarding user expectations, we will analyze expectations of various facets of intelligent environments in a broad sense, based on published research results and our own experiences from user studies with concepts and prototypes. First, in Section 2 we will discuss potential application fields for intelligent environments, focusing mainly on consumer services. Then in Sections 3 to 5 we will review user expectations of intelligent environments from the three viewpoints presented in Figure 1: user acceptance, user experience and users as designers of their own environments. Finally, based on the presented results of user expectations, we will discuss how user expectations should be dealt with in order to facilitate the take-off of large scale intelligent environments.

2 CHARACTERISTICS OF INTELLIGENT ENVIRONMENTS

In future visions [2, 12–15] intelligent environments are characterized by information and communication technology embedded so seamlessly into our physical environments and in various everyday objects that ICT-enabled features will become a natural part of our living and working environments. People are surrounded by intuitive interfaces, and the environment is capable of recognizing and proactively responding to the presence of different individuals in a seamless, unobtrusive and often invisible way. In the visions,

ICT EVERYWHERE	ADVANCED INTERACTION	ALGORITHMIC INTELLIGENCE
Embedded information and communication technologies	Natural interaction	Context-awareness
Communication networks	High level concepts in interaction	Learning environment
Mobile technology	Environment evolving gradually both by design and use	Anticipating environment

Table 1.
The three technology development paths required for intelligent environments [12].

people are given situation-aware support in their everyday activities; they gain new possibilities to act, and they are provided with new opportunities to interact with each other, irrespective of time and space.

In the ISTAG report [2], 5 key technology requirements for Ambient Intelligence were identified: very unobtrusive hardware, seamless web-based communications infrastructure, dynamic and massively distributed device networks, a natural-feeling human interface as well as dependability and security. The technical enablers for intelligent environments can be classified in three groups: information and communication technology (ICT) embedded to our environment; advanced interaction possibilities; and algorithmic intelligence [12] (Table 1). Users experience embedded ICT so that everyday objects and environments are starting to have new, intelligent features. Advanced interaction possibilities appear to users as novel interaction concepts and as possibilities for interacting using high level concepts. Advanced interaction possibilities also make it possible for users to shape the environments themselves, instead of just using environments designed by others. Users experience algorithmic intelligence in such a way that the environment understands the user and the context of use and adapts accordingly. In addition, the environment learns from the past behavior of the user, and can proactively prepare for the user's future needs [12].

Intelligent environments are still rare as real life environments. Experimental intelligent environments have been built in enclosed spaces such as laboratories, homes and museums, where the technical arrangements are manageable and affordable, and where there are fewer stakeholders involved. Research results on intelligent environments have been described in the fields of housing [16-18], health [18, 19], assisted living [20-23], ambient media [13, 24] as well as security and safety [18, 23, 25, 26]. These application fields are often interconnected as, for instance, home services may include security features.

Kaasinen and Norros [12] classify potential application fields for intelligent environments as living environments, service environments and production environments. The living environment is a personal environment in which an individual is managing his/her life. The environment does not represent a specific physical space, but moves with the user from home to work, to hobbies and so on. The service environment integrates several users and different infrastructures. A typical example is traffic. The production environment integrates several actors working towards a common goal. A typical example is a production process in a factory. Intelligent environments may include an ecosystem of services, where new services have to compete for their share of user attention with already existing services. The designers cannot design new services in a vacuum—in addition to designing the service itself, the designer also has to design how the new service fits into the service ecosystem.

The relationship of people with intelligent environments is not only a relationship of a user and a system. People use the services provided by the environments, but they do not "use" the environments themselves. Instead they are in them, and at the same time live with the smart systems that inhabit the environments. This calls for a holistic understanding of experience, and requires that the services are not only designed for users, but also take account of other people who share the environment [27]. Roto [28] makes a distinction between "user experience" and "experience". In her definition, user experience requires the possibility of the user manipulating or controlling the system in a two-way interaction. This is what makes the person a user. Experience is a broader concept, including all the other ways people are experiencing the world they are living in. When studying and designing intelligent environments, both types of experience must be taken into account. Furthermore, many of the systems in intelligent environments do not require human interaction, but work autonomously, though still changing the environment and affecting people's experience.

3 User acceptance of intelligent environments

Originally, the user's acceptance of technology—the user's intention to use and sometimes also the actual usage of a new technology—has been studied in organizational contexts in order to understand how workers adopt new information systems and to develop the means to support the adoption process in the organization [29-31]. Lately, with the rapid expansion of personal computers and smart devices in the number and places in which they are used, research into user acceptance has been extended to include the voluntary contexts of consumer-oriented applications, as well as complex, inter-relating systems and ecosystems, which are critical in intelligent environments (e.g., [32, 33]).

The user's willingness to adopt a new technical system is based on their expectations of what the system would be like in use. These expectations arise from experiences and information the user acquires from the world around him/her—what the user perceives in their physical and social environment and what their possible hands-on experiences are with similar or related systems. In user acceptance theories, the user's expectations and perceptions are categorized into so-called factors of user acceptance. With regard to intelligent environments, the following factors have been identified as making a significant impact on the user acceptance [32-36]:

- usefulness
- value
- ease of use
- a sense of being in control
- integrating into practices
- ease of taking into use
- trust
- social issues
- cultural differences
- individual differences

The list highlights the various psychological viewpoints from which people weigh intelligent environments when pondering the decision of whether to adopt. This list is not meant to be an inclusive acceptance check list for developers. Nor it is a framework for user evaluations of intelligent environments (for this purpose, see *e.g.*,. [37]). User acceptance depends not just on technical features but also on the social and cultural context of the user as well as his/her individual characteristics. Furthermore, the importance of different factors naturally varies depending on the application field (for instance, usefulness as efficiency may be less critical at home than at work).

Nevertheless, it is useful for technology and application developers to understand which features of intelligent environments actually have been found to affect these factors, and so increase or decrease user acceptance. In the following, we review some representative research results in this domain.

3.1 Usefulness, value and benefit

The anticipated usefulness of a new technology is one of the critical factors in user acceptance of the technology (e.g., [29]). In the context of consumer-oriented applications and voluntary use, where achieving certain results in an effective manner is less important than at work, this factor has been extended beyond rational usefulness, for example to "value" [32] or "benefit" [33]. The first comprises the consumer's appreciation of and motivation for the technology, and the latter the user's current need but also the future benefits the user expects to obtain from using the system.

In an interview study by Lee and Yoon [26], the users expected the value of ubiquitous technology to be in helping them in effective decision-making, increasing personal and family safety, helping personal management, increasing personal freedom, improving ease of use, increasing the portability of services and decreasing the cost of living. For elderly people, the value of intelligent applications is especially in increased safety and more effortless health care activities at home [21].

In a mass survey study of more than a thousand respondents, Allouch and colleagues [38] discovered that people expected the benefits of an intelligent home to be entertainment and facilitation in everyday routines. In addition, intelligent applications would help the users to be “ahead of their time”. The users valued the feeling of being involved in technological development, being modern and acquiring higher social status with the intelligent applications at home.

Outside the home, usefulness or benefit means something different. For instance, efficiency is specifically related to work but less often to home or leisure time. Röcker [39] asked users to evaluate scenarios for several typical smart office applications, including content adaptation, speech interface, ambient displays and personal reminders. Röcker was surprised that the level of expected usefulness and ease of use of the applications was only moderate. This indicates that the users did not expect that the intelligent office would help them a great deal to be more efficient at work, or otherwise support them in their tasks. In a museum environment, the value of an intelligent service was found to be in enriching the visitor’s museum experience with additional and multimodal information, in addition to assisting the user in finding interesting objects [40].

3.2 Ease of use and control

Another significant feature that people expect from intelligent environments is that the applications and services in them are easy to use and control. For instance, Ziefle and Röcker [41] studied the acceptance of smart medical systems among the middle-aged and elderly. The system, presented in scenarios, monitored the biosignals of the user, communicated automatically with health care personnel and if necessary activated an alarm. The most critical characteristics of the system were ease of use, controllability and communication with the device. The users were less interested in the design or appearance of the system, or whether the system could be recognized as medical by outsiders.

Sometimes the assumption is that an automatic system is the most easy to use. However, an automatic system may cause the user to feel that (s)he is not in control. Misker and colleagues [42] studied experimentally different user interaction styles of combining various resources of an environment, *i.e.*, input and output interaction devices, ad hoc. The test subjects preferred a style in which they had control over the device selection, even if they had to use extra effort, compared to an automated selection. Zaad and Allouch [22] conducted a study of a motion sensor system for elderly people and compared two versions of the system: a fully automatic system and one in which the system carried out checks with the user on whether the information detected by the system was correct. It was found that those elderly people who perceived having more control over the system and thus over their wellbeing had a greater intention of using it.

The intelligence—context-adaptive, learning, and proactive behavior—of a system may be a reason for the loss of user control. If the user does not understand the logic by which the system behaves, that is, the system lacks intelligibility, the result will be a loss of user trust, satisfaction and acceptance [43]. For instance, Cheverst and colleagues [44] tested this with an intelligent, learning-able office system prototype. The system allowed the user to scrutinize and control the rules that the system followed in action. In the questionnaire study, more than 90% of 30 participants expressed the need for controlling the system. Independent system action was sometimes found useful, as two third of the participants would have liked to switch between the two system modes, automatically or by prompt. The participants who had more expertise in computer knowledge expressed more interest in controlling the system.

Lim and colleagues [43] studied if different types of explanations about a system’s decision process would add intelligibility of a system for the user. They carried out a comparison experiment with over 200 users, and found that explanations clarifying why the system behaved in a certain way resulted in increased user understanding and trust.

Therefore, to prevent the threat of intelligent environments taking control over the user, the user needs to be provided with enough information and tools to control system actions. For this purpose, Bellotti and Edwards [45] propose a design framework for context-aware systems. Their framework declares the following four principles to support intelligibility and accountability in design: 1) Inform the user of current contextual system capabilities and understandings, 2) Provide feedback (both feedforward and confirmation for actions), 3) Enforce identity and action disclosure particularly with sharing nonpublic (restricted) information, and 4) Provide control to the user. Also, the framework by Assad and colleagues [46] for creating ubiquitous applications ensures that the applications will be such that the user has control over what information is modeled (especially about people) and how it is used.

Sometimes, users are willing to give up control for benefits. In a study by Barkhuus and Dey [47], users felt a lack of control when using fully or partly autonomous mobile interactive services, but still preferred them over applications that required manual personalization. The usefulness of the autonomous applications overrode the diminished sense of control. However, Barkhuus and Dey warn that loss of control may still result in user frustration and turning off services.

Multimodality may increase the usability of intelligent environments. Blumendorf and colleagues [48] found that multimodal interaction (voice, mouse, keyboard, and touchscreen) was preferred and more positively evaluated by users carrying out interactive tasks, compared to single modality interaction. Multimodality enables a more personal use and creates flexibility; for instance, speech-based interaction with office applications is avoided in public places but may be the most preferred interaction method elsewhere [39].

However, multimodal interaction can be implemented in a more or less usable way. Badia and colleagues [49] found that, if the interaction is as hidden and as natural as possible, the results and consequences of the interaction may actually be more difficult to understand.

Furthermore, some user groups such as the elderly may have difficulties in accepting an intelligent environment despite easy and flexible control and interaction. For the elderly, it is important that the intelligent applications and services integrate to and support the existing practices and routines of the user—who may never have used a computer [21].

3.3 Trust and privacy

Trust is related to control, privacy and monitoring, but also to security and the data protection of intelligent systems [32, 50]. Trust is a multi-dimensional, complex issue (for analytic definition, see e.g., [51]) that may grow slowly but is easily lost [32]. In a long-term experiment, the inhabitants of an intelligent home did not gain complete trust in the system even in six months [17]. Lack of people's trust and belief is a critical shortcoming regarding the acceptance of intelligent environments. One of the main challenges in gaining trust seems to be users' fear of losing their privacy.

Intelligent environments face a privacy dilemma: the user's personal data, current and historical, needs to be collected and stored to be able to provide intelligent, contextual and pro-active services for the user [52]. Indeed, in Allouch and colleagues' [38] study of an intelligent home, users did not accept a smart mirror sending private health data to a doctor. Nor did they accept automated home services functioning without the user's intervention. In other words, user acceptance is low if users cannot trust the system to protect their privacy and to be fully in control. Privacy and control are especially important at home. In Ziefle and Röcker's study [41], a medical system, which monitored users and automatically communicated data to health care staff was least accepted when integrated at home, but better accepted when implemented as a mobile or wearable system.

Privacy is also an issue outside the home. Röcker [39] found that users were willing to use smart office applications which may reveal something personal about the user more in private places (a private office room) than in public offices. Because of privacy worries, gaining user acceptance for one of the core functions of intelligence environments, namely continuous monitoring, is a challenge. Moran and Nakata [53] reviewed several studies of the effects of monitoring (as in data collection, with no surveillance) and concluded that in general, awareness of monitoring has a negative effect on user behavior. However, the studies were often conducted under laboratory conditions ("smart home labs") which may cause different behavior compared to the real world. The researchers analyzed several factors that may impact behavior: the number of devices, disturbance of the devices in looks and positioning, control functions such as deletion, deactivation, inhibition and avoidance, the frequency of data collection, informing the user, *etc.* Systematic studies of the effects of these factors are still lacking due to the rarity of real intelligent systems.

3.4 Cultural and individual differences

There are some research results showing that nations or cultures may differ in how people accept intelligent environments. Forest and Arhippainen [54] studied the cultural aspects of the social acceptance of proactive mobile services. They discovered that the concept of labor was different in France and in Finland, which caused Finnish users to more readily accept solutions that organized the entire life of the user in order to improve his work efficiency. French users did not accept the approach where life was devoted to work, as it threatened their identity and the meaning of their life. Also, the roles of women and men in society were different, and this caused differences in acceptance of services for controlling the activities of other people. For Finnish people, it seemed to be more natural to accept living in symbiosis with a device ecosystem, whereas French people would have wanted a device environment where the human being can keep control of what is happening all the time. Röcker [39] found that willingness to use intelligent office applications in private or public places differed more clearly with American users and less with German users. However, the difference was not put to a statistical test.

Individuals clearly differ in their willingness to adopt technologies and intelligent services. For example, gender, region of residence, job and usage of the Internet predict an acceptance of digital home care services [18]. Other individual characteristics might be age, education, social status, wealth, *etc*. Even personality characteristics such as conscientiousness, extraversion, neuroticism and agreeableness may matter [55]. In the field of mobile Internet services, it seems that socially well networked and "personally innovative users" (those having a tendency to take risks) may find the services more useful and easy to use, and this way are also more willing to take them into use [56].

A widely known description of how different types of individuals adopt new technologies is Rogers' [57] categories of adopters: innovators, early adopters, early majority, late majority and laggards. As Punie [52] notes, it is difficult to believe that intelligent environments would be accepted by everyone. There will always be early adopters as well as late adopters and those who totally resist. However, it is important to develop intelligent technologies for a variety of user groups, not just those who appear to be the most ready and willing, to avoid the growth of a digital divide between those who can and those who cannot use intelligent environments.

4 User experiences of embodied interaction techniques for intelligent environments

In this section, we continue our analysis of user expectations of intelligent environments by analyzing user experience in interaction with intelligent environments. Related research into two novel interaction tools that can be seen as salient in intelligent environments—*i.e.*, haptic interaction and augmented reality—are summarized and discussed from the perspective of experiential user expectations. Novel interaction tools in particular can embody new metaphors and interaction philosophies for the user, which, along with the novel functionalities and content, play an important role in how the overall user experience of intelligent services is created.

Interaction with intelligent environments in general has been proposed as natural, physical, and tangible [14, 58]. Consequently, new interaction paradigms have been extensively researched and developed over the past few decades, centering especially around 'embodied' and 'tangible' interaction. Prominent examples of such are augmented reality (AR) and haptic interaction based especially on touch and kinesthetic modalities. In what follows, we discuss the possibilities and users' expectations of specifically augmented reality and haptic interaction, as well as their potential as solutions for interacting with intelligent environments and services. The main focus in this section is on user experience provided by the interaction tools.

The growing extent of tangible and other related interfaces becomes apparent in the diversity of terminology that is used to describe such technologies: e.g., 'graspable', 'manipulative', 'haptic' and 'embodied' interaction (see, e.g., [59]). Despite the complexity, most of these concepts include, first, touch and movement as input or/and output in some form and, second, the principles of physical representations being computationally coupled to underlying digital information and embodying mechanisms for interactive control [14]. Furthermore, to conceptually clarify the terminology, Fishkin [60] developed a taxonomy for tangible user interfaces. It consists of varying degrees of 'tangibility', based on two axes: 1) embodiment, *i.e.*, how close the input and output are to each other, and 2) metaphor, *i.e.*, how analogous the user interaction is to similar real-life action. Augmented reality and haptic interaction can be regarded as embodied interaction as well as tangible user interfaces (TUI) in many ways [14]. For example, although AR is inherently based on the visual modality, natural body movements can be utilized to change the point of view and the augmented objects can even allow direct manipulation, hence extensively defining the way of providing user input (cf. [60]).

A focus on this area of interaction techniques is justifiable as operating, reacting to and controlling intelligent environments in general often intends to mimic the embodied interactions that are familiar from interactions with other people and the physical world [59]. Tangible interfaces have been most popularly applied in the fields of music and edutainment, but also in other areas such as planning, information visualization and social communication (see, for example, an extensive survey on tangible user interfaces by Shaer and Hornecker [61]). In addition to AR and haptic interaction, other examples of tangible and embodied interaction do exist. For example, speech-based interaction can also be regarded as intuitive and even embodied interaction. However, this section focuses on AR and haptic interaction because (1) they serve as good examples of embodied interaction, involving two different modalities, (2) speech-based interaction has often been envisioned in the early scenarios of intelligent environments, and hence offers less novelty with regard to understanding new user-based requirements and expectations of such technology, (3) interaction with the physical environment is inherently visual and haptic, meaning that AR and haptic interaction embody potential emerging interaction metaphors, and most importantly, (4) in these two fields there is recent related work with a focus on the novel concept of user experience. In addition, ambient and peripheral displays are often discussed in relation to intelligent environments (e.g., [62]) but this is similarly left out from the scope of this paper.

Despite the originally technological focus in building enabling technologies for embodied interaction, the research increasingly includes approaches to specific human factors like perception and cognition issues and user task performance (e.g., [63]). However, user acceptance and user experience, as concepts that look at the human-centric aspects from a slightly more abstract and holistic perspective, have also lately received research interest (e.g., [64–66]). Consequently, the concept of user experience (UX) is next specified in more detail.

User experience is regarded as a comprehensive concept describing the subjective experience resulting from the interaction with technology [11]. Although the concept of UX is still rather young, there are a few common key assumptions that are widely accepted [67-69]: UX is generally agreed to depend on the person (*i.e.*, subjective) and contextual factors like physical, social and cultural aspects in the situation of use, and to be dynamic and temporally evolving over the instances of use. As a multifaceted concept, user experience has various manifestations, consisting of subjective feelings, behavioral reactions such as approach, avoidance and inaction, expressive reactions like facial, vocal and postural expressions, and physiological reactions [70]. Experience as a novel quality attribute of products and services is considered to be a critical asset in global business—in order to achieve success, companies must orchestrate memorable events for their customers, and that the memory itself becomes the product [71]. Consequently, it is also important to research users' expectations from the perspective of user experience. For example, the services built around AR or haptic interaction can be expected to allow such experiences and activities that people inherently desire but have not been possible with existing technologies and ways of interacting with technology.

4.1. User experience and expectations of haptic, tangible and tactile interaction

First, based on a review of relevant literature, the following highlights various aspects related to user experience of haptic, tangible and tactile interaction.

Because of the fact that not much research literature exists on the user-centric aspects of haptics, various elements of experience are discussed based on papers on both actual experiences and expectations. This is crucial with regard to both expectations and experiences, as these two interplay closely with and influence each other; expectations affect the actual experiences, and understanding actual experiences can indicate aspects that would also be central in the users' expectations.

To clarify the terminology first, in describing touch-based interaction, a widely accepted term is haptic interaction, which pertains to sensory information derived from both tactile (*i.e.*, cutaneous, skin sensor -based) and kinesthetic (limb movement -based) receptors [72]. Examples of tactile interaction are vibration, pressure- or temperature-based output, and smoothing, pressing or squeezing as input. Kinesthetic gestures have been categorized as, for example, manipulative, conversational, iconic, metaphoric, or semaphoric [73, 74]. In day-to-day interaction, touch and gestures are essential in a wide range of daily ad hoc tasks, such as in providing a feedback loop for manipulating objects, guiding our movements in three-dimensional space and various social interaction settings. Considering this and the fact of haptic being an underused modality, TUIs can also be considered to be a potential technology in the development of new ambient intelligence services. A system with haptic output provides the users with heads-up interaction—that is, letting the user visually scan their surroundings instead of reserving them for interaction with a handheld device. Incorporating the sense of touch into remote mobile communication has also been proposed as one solution in enriching multimodality in mobile communication [75].

Touch and gestures could allow more accurate interaction with intelligent environments, for example initiating object-based services, downloading further embedded information, user registering to a service/location, selecting augmented information in an AR browsing view (see 4.2), *etc.* In addition, the haptic modality serves well in multimodal interaction, supporting and enriching interaction based mainly on other sensory modalities, such as vision or audition.

To start with, several studies indicate that tangible interaction can enhance creativity, communication and collaboration between people. Africano *et al.* [76], Ryokai *et al.* [77] and Zuckerman *et al.* [78] have tested tangible interaction concepts in the learning environment with children using hi-fidelity prototypes. All of the studies report that the tangible interfaces promoted collaboration and communication; the children were engaged in the interaction and considered it fun. Hornecker & Buur [79] show examples of three case studies of tangible interfaces where the same applies to adults.

When tangible interfaces clearly enhance the social aspects of interaction, virtual and augmented reality tend to serve more solitary experiences, since the environment is generally viewed through a personal device such as goggles or a hand-held display device. These technologies have the potential to significantly change people's perception and experiential relationship with the environment by immersing them in the interaction. Hornecker [80] has compared experiences with two different kinds of exhibition installations in a museum environment. One installation consisted of a multi-touch interactive table and the other provided an augmented reality view of the museum environment with a telescope device. The ethnographic study indicated that, while the telescope installation provided a more immersive experience, the multi-touch table enabled more social and shared experiences.

With regard to tangible interaction, one of the earliest examples is by Ullmer and Ishii [81], where user's hands manipulate physical objects via physical gestures; a computer system detects this, alters its state, and provides feedback accordingly. More recently, RFID-based NFC (Near-field communication) 'touching' has generated greater interest in the research community. For example, Riekki *et al.* [82] and Välkkynen *et al.* [83] have built systems that allow the requesting of ubiquitous services by touching RFID tags. In the studies by Välkkynen *et al.* [83], touching and pointing turned out to be a useful method for selecting an object for interaction with a mobile device. Kaasinen *et al.* [84] studied physical selection as an interaction tool, both for selecting an object for further interaction, and for the device also scanning the environment and proposing objects for interaction. They found that in an environment with many tags, it will be hard to select the correct one from the list presented after scanning. Distance and directionality in tag interaction need to be precise, because indefiniteness in them can cause a confusing user experience. The results by Kaasinen *et al.* [84]

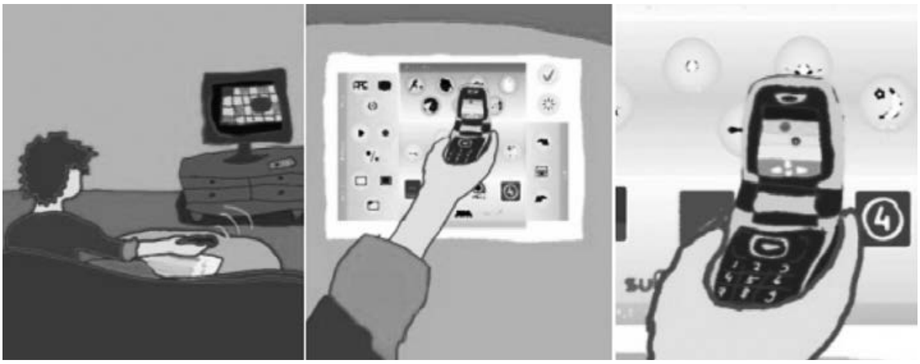

Figure 2.
Example scenarios of using near-field communication (NFC) to control a home media center [85].

indicated that the best technique for touching would probably be having a 'touch mode' that can be activated and deactivated either manually or automatically.

More recently, Kaasinen *et al.* [24] have studied the acceptance and user experience of touchable memory tags. Ease of upload and fun interaction were identified as the main strengths of such an interaction metaphor. The main concerns related to control over the interaction between the mobile phone and the memory tag as well as fears regarding security and reliability. Users should have ways to assess and ensure the trustworthiness of memory tag contents, and the user-generated content may require moderation.
The studies by Kallinen [85] also support these findings: touch-based interaction with NFC-enabled mobile phones was regarded as an efficient, intuitive and novel interaction technique that is suitable for a variety of domains and applications. Such interaction could be considered in, for example, smart home environments (see Figure 2). It was found to be the most efficient, effective, practical, and simple method compared with speech and gesture-based interaction in both subjective and objective measures.
In addition, touch-based interaction was considered to be socially very acceptable, exciting, and innovative. The biggest user concerns were device dependency and security, especially in use cases with payment and access control features. Furthermore, Isomursu [86] identified a need for tag management. They propose that if NFC technology becomes common and if management practices are not used or available, tags can create "tag litter" that ruins the user experience by corrupting the trust in tags and tag-based services.

Also the potential users' expectations of haptic interaction in interpersonal communication have been studied [75, 87]. In these papers, the main benefits of tactile communication were seen to be the added richness and immersion it can bring to interpersonal communication. The interaction could become more holistic and thus richer information could be conveyed. The haptic modality was seen to add the currently missing contextual nuances and thus ease the use of mobile technology. For example, to convey an emotion, a tactile input could either enrich the multimodal message as tactile output or be transformed into another sense modality (e.g., represented in a certain type of sound). Another clear benefit was expected to be the spontaneity and speed of communication. Haptic communication was seen to be an easy, simple and fun way to convey sudden emotions. Furthermore, the added privacy in the unobtrusiveness of tactile interaction was seen as beneficial for remote communication. On the other hand, touch was regarded as such a private sense that the user must be in control of who can communicate with them via the haptic modality. The authors conclude that, to make it fluent, the interaction itself should resemble or have similar metaphors to our everyday use of the touch.

To summarize, the above-mentioned studies clearly confirm even the earliest researcher-originated expectations of touch-based interaction—intuitiveness and efficiency in interaction with real world objects. Publications about user research in this area are diverse and do not currently allow a holistic view of UX and expectations of haptic interaction. Nevertheless, the following provides an early consolidation of the UX-related aspects discussed above, mainly to be used as early guidance in the design of touch- and movement-based interactions in general and especially in AmI services:

- Fun, enjoyable and exciting interaction [24, 85]
- Efficient, practical and intuitive [75, 85]
- Collaboration and communication: facilitating and catalyzing collaboration and communication between people, shared experiences in multi-user applications (e.g., [79])
- Socially acceptable [85]
- Added richness and immersion [75]
- Accuracy in selecting and manipulating objects in the real world and the digital content related to them
- Inherent challenge in specifying distance and direction [84]
- Requirements of privacy and control [75]

The different submodalities in the haptic modality enable extensive ways of inputting information into a system and providing immersive and intuitive output for the user in a multi-modal, holistic way. Thus, touch-based interaction also has great potential to help make ambient intelligence a well-accepted technology and a central part of the everyday life. Currently, such interaction technologies becoming more general might mostly depend on how the possibilities of touch can be mapped into the input and output for a system in a universally understandable way, and what the first widely accepted services utilizing these technologies are to be.

4.2 Expected user experience of augmented reality

Augmented Reality (AR) is another central interaction tool that can be seen as a promising interface and interaction tool for intelligent environments, and has recently received considerable interest also from the user-centered perspective. Generally, AR can be considered to be one key technology in catalyzing the paradigm shift towards mobile and ubiquitous computing, happening "anytime, anywhere" [1, 66, 88]. The general approach of AR is to combine real and computer-generated digital information into the user's view of the physical and interactive real world in such a way that they appear to be one environment [89, 90]. This allows integrating the realities of the physical world and the digital domain in meaningful ways: AR enables a novel and multimodal interface to the digital information in and related to the physical world. This new reality of mixed information can be interacted with in real time, enabling people to take advantage both of their own senses and skills and the power of networked computing, while naturally interacting in the everyday physical world [91]. Therefore, it also serves as a versatile user interface for intelligent environments [92]: for example, browsing the digital affordances embedded in the real world as well as manipulating the ambient information in a natural and immersive way. This aspect emphasizes that objects themselves including digital information can create 'smart' services, in which AR could be used as a paradigmatic interface metaphor (see, e.g., [93]). On an abstract level, this is closely related to the concept of physical browsing, *i.e.*, accessing information and services by physically selecting common objects or surroundings [94], but approaches the paradigm from a visual perspective.

Augmented reality has been applied in diverse practical day-to-day use cases, in entertainment and gaming, as well as in tourism (Figure 3) and navigation. Examples of augmentable targets have varied from surrounding buildings, machinery or other static objects to vehicles, people, and other dynamic objects.

The diversity of AR as a concept provides a powerful toolkit to design new services, but at the same time creates great challenges for the design of pleasurable user experiences. In our earlier research [65, 66, 95] we have identified various categories of user experience that potential users expect to arise in interaction with mobile AR, considering it not only as an interaction technology but, rather, as a holistic service entity encompassing AR content and various ubicomp- and AmI-related functionalities. The most central experiential expectations reported in the papers are summarized in what follows (see [66] for more detailed descriptions).

The expectations can be categorized in six main classes of experiences. First, various instrumental experiences were often expected, demonstrating sense of accomplishment, feeling of one's activities being supported and enhanced by technology, and other pragmatic and utilitarian perceptions of service use. Second, cognitive and epistemic experiences relate to thoughts, conceptualization and rationality. Especially experiences of increased awareness of the digital content related to the environment and intuitiveness of the interaction were found to be much anticipated.

"With data glasses Jack and Lisa can easily see additional information from attractions in the national park, as well as interact with the park's info boards. They can browse, for example, the historical information and shared comments from previous visitors. They end up in a stalactite cavern, in which a guide tells them about the history of the cavern by sharing an augmentation of what it might have looked like 10,000 years ago. Jack and Lisa can also obtain navigation guidance, and are able to see through objects to easily locate where they are."

Figure 3.
An illustration and excerpt of the tourism scenario used as stimulus in focus groups [95].

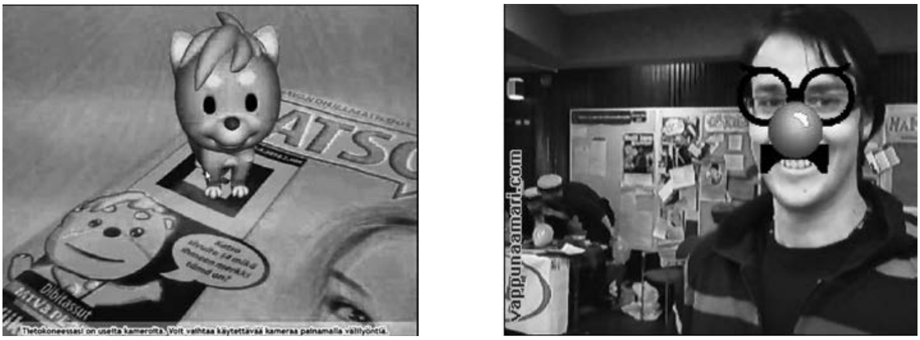

Figure 4.
Examples of playful, leisure-oriented, or fun augmented reality (AR) applications. Left: Dibidogs augmented on paper magazines, Right: vappumask mobile application to create humoristic views of people. (VTT archive)

Table 2 (following page).
Summary of the main experience classes and the experience categories representing them (see esp. [66] for details).

Third, emotional experiences relate to the subjective, primarily emotional responses in the user: for example, amazement, positive surprises and playfulness were often expected from services with AR interaction. Figure 4 illustrates two examples of AR applications focusing especially on playful experiences. [66]

Fourth, sensory experiences relate to sensory-perceptual experiences that are conceptually processed, originating from the service's multimodal AR stimuli and influences on the user's perception of the world around them. Fifth, social experiences relate to human-to-human interactions that are intermediated by technology and features providing a channel for self-expression or otherwise support social user values. For example, connectedness and collectivity relate to the expectation of mobile AR offering novel ways for reality-based mediated social interaction and communication. Social experiences would develop from the collective use and creation of the AR content, in utilizing the socially aggregated AR information in personal use, in co-located and collaborative use of the services, as well as in using the AR as a tool for communication. Finally, motivational and behavioral experiences are created when the use or ownership of an AR service causes a certain behavior in the users [66]. Overall, the more detailed experiences under each class are summarized in Table 2.

All in all, potential users attributed a diverse range of expectations to services based on mobile AR. Clearly, the end user's perception of a service entity

EXPERIENCE CLASS	CATEGORY OF UX CHARACTERISTIC	SHORT DESCRIPTION
INSTRUMENTAL	Empowerment	feelings of powerfulness and achievement, being offered new possibilities by technology, and expanding human perception
	Efficiency	feeling of performing everyday activities and accomplishing practical goals with less effort and resources
	Meaningfulness	mobile AR showing only the content that corresponds to the surrounding visible things in the real world, thus making it feel relevant and worthwhile in the current location
COGNITIVE AND EPISTEMIC	Awareness	sense of becoming aware of, realizing something about or gaining a new insight into one's surroundings
	Intuitiveness	the interaction with AR feeling natural and human-like
	Control	sense of controlling the mixing of the realities and the extent to which the service is proactive and knows about the user
	Trust	being able to rely on the acquired AR content (e.g., faultlessness and timeliness of the content), as well as the realism and correspondence of digital when aiming to replace a traditionally physical activity with virtual
EMOTIONAL	Amazement	feeling of having experienced something extraordinary or novel
	Surprise	positive astonishment, 'wow-effects' and a service surpassing one's expectations in general
	Playfulness	feelings of amusement and joy at the novel way of interacting with mobile AR
	Liveliness	feeling of continuous change and accumulation of the service and the physical environment, hence feeling vivid and dynamic, and reviving pleasing memories
SENSORY	Captivation	feeling of being immersed and engaged in the interaction with the mixed reality, possibly also creating feelings of presence in the mixed reality and flow in one's activities
	Tangibility	sense of physicality and the content seeming to be an integral part of the environment
SOCIAL	Connectedness	mobile AR offering novel ways for reality-based mediated social interaction and communication
	Collectivity	sense of collective use and creation of the AR content
	Privacy	1) what information about them and their activity will be saved and where?, 2) how public is the interaction with the service, and how publicly the augmentations are delivered?, 3) who can eventually access the content?, and 4) can people be tracked or supervised by others?
MOTIVATIONAL AND BEHAVIORAL	Inspiration	feelings of being stimulated, curious about the new reality, and eager to try new things with the help of mobile AR
	Motivation	being encouraged and motivated to participate in the service community and contribute to its content
	Creativity	self-expressive and artistic feelings that AR could catalyze by triggering the imagination and serving as a fruitful interface to demonstrate artistic creativity by, for example, augmenting one's appearance

or an interaction technology is not limited by theoretical or technical definitions, but driven by their own needs and practices. For example, social experiences, community-created content or proactivity are perhaps not specific to mobile AR —based interaction *per se* but were expected nevertheless. In addition, many expected mobile AR services to include features like context-awareness and proactivity, which could also be seen as characteristics of intelligent environments. Hence, the expectations related to one aspect or embodiment of intelligent environments (here, mobile AR) can easily highlight issues that can be seen as equally important in other technologies. These anticipated experiences can be considered to be positive and satisfying experiences, that is, something for the user to pursue and the designer to target in their design, and something that could also be utilized in design activities around systems that more fundamentally represent intelligent environments.

To summarize, this section has introduced various expectations and experiential aspects that can be considered important in designing tangible and embodied interaction for intelligent environments. The results on augmented reality in particular imply that people's expectations of new interaction tools and the experiences they can evoke display a very extensive spectrum of facets that demonstrate minor aspects of the overall UX—from instrumental experiences to emotional and epistemic, for example. The relevance and importance of the various aspects listed here most probably vary from case to case and from context to context. Consequently, the section aims simply to identify and highlight different aspects that should be considered, but the questions of "which of them", "to what extent", and "how to incorporate them" should be considered in each development case based on its context and other boundaries.

Overall, user experience includes several dimensions on different levels from instrumental needs for motivation. Even if the dimensions of user experience were identified with the selected interaction tools, the same framework can serve as a starting point when studying other interaction tools and the entities of intelligent environments. The overall user experience is partly based on the interaction tools and the whole interaction experience when acting in an intelligent environment, which makes this point of view on interaction-based experiences a relevant one.

In the next section, we will enhance our focus from mere interaction to the design of intelligent environments and the role of users as crafters of intelligent environments. User role as a crafter of intelligent environments in particular serves the emotional and motivational user experience goals, such as playfulness, inspiration and creativity.

5
USERS AS CO-CRAFTERS OF INTELLIGENT ENVIRONMENTS

As the existing living and working environments are gradually acquiring intelligent features, it is clear that the existing users or inhabitants of the intelligent environments have to be taken into account in the change process. If people can themselves influence their environments, it may be easier for them to accept and adopt the changes. In this section we describe our approach to providing people with the means to build their own intelligent environments: a scene in which the inhabitants are actively taking part to the construction process; people are not merely consumers or users of ready-made artifacts and environments, but active crafters of their own environments. Consequently, the approach leads people to carry out some of the setting up, configurations and maintenance of their smart environments. We call this approach Do-it-yourself-smart-environment (DIYSE).

In terms of user expectations, the Do-it-Yourself (DIY) culture involves a lot of active enthusiasm. According to Kuznetsov and Paulos, the do-it-yourself culture aspires to explore, experiment, create and modify objects in application fields that range from software to music, and gadgets [96]. They continue, that over the past few decades the integration of social computing, online sharing tools, and other HCI collaboration technologies have facilitated an interest in and a wider adoption of DIY cultures and practices through 1) easy access to and affordability of tools, and 2) the emergence of new sharing mechanisms. The more intelligent technology-driven DIY, which is the topic of this section, refers to approaches in which users themselves install and create the electronics, hardware and software, and share the knowledge and outcomes. Also with the technology-driven DIY, by doing something yourself allows people to identify and relate to objects on a much deeper level than

Figure 5.
Left: visualization of the Home Control System, Right: Music Creation Tool and instruments (Kymäläinen 2012, with the contribution of Geneim Oy and Matti Luhtala).

merely the functional [97]. Thus the aim of the DIY approach is to allow users to deploy intelligent systems and environments easily in a do-it-yourself fashion. Another aim is to lead developers to write applications and to build augmented artifacts in a more generic way regardless of the constraints of the environments [98].

There are high expectations of empowering users to build the intelligent applications and environments by themselves. The advantages of constructing a smart environment in a DIY fashion, according to Beckmann *et al.*, relate to: lower cost, greater user-centric control, more acceptance, better personalization and frequent upgrade support [99]. Active participation of users is expected to be particularly essential in domestic environments, as the DIY approach offers simplicity, better control, lower deployment costs and support for ad hoc personalization [98].

The technology-aided DIY experiences were studied in the European research program DiYSE: Do-it-Yourself Smart Experiences (http://diyse.org/), which aimed at enabling ordinary people to easily create, setup and control applications in their smart living environments as well as in public environments [97]. User expectations were studied in more than 20 projects that defined intelligent environment as the main research objective, but the projects also focused on creating web-services and traditional PC applications. Correspondingly e.g., Beckmann, Consolvo and LaMarca have envisioned that the emergence of interactive ubiquitous environments makes it important that we consider how devices are placed within an environment, how combinations of these devices are practically managed, and how these devices work as an ensemble [99]. In DiYSE projects, it was presumed that the foremost challenge would lie in the different characteristics of users operating with the systems, and with their competing expectations and needs for the self-crafted smart experiences.

5.1 Home as the smart installation environment

Home was seen to provide the perfect settings to consider the user expectations relating to DIY creation culture. According to Rodden and Benford, the essential property of home is its evolutionary nature and receptibility to continual change [100]. Beckmann, Consolvo and LaMarca see that the need to support this change is critical to the successful uptake of ubiquitous devices in domestic spaces [99]. They emphasize that the aim of using DIY methodology in the assembly of the ubiquitous devices (which share the environment) is to allow users to have more control in the space they live in.

Kawsar *et al.* continue that, ideally, the inhabitants should carry out the installing and configuring of the devices [98]. They have in-depth knowledge of the structure of their home and their activities, resulting in a better understanding of where and which physical artifacts and applications to deploy [98]. System issues for involving end users in constructing

TOPIC	MANIFESTO DESCRIPTION
1. Inspire creativity	The system should be a platform that inspires and supports people to be creative, to self-actualize in their projects. It should motivate them to think outside the box.
2. Characteristics of users	Support a spectrum of expertise in computational thinking by offering different layers of computational abstractions. The system should support at least three different types of users (the amateur, the professional-amateur and the professional).
3. Useful components	Instead of requiring programming skills from every user, the system enables the users to start from (sets of) useful components. The system helps people to create useful components.
4. Supporting ecosystem	The system does not teach how to program, but should provide an ecosystem to support people in creating ideas, solutions. It present the (sets of) useful components in such a way that their purpose is evident and that combining useful components is easy, for example by offering templates.
5. Variances in purpose	The system equally supports idea generation, material-inspired projects and projects based on other projects. The system takes into account different purposes, from clear purpose to a vague idea, and different personalities of users.
6. Playground and recycling opportunities	The system offers a playground providing leftovers from other projects and collectables. It allows both finished and unfinished projects to linger and users to tinker with these projects.
7. Sharing of evolving projects	Support sharing of unfinished or evolving projects. Users are able to share their projects in either the seeding phase, the flourishing phase or the finished phase.
8. Collaboration between users	Support and facilitate collaboration between users with various roles (creators, debuggers, cleaners, collectors, spectators/fans, etc.) in the creation process.
9. Subtle tuition	Help users to finish projects by subtle coaching without harassment.
10. User-preferred terminology	With knowledge of any domain users can employ their own terminology while using the system. The system learns to adapt to this terminology, resulting in a common terminology.
11. Multimodal systems and haptic interfaces	The system should provide multimodal interfaces to create (sets of) useful components and projects. Users are not restricted to PC-based applications only. Instead, they are stimulated to make use of their everyday interaction patterns with their body or with objects to provide input.
12. Confusing situations	The system should express and clarify ambiguous situations with the user.
13. Added value	The system should provide added value for all stakeholders. Hence it is necessary to understand the different expectations of all stakeholders at each step of the system.

Table 3.
Topics formed from the user studies and manifesto statements for constructing an ideal do-it-yourself smart system [104].

and enhancing a smart home entail two requirements: 1) a general infrastructure for building plug and play augmented artifacts and pervasive applications (the architecture) and 2) simple, easy to use tools that allows end users to deploy the artifacts and the applications [98]. To study these two approaches and consequent user expectations in the DiYSE program, we developed and carried out user research into a Home Control System [101]. The use and expectations of pervasive applications and augmented artifacts were studied in Life Story Creation [102] and Music Creation Tool [103] research projects. Figure 5 illustrates these projects.

The three projects were studied from August 2010 to January 2012. The Home Control System was developed for supporting elderly people in living more independently in their own homes and in a (smart) nursing home. The system was expected to enable the creation and combination of interactive operations in a sensor network-enabled intelligent environment. The user expectations were considered with a group of nurses (four users: 4 female and 1 male, varying in age between 28 and 42). The Life Story Creation -project was about constructing an easy do-it-yourself application for elderly people to create their personal retrospections. The acceptance and user experience factors were studied first with focus groups involving senior citizens (15 users: with an average age of 70), and later the application was co-designed with expert-amateur writers (five users: 4 female and 1 male, varying in age between 55 and 69 years). The aim of the Music Creation Tool was to allow disabled people to play music together. The tangible, interactive system was considered to provide an easy means of composing and configuring digital instruments. User expectations were studied with end-user observations (four users: all male, varying in age between 26 and 58) that focused on learning, independent action, supporting creativity and managing confusing situations.

5.2 Emerging user expectations for the do-it yourself intelligent environments

User research, focusing on user acceptance and user expectations, was considered to help in constructing an ideal DIY smart system. The results from all user studies of the DIYSE program were refined into manifesto statements that were published after the project for opening up the technology-driven DIY creation to a wider audience [104]. Table 3 presents the 13 topics of the manifesto for constructing an ideal do-it-yourself smart system.

To illustrate these manifesto statements and to consider them in the terms of user expectations of intelligent environments, in what follows they will be reflected to the three DIYSE -projects: Home Control System, Life Story Creation and Music Creation Tool.

At the core of the do-it-yourself culture is the creativity and craftsmanship that is expected to be provided from the part of users. When DIY is positioned in the intelligent environment context, support for self-actuality and creativity is equally essential. Two case projects, Life Story Creation and Music Creation Tool, provided an interactive writing application and tangible musical instruments that were explicitly intended be creativity supporting tools. User studies of the Life Story Creation focused on defining experiences relating to writing as a creative activity, but discovered user expectations also led to study the issues around the processes—the flexibility to extend and modify the writing process according to the flow of creativity; the different types of writing persons and how various kinds of creativity should be supported, and the difficult issues relating to sharing an intimate piece of writing.

Several different expectations were made of all the case DiYSE systems, as in each case users were different and had various levels of computational skills. The extreme case was the Music Creation Tool, in which there were many variations in the intellectual and adaptive skills of the people it was studied with. The Music Creation Tool designed for a special group, people with a mild or moderate (Diagnosis ICD-10) intellectual learning disability, had to be flexible and provide options according to various skill levels. The anticipated use of the system was considered at first with a music therapist; then observation studies confirmed the usage of the instruments and by analyzing the results the user expectations could be determined. Life Story Creation and Home Control System focused on finding 'warm' experts who would be the support persons for the DIY ecosystems. A 'warm' expert is a person who has some degree of emotional ties to the (end-) users of the application they help to design and/or implement [105].

The principal expectations of the Home Control System user research related to the component creation—what kind of components users wanted to create and what they expected to be ready-made. The studies revealed that the nurses, the 'warm' expert of the ecosystem in question, preferred ready-made templates for constructing the setups, and their task would only be to fine-tune the templates. Also according to the results from Mackay [106], when studying triggers and barriers to customizing software, simply providing a set of customization features does not ensure that users will take advantage of them. The process involves a trade-off—the choice between activities that accomplish work directly and activities that may increase future satisfaction or productivity. This was also our important finding relating to user expectations of the component creation.

According to Gershenfeld [107], digital recycling is about a digital processes being reversible, based on an assumption that the means to make something are distinct from the thing itself. And further, the construction of digital materials can contain the information needed for their deconstruction. In all DiYSE projects the possibility of recycling templates and projects were presented as an option, but the developed proof-of-concept prototypes concentrated more on speculating about meaningful opportunities for reuse. In the contemporary digital world it should be easy to organize sustainable conditions in which things are not thrown away, but rather (scrap) materials and older projects are kept in store for recycling.

As regards the culture of collaboration, Kuznetsov and Paulos [96] clarify that DIY communities invite individuals across all backgrounds and skill levels to contribute, resulting in: 1) rapid interdisciplinary skill building as people contribute and pollinate ideas across communities, and 2) increased participation supported by informal ("anything goes") contributions such a comments, questions and answers. The study by Fischer *et al.* [108] also reveals that question asking and answering is the core process behind the propagation of methods and ideas, *i.e.*, participants tend to "learn more by teaching and sharing with others". From the three DIYSE projects, Life Story Creation was the only project in which the users actually shared their work with each other during the evaluations, by providing instructions and comments or by just reading each other's stories. According to our studies, collaboration has a central role when defining the efficiency and usefulness of the DIY system; collaboration provides most value for individual users. According to Kuznetsov and Paulos, DIY is a culture that strives to share together while working alone [96]. Social media was thought to be the entryway for publishing music in the Music Creation Tool and sharing memories in the Life Story Creation, and the people who were studied appreciated this opportunity. However, in both cases, the sharing of unfinished projects was seen to be unpleasant.

An important part of the user experience of the intelligent system is that it should motivate and support users to create the projects by means of subtle, non-harassing coaching. As a result, all users, regardless of their level of expertise, are able to use the system to the fullest [104]. In the Home Control system, for subtle tuition, there were various different attempts to employ diverse methods for the subtle tuition. The attempts comprised, e.g., step by step wizards that would guide the users through processes; a puzzle metaphor for connecting the components representing tasks and devices together; use of a sentence structure for supporting to create the setups; enlarging and diminishing grids, palette type of selection methods and ultimately, voice feedback for detecting the objects of the environment [101]. It appeared that the level of expertise set most critical requirements for the tuition method.

Smith *et al.* [109] have claimed that any textual computer language represents an inherent barrier to user understanding. According to them, a programming language is an artificial language that deals with the arcane world of algorithms and data structures—people do not want to think like a computer, but they do want to use computers to accomplish tasks they consider meaningful. The above-mentioned numerous tuition methods illustrate how in the development of the Home Control System special attention was given to how the system would adapt to user's terminology.

To better make use of what is offered by the physical environment, DIY environment should be facilitated with multimodal system inputs. The Music Creation Tool consisted of tangible instruments that provided musical experiences, and one of the key objectives was to observe how users interacted with them in their environment. Observations surprisingly revealed that there were several (learned) expectations of corresponding analogue, tangible objects. A fine example of the use of physical modality is one of the considered alternatives for configuring the Home Control System. The research group developed the idea of taking a snapshot of the environment by physically selecting devices: a switch could first be turned on, and then the state of it would become visible in the user interface. In this way the user could have a better cognition of the control environment. According to Fischer *et al.* [108], this responds to the aim of reducing the cognitive burden of learning by shrinking the conceptual distance between actions in the real world and programming.

At best, the Do-it-yourself approach should respond to the challenge of many different expectations of the different characteristics of users. The main value of the Home Control System, for the nurses, was the pre-configured tasks that they expected to ease their workload. An unexpected value, that was not thought initially, was that the system could also assist patients who cannot move from their beds. The Music Creation Tool observation period confirmed that the unexpected end-users' needs were related to publishing music and performing for an audience. In the Life Story Creation, the interviewees anticipated that the system would respond to the need to trace back one's personal history and learn about lost family ties.

In addition to the topics we identified in our DIYSE studies, other topics may also influence the value of DIY intelligent environments. One potential topic is context-awareness. Context-aware applications are applications that implicitly take their context of use into account by adapting to changes in a user's activities and environments [110]. Context-awareness has been successfully introduced in projects such as iCAP [111] and CAPella [110]. iCAP is a tool that allows users to quickly define input devices that sense context, and output devices that support response, create application rules with them, and test the rules by interacting with the devices in the environment. CAPpella empowers users to build context-aware applications that depend on intelligence—making inferences based on sensed information about the environment.

6
DISCUSSION

In ISTAG's vision of Ambient Intelligence [2], the human viewpoint is central: AmI should pursue user-friendliness, efficient service support, user-empowerment, and support for human interactions. Modifying Weiser [1], entering a properly implemented intelligent environment should, for the user, be as refreshing as taking a walk in the woods. And as Aarts and Grotenhuis [5] propose, intelligent environments should provide meaningful solutions that balance mind and body rather than solutions that drive people to maximum efficiency. The progress of technology can certainly be headed towards these human-driven aims, but we need to know more about specifically what kind of user expectations the technology should meet.

For this purpose, we have reviewed and analyzed user expectations with a three-level approach: user acceptance (willingness to adopt intelligent environments or their services), user experience (actual use and interaction in intelligent environments) and do-it-yourself (user-based modifying and building the intelligent environment).

User acceptance of intelligent environments is affected by several factors. Intelligent environments can help people in their everyday routines and they may increase safety. More entertainment and enriched information for the user are benefits as well. Ease of use and a sense of control need to be in balance—a totally automated environment may require no action from the user, thus being easy to use, but the user should have the means to control their environment and should understand how their actions impact the system. Trust is related to privacy and monitoring, control, security and data protection of intelligent systems [5, 32]. The privacy dilemma in particular is a critical challenge to user acceptance of intelligent environments, and one of the reasons people find it difficult to trust intelligent environments. Trust perceived by users is part of the wider ethical issues related to intelligent environments. The technology and applications should be safe and secure and human values such as privacy, self-control, trust, *etc.*, should not be violated by the technology or the applications. (e.g., [50,112,113]). Intelligent environments aim to raise people's quality of life and well-being, but in many cases these issues are not so simple. Technologies are not neutral as, even in the basic development phase, they carry assumptions about their usages which again are based on our understanding of how peoples' lives and society in general should be developed locally and globally. Experts on ethics should be consulted during technology development in order to deal fully with these issues.

Even if user acceptance can be "designed into" intelligent environments, the full penetration of technology into society may face problems in terms of societal acceptance. Bohn *et al.* [114] discuss the feasibility and credibility of Ambient Intelligence scenarios and applications and wonder whether the promises made for technology are too optimistic—technology should simplify our lives, help us save time, relieve us of laborious tasks, and so on. If these kinds of promises prove to be continuously unrealistic, the general public may end up generally critical and see only a serious credibility gap, thus lowering the acceptance of intelligent environments. Other criticisms a future user might raise would be being too dependent on the technical infrastructure; the unpredicted impacts of intelligent environments on health and the environment; and finally, the fear of a fundamental change in the relationship between human beings and the environment as we replace the unmanageable physical world with a manageable digital world [114]. To gain wide acceptance of intelligent environments, this kind of thinking should be faced and tackled by taking into account the specific needs and values of individual users and user groups at the very beginning of the development of intelligent environments.

Intelligent environments should be adjusted to different user groups, targeting the specific values and challenges in their lives. The development of intelligent environments should start with understanding the targeted user groups. For example, what is useful to the elderly, what the expected level of ease of use is, and how to ensure a sense of control and trust in their environments. The expected impact on the user's social status and social pressure also affects the intention to use and act in the intelligent environment. Intelligent environments should fit into the users' daily practices and cultural context. Different cultures seem to expect different functionalities and aims from intelligent environments (e.g., [54]), and certain types of individuals seem to be more eager to take intelligent environments into use. It may well be that intelligent environments will never be accepted by everyone [52]. However, any permanent digital divide should not be allowed to grow between "innovators" and "laggards" [57], and intelligent environments should be designed for all.

People are not "using" intelligent environments but they live in them, and they experience the environments via embedded services, the new interaction tools as well as the physical and social environment itself. The overall experience in the intelligent environment should be pleasing to all the human actors who live, visit and act in the environment. Intelligent environments should be designed as continuously evolving ecosystems that include people in different roles, and different services that are launched and withdrawn.

Augmented reality and tangible interaction are promising interaction techniques for intelligent environments as they provide the means to balance user control and natural interaction. User expectations of the interaction tools depend on the environment and task at hand. The experience-related expectations for augmented reality may be instrumental, cognitive, emotional, sensory, social or motivational. Tangible interaction is expected to be intuitive and efficient. As these interaction concepts may be new to users, they will require learning before they are fully adopted.

As the environments where people live and work are gradually getting intelligent features, the change cannot take place without providing users ways to influence the change. Intelligent environments may change user practices, and if users have a role as co-crafters, these changes can be positive. The culture of cooperation shares the responsibility for developing new solutions for intelligent environments, and provides instant comprehension of what the user expectations of the created systems are. Fischer *et al.* [108] assert that the success of end-user development depends on creating tools that the end-users are motivated to learn and use in daily life. Furthermore, success depends on a fine balance between user motivation, effective tools, and external support. Engaging users in the design of intelligent environments helps to construct evolutionary intelligent environments that will truly match users' expectations.

The adoption process of intelligent applications and environments as a part of everyday life—may not always be harmonious and smooth. Punie [52] describes domestication according to which the user aims to tame, gain control, shape or ascribe meaning to the technological artifact (*ibid.*, 31). Punie [52] sees the domestication as a struggle for the user to win. For successful domestication, users should be allowed to take part in that struggle, get in touch with technology, to trial and experiment for different uses in order to find uses of their own. Rather than a struggle, we see taming intelligent environments as a collaborative, on-going design process. Our everyday environments are gradually becoming intelligent, facilitated both by technological development and user activities in complementing the design and in creating usage practices. Understanding user expectations helps to shape these environments so that they are meaningful and pleasing to all those people who live and act in them.

1 Weiser, M. The Computer for the 21st Century. *Sci. Am.* 1991, 265, 94-104 (reprinted in *IEEE Pervasive Comput.* 2002, 1, 19-25).

2 Ducatel, K; Bogdanowicz, M; Scapolo, F.; Leijten, J; Burgelman, J.C. *ISTAG Scenarios for Ambient Intelligence 2010*; European Commission, 2001.

3 Cook, D. J.; Das, S. K. How smart are our environments? An updated look at the state of the art. *Pervasive and Mobile Comput.* 2007, 3, 53-73.

4 Aarts, E. Technological Issues in Ambient Intelligence. In *The New Everyday Visions of Ambient Intelligence*; Aarts, E., Marzano, S., Eds; 010 Publishers: Rotterdam, The Netherlands, 2003, pp. 12-17.

5 Aarts, E.; Grotenhuis, F. Ambient Intelligence 2.0: Towards Synergetic Prosperity. In *AmI 2009, LNCS* 5859; Tscheligi, M. *et al.*, Eds.; Springer-Verlag: Heidelberg, Germany, 2009; pp. 1-13.

6 Pine, B.J.; Gilmore, J.H. *Welcome to the experience economy. Harvard Bus. Rev.* 1998, 110, 145-172.

7 Hiltunen, M.; Laukka. M.; Luomala, J. *Professional mobile user experience.* IT Press: Helsinki, Finland, 2002.

8 Bhattacherjee, A. Understanding information systems continuance: an expectation—confirmation model. *MIS Quart.* 2001, 25, 351-370.

9 Arhippainen, L.; Tähti, M. Empirical evaluation of user experience in two adaptive mobile application prototypes. In *Proceedings of the 2nd International Conference on Mobile and Ubiquitous Multimedia (MUM'03)*; ACM Press; New York, NY, USA, 2003; pp. 27-34.

10 Karapanos, E.; Zimmerman, J.; Martens, J-B. User experience over time: an initial framework. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'09)*; ACM Press: New York, NY, USA, 2009; pp. 729-738.

11 International Organization for Standardization. ISO FDIS 9241-210: Ergonomics of human system interaction—Part 210: Human-centred design for interactive systems. ISO, 2010.

12 *Älykkäiden ympäristöjen suunnittelu* (Designing smart environments); Kaasinen, E., Norros, L., Eds. Teknologiateollisuus, 2007 (in Finnish).

13 Plomp, J.; Heinilä, J.; Ikonen, V.; Kaasinen, E.; Välkkynen, P. Sharing content and experiences in smart environments. In *Handbook of Ambient Intelligence and Smart Environments*; Nakashima, H., Aghajan, H., Augusto, J. C, Eds; Springer: New York, NY, USA, 2010; pp. 511-533.

14 Ishii, H.; Ullmer, B. Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'97)*; ACM Press: Atlanta, GA, USA, 1997; pp. 234-241.

15 Ikonen, V.; Niemelä, M; Kaasinen, E. Scenario-Based Design of Ambient Intelligence. *Lecture Notes Comput. Sci.* 2006, 4239, 57-72.

16 Albrechtslund, A. House 2.0: towards an ethics for surveillance in intelligent living and working environments. In *Proceedings of 7th International Conference of Computer Ethics: Philosophical Enquiry (CEPE 2007)*; Hinman, L.; Brey, P.; Floridi, L.; Grodzinsky, F.; Introna, L., Eds.; Centre for Telematics and Information Technology (CTIT), University of Twente: Twente, The Netherlands, 2007; pp. 7-16.

17 Koskela, T.; Väänänen-Vainio-Mattila, K. Evolution towards smart home environments: empirical evaluation of three user interfaces. *Pers. Ubiquitous Comput.* 2004, 8, 234-240.

18 Noh, M.J.; Kim, J.S. Factors influencing the user acceptance of digital home services. *Telecomm. Policy* 2010, 34, 672-682.

19 Brown, I. ; Adams, A.A. The ethical challenges of ubiquitous healthcare. *Int. Rev. Inf. Ethics* 2007, 8, 53-60.

20 Gill, J. *Ambient Intelligence – Paving the way*; Gill, J, Ed. Cost, 2008. Available online: http://www.tiresias.org/cost219ter/ambient_intelligence/ (accessed 17 December 2012)

21 Niemelä, M.; Fuentetaja, F. R.; Kaasinen, E.; Gallardo, J. L. Supporting independent living of the elderly with mobile-centric ambient intelligence: user evaluation of three scenarios. *Lecture Notes Comp. Sci.* 2007, 4794, 91-107.

22 Zaad, L.; Allouch, S.B. The influence of control on the acceptance of Ambient Intelligence by elderly people: an explorative study. *Lecture Notes Comput. Sci.* 2008, 5355, 58-74.

23 Aarts, E.; Wichert, R. *Ambient Intelligence. Technology Guide.* Springer-Verlag: Heidelberg, Germany, 2009; pp. 244-249.

24 Kaasinen, E.; Niemelä, M.; Tuomisto, T.; Välkkynen, P.; Jantunen, I.; Sierra, J.; Santiago, M.A.; Kaaja, H. Ubimedia based on readable and writable memory tags. *Multimedia Systems* 2010, 16, 57—74.

25 Ikonen, V.; Kaasinen, E. Ethical Assessment of Future-Oriented Design Scenarios. In *Proceedings of the Tenth International Conference ETHICOMP 2008*; Bynum, T.W., Calzarossa, M.C., De Lotto, I., Rogerson, S., Eds.; Mantova, Italy, 2008.

26 Lee, J.; Yoon, J. Exploring users' perspectives on ubiquitous computing. In *Proceedings of the 4th International Conference on Ubiquitous Information Technologies & Applications (ICUT'09)*, IEEE: Piscataway, NJ, USA, 2009; pp. 1-6.

27 Kuutti, K.; Keinonen, T.;Norros, L.; Kaasinen, E. Älykäs ympäristö suunnittelun haasteena (Smart environment as a design challenge). In *Älykkäiden ympäristöjen ekologinen suunnittelu (Ecological approach to the design of intelligent environments);* Kaasinen, E.; Norros, L., Eds; Teknologiateollisuus, 2007. (In Finnish)

28 Roto, V. *Web browsing on mobile phones—characteristics of user experience*. Doctoral Dissertation, Helsinki University of Technology, Espoo, 2006.
29 Davis, F. D. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly* 1989, *13*, 319-340.
30 Venkatesh, V.; Davis, F.D. A theoretical extension of the technology acceptance model: four longitudinal field studies. *Manag. Sci.* 2000, 46, 186-204.
31 Venkatesh, V.; Morris, M.G.; Davis, G.B.; Davis, F.D. User acceptance of information technology, *MIS Quarterly* 2003, *27*, 425-478.
32 Kaasinen, E. User Acceptance of Mobile Services. *Int. J. Mobile Human Comput. Interaction* 2009, *1*, 79—97.
33 Shin, D.-H. Ubiquitous computing acceptance model: end user concern about security, privacy and risk. *Int. J. Mobile Commun* 2010, 8, 169-186.
34 Hossain, M.M.; Prybutok, V.R. Consumer acceptance of RFID technology: An exploratory study. *IEEE Trans. Eng. Manag.* 2008, 55, 316-328.
35 Kim, S.; Garrison, G. Investigating mobile wireless technology adoption: An extension of the technology acceptance model. *Inf. Syst. Front*. 2009, *11*, 323-333.
36 Niemelä, M.; Walldén, S. Expert views on user acceptance of smart environments. *J. Ambient. Intell. Smart. Environ.* 2012, (submitted).
37 Scholtz, J.; Consolvo, S. Toward a Framework for Evaluating Ubiquitous Computing Applications. *Human-Computer Interaction* 2001, *16*, 97-166.
38 Allouch, S.B.; van Dijk, J.; Peters, O. The acceptance of domestic ambient intelligence appliances by prospective users. *Lecture Notes Comput. Sci.* 2009, 5538, 77-94.
39 Röcker, C. Perceived Usefulness and Perceived Ease-of-Use of Ambient Intelligence Applications in Office Environments. *Lecture Notes Comput. Sci.* 2009, 5619, 1052-1061.
40 Yu, Z.; Zhou, X.; Yu, Z.; Park, J.H.; Ma, J. iMuseum: A scalable context-aware intelligent museum system. *Comput. Commun.* 2008, *31*, 4376-4382.
41 Ziefle, M.; Röcker, C. Acceptance of pervasive healthcare systems: A comparison of different implementation concepts. In *Proceedings of the 4th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth)*; ICST: Gent, Belgium, 2009; pp. 1-6.
42 Misker, J.M.V.; Lindenberg, J.; Neerincx, M.A. Users want simple control over device selection. In *Proceedings of the Joint sOc-EUSAI Conference 2005*, Grenoble, France, 2005.
43 Lim, B.; Dey, A.; Avrahami, D. Why and why not explanations improve the intelligibility of context-aware intelligent systems. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2009, pp. 2119-2128.
44 Cheverst, K.; Byun, H.E.; Fitton, D.; Sas, C.; Kray, C.; Villar, N. Exploring issues of user model transparency and proactive behaviour in an office environment control system. *User. Model. User-adapt. Interact.* 2005, *15*, 235- 273.
45 Bellotti, V.; Edwards, K. Intelligibility and accountability: human considerations in context-aware systems. *Human—Computer Interaction* 2001, *16*, 193-212.
46 Assad, M.; Carmichael, D.J; Kay, J.; Kummerfeld, B. PersonisAD: Distributed, active, scrutable model framework for context-aware services. *Lecture Notes Comput. Sci.* 2007, 4480, 55-72.
47 Barkhuus, L.; Dey, A. Is context-aware computing taking control away from the user? Three levels of interactivity examined. In *Ubiquitous Computing*; Springer -Verlag: Berlin/Heidelberg, Germany 2003.
48 Blumendorf, M.; Feuerstack, S.; Albayrak, S. Multimodal Smart Home User Interfaces. *International Workshop on Intelligent User Interfaces for Ambient Assisted Living (IUI4AAL)*. Presented at the International Conference on Intelligent User Interfaces, Spain, 2008.
49 Badia, S.B. I..; Valjamae, A.; Manzi, F.; Bernardet, U.; Mura, A.; Manzolli, J.; Verschure, P.F.M.J. The effects of explicit and implicit interaction on user experiences in a mixed reality installation: The synthetic oracle. *Presence* 2009, 18, 277-285.
50 Aarts, E.; Markopoulos, P.; de Ruyter, B. The Persuasiveness of Ambient Intelligence. In *Security, Privacy, and Trust in Modern Data Management;* Petkovic, M; Jonker, W, Eds.; Springer-Verlag: Berlin/Heidelberg, Germany, 2009; pp. 367-381.
51 Nixon, P.A.; Wagealla, W.; English, C.; Terzis, S. Security, privacy and trust issues in smart environments. In *Smart Environments: Technologies, Protocols, and Applications*; Cook, D.J., Das, S.K., Eds.; John Wiley & Sons: New York, NY, USA, 2005; pp 249-270.
52 Punie, Y. A social and technological view of Ambient Intelligence in Everyday Life: What bends the trend? Technical Report EUR 20975 EN, 2003.
53 Moran, S.; Nakata, K. Analysing the factors affecting users in intelligent pervasive spaces. *Intell. Buildings Int.* 2010, 2, 57-71.
54 Forest, F.; Arhippainen, L. Social acceptance of proactive mobile services: Observing and anticipating cultural aspects by a sociology of user experience method. In *Proceedings of the 2005 Joint Conference on Smart Objects and Ambient Intelligence: Innovative Context-Aware Services: Usages and Technologies*, 2005; pp. 117-122.
55 Devaraj, S.; Easley, R.F.; Crant, J.M. How does personality matter? Relating the five-factor model to technology acceptance and use. *Inf. Syst. Res.* 2008, *19*, 93-105.
56 Lu, J.; Yao, J.E.; Yu, C.-S. Personal innovativeness, social influences and adoption of wireless Internet services via mobile technology. *J. Strat.Inf. Syst.* 2005, *14*, 245-268.
57 Rogers, E. M. *Diffusion of innovations,* 5th ed.; Free Press: New York, NY,USA, 2003.

58 Tennenhouse, D. Proactive Computing. *Communications of the ACM* 2000, *43*, 43-50.
59 Dourish, P. *Where the Action Is—The Foundations of Embodied Interaction*; MIT Press: Cambridge, MA, 2001.
60 Fishkin, K.P. A taxonomy for and analysis of tangible interfaces. *Pers. Ubiquitous Comput.* 2004, 8, 347–358.
61 Shaer, O.; Hornecker, E. Tangible User Interfaces: Past, Present and Future Directions. *Found. Trends Human-Comput. Interaction* 2009, 3,1-137.
62 Mankoff, J., Dey, A., Hsieh, G., Kientz, J., Lederer, S., Ames, M. Heuristic evaluation of ambient displays. In *Proceedings of CHI'03*; ACM Press: Ft. Lauderdale, FL, USA, April 5-10, 2003; pp. 169-176.
63 Gabbard, J.L.; Swan, E. Usability engineering for augmented reality: employing user-based studies to inform design. *IEEE Trans. Vis. Comput. Graphics* 2008, *14*, 513–524.
64 Nilsson, S. Augmentation in the wild: user centered development and evaluation of augmented reality applications. Doctoral Dissertation, Linköping University, 2010.
65 Olsson, T.; Lagerstam, E.; Kärkkäinen, T.; Väänänen-Vainio-Mattila, K. Expected User Experience of Mobile Augmented Reality Services: A User Study in the Context of Shopping Centers. *Pers. Ubiquitous Comput.* 2011, doi:10.1007/s00779-011-0494-x
66 Olsson, T. User expectations and experiences of mobile augmented reality services. Doctoral dissertation, Tampere University of Technology, 2012.
67 Hassenzahl, M.; Diefenbach, S.; Göritz, A. Needs, affect, and interactive products—Facets of user experience. *Interact. Comput.* 2010, *22*, 353-362.
68 Law, EL-C.; Roto, V.; Hassenzahl, M.; Vermeeren, A.; Kort, J. Understanding, scoping and defining user experience: a survey approach. In *Proceedings of CHI'09*; ACM Press: NY, USA, 2009; pp. 719-728.
69 Roto, V.; Law, EL-C.; Vermeeren, A.P., Hoonhout, J., eds. User experience white paper: Results from Dagstuhl seminar on demarcating user experience, 2011. Available online at: http://www.allaboutux.org/files/UX-WhitePaper.pdf (accessed 17 December 2012).
70 Desmet, PMA.; Hekkert, P. Framework of product experience. *Int. J. Design* 2007, 1,57-66.
71 Pine, B.J.; Gilmore, J.H. *The experience economy*; Harvard Business School Press: Boston, MA.
72 Kortum, P. *HCI Beyond the GUI. Design for Haptic, Speech, Olfactory, and Other Nontraditional Interfaces*; Morgan Kaufman Publishers, 2008; pp. 25-73.
73 Quek, D.; McNeill, R.; Bryll, S.; Duncan, X.; Ma, C.; Kirbas, K.E.; McCullough, R. Ansari, Multimodal human discourse: gesture and speech. *ACM Trans. Comput.—Human Interac.* 2002, 9,171–193.
74 Cassell, J.; Sullivan, S.; Prevost, F. *Embodied Conversational Agents*; The MIT Press: Cambridge, MA, 2000.
75 Heikkinen, J.; Olsson, T.; Väänänen-Vainio-Mattila, K. Expectations for user experience in haptic communication with mobile devices. In *Proceedings of MobileHCI'09*; ACM Press: New York, NY, USA, 2010; pp. 1-10.
76 Africano, D.; Berg, S.; Lindbergh, K.; Lundholm, P.; Nilbrink, F.; Persson, A. Designing tangible interfaces for children's collaboration. In *Proceedings of the CHI '04 extended abstracts on Human factors in computing systems*; ACM Press: New York, NY, USA, 2004; pp. 853-868.
77 Ryokai, K.; Marti, S.; Ishii, H. I/O brush: drawing with everyday objects as ink. In *Proceedings of the SIGCHI conference on Human factors in computing systems*; ACM Press: New York, NY, USA, 2004; pp. 303-310.
78 Zuckerman, O.; Arida, S.; Resnick, M. Extending tangible interfaces for education: digital montessori-inspired manipulatives. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (CHI'05); ACM Press: New York, NY, USA, 2005; pp. 859-868.
79 Hornecker, E.; Buur, J. Getting a grip on tangible interaction: a framework on physical space and social interaction. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*; ACM Press: New York, NY, USA, 2006; pp. 437-446.
80 Hornecker, E. Interactions around a contextually embedded system. In *Proceedings of the fourth international conference on tangible, embedded, and embodied interaction*. Cambridge, MA, USA, 2010; pp. 169-176.
81 Ullmer, B.; Ishii, H. Emerging frameworks for tangible user interfaces. In Human—computer interaction in the new millennium, Carroll J. M.; Addison-Wesley: New York, USA, 2001; pp. 579-601.
82 Riekki, J.; Salminen, T.; Alakärppä, I. Requesting pervasive services by touching RFID tags. *Pervasive Comput.* 2006, 5, 40-46.
83 Välkkynen, P.; Niemelä, M.; Tuomisto, T. Evaluating touching and pointing with a mobile terminal for physical browsing. In *Proceedings of the 4th Nordic Conference on Human—Computer Interaction*; ACM Press: New York, NY, USA, 2006; pp. 28–37.
84 Kaasinen, E., M. Niemela, T. Tuomisto, P. Valkkynen, and V. Ermolov. 2006. Identifying user requirements for a mobile terminal centric ubiquitous computing architecture. FUMCA 2006: System support for future mobile computing.
85 Kallinen, A. Studies on User Experience of Touch-Based Interaction with NFC Enabled Mobile Phones. Master's thesis, Tampere University of Technology, 2010.
86 Isomursu, M. Tags in the city. *PsychNol J.* 2007, 6, 131–156.
87 Heikkinen, J. Expectations and User Experience in Haptic Mobile Communication. Master's thesis, Tampere University of Technology, 2009.
88 Satyanarayanan, M. Pervasive computing: vision and challenges. *IEEE Pers. Communic.* 2001, 8, 10-17.

89 Azuma, RT. Tracking requirements for augmented reality. *Communic. ACM* 1993, 36, 50-51.
90 Vallino, J. Interactive augmented reality. Doctoral Dissertation, University of Rochester, 1998.
91 Mackay, W.E. Augmenting Reality: A new paradigm for interacting with computers. *La Recherche*, 1996, Issue 3 (March 1996).
92 Remagnino, P.; Foresti, G.L. Ambient intelligence: a new multidiciplinary paradigm. *IEEE Trans. Syst., Man, Cybernetics—Part A: Systems and Humans* 2005, 35, 1.
93 Atzori, L.; Iera, A.; Morabito, G. The internet of things: a survey. *Comput. Networks* 2010, 54, 2787-2805.
94 Kindberg, T. Implementing physical hyperlinks using ubiquitous identifier resolution. In *Proceedings of Eleventh International Conference on World Wide Web*. ACM Press: New York, NY, USA, 2002; pp. 191-199.
95 Olsson, T.; Ihamäki, P.; Lagerstam, E.; Ventä-Olkkonen, L.; Väänänen-Vainio-Mattila, K. User Expectations for Mobile Mixed Reality Services: an Initial User Study. In *Proceedings of 4th European Conference for Cognitive Ergonomics*; ACM Press: New York, NY, USA, 2009; pp. 177-184.
96 Kuznetsov, S.; Paulos, E. Rise of the Expert Amateur: DIY Projects, Communities, and Cultures. In *Proceedings NordiCHI 2010*; ACM Press: New York, NY, USA, 2010.
97 Roelands, M.; Claeys, L.; Godon, M.; Geerts, M.; Feki, M.A.; Trappeniers, L. Enabling the Masses to Become Creative in Smart Spaces – Orienting User Creation in the Internet of Things in the Context of the ITEA2 DiYSE Project. In *Architecting the Internet of Things*; Uckelmann, D., Harrison, M., Michahelles, F., Eds.; Springer-Verlag: Berlin/Heidelberg, Germany, 2011; pp. 37-64.
98 Kawsar, F; Nakajima, T; Fujinami, K. Deploy Spontaneously: Supporting End-Users in Building and Enhancing a Smart Home. In *Proceedings of the International Conference on Ubiquitous Computing (UbiComp 2008)*; ACM: New York, NY, USA, 2008; Volume 344, pp. 282-291.
99 Beckmann, C; Consolvo, S; LaMarca, A. Some assembly required: Supporting end-user sensor installation in domestic ubiquitous computing environments. In *Proceedings of the International Conference on Ubiquitous Computing (UbiComp 2004)*; Springer-Verlag: Berlin/Heidelberg, Germany, 2004; Volume 3205, pp. 107—124.
100 Rodden T.; Benford S. The evolution of buildings and implications for the design of ubiquitous domestic environments. In *Proceedings of ACM Conference on Human Factors in Computing Systems (CHI 2003)*; ACM Press: Florida, USA, 2003; pp. 9-16.
101 Kymäläinen, T.; Heinilä, J.; Tuomisto, T.; Plomp, J.; Urhemaa, T. Co-design Process and Evaluations of a Home Control System, in the Context of Intelligent Nursing Environment. In *Proceedings of 8th International Conference on Intelligent Environments – IE2012*.
102 Kymäläinen T.; Plomp J. Life Story—Constructing a Memoir Writing Service. In *Prodeedings of Academic Mindtrek*; ACM Press: New York, NY, USA, 2012.
103 Luhtala, M.; Kymäläinen, T.; Plomp, J. Designing a music performance space for persons with intellectual learning disabilities. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, Oslo, Norway, 2011; pp. 429-432.
104 De Roeck. D.; Slegers K.; Criel J.; Godon M.; Claeys L.; Kilpi K.; Jacobs A. I would DiYSE for it! A manifesto for do-it-yourself internet-of-things creation. In *Proceedings of the NordiCHI '12*; ACM Press: New York, NY, USA, 2012.
105 Bakardjieva, M. *Internet society: the Internet in everyday life*; Sage: London, UK, 2005.
106 Mackay, W. E. Triggers and barriers to customizing software. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems 1991*; ACM Press: New Yoek, NY, USA, 1991; pp. 153-160.
107 Gershenfeld, N.A. *Fab: The coming revolution on your desktop – from personal computers to personal fabrication*. Basic Books: New York, NY, USA, 2005.
108 Fischer, G.; Giaccardi, E.; Ye, Y.; Sutcliffe, A. G.; Mehandjiev, N. Meta-design: A manifesto for end-user development. *Commun. ACM.* 2004, 47, 33-37.
109 Smith, D.C.; Cypher, A.; Tessler, L. Novice programming comes of age. In *Your Wish is My Command*; Lieberman, H., Ed.; Morgan Kaufmann: San Francisco, CA, USA, 2001; pp. 7-20.
110 Dey, A.K; Hamid, R; Beckmann, C; Li, I; Hsu, D. a CAPpella: Programming by Demonstration of Context-Aware Applications. In *Proceedings of ACM Conference on Human Factors in Computing Systems (CHI 2004)*; ACM Press: New York, USA, 2004; pp. 33-40.
111 Sohn, T; Dey, A. K. iCAP: An Informal Tool for Interactive Prototyping of Context-Aware Applications. In *Proceedings of ACM Conference on Human Factors in Computing Systems (CHI 2003)*; ACM Press: Florida, USA, 2003; pp. 974 – 975.
112 Kosta, E.; Pitkänen, O.; Niemelä, M.; Kaasinen, E. Mobile-Centric Ambient Intelligence in Health- and Homecare—Anticipating Ethical and Legal Challenges. *Sci. Eng. Ethics* 2010, 16, 303—323.
113 Rotter, P. A Framework for Assessing RFID System Security and Privacy Risks. *IEEE Pervasive Comput. Archive* 2008, 7, 70-77.
114 Bohn, J; Coroamă, V.; Langheinrich, M.; Mattern, F.; Rohs, M. Living in a World of Smart Everyday Objects – Social, Economic, and Ethical Implications. *Human Ecol. Risk Assessment* 2004, 10, 763-785.

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IF ALICE ARRIVES

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THEN

WONDERHOME INCITES

ABSTRACT

The science fiction prototype 'Alice's incitements in Wonderhome' introduces an intelligent home for the aged that provide motivational and personalized activities, assistance, and memory support. The prototype is based on two intelligent environment research studies: 1) a study that constructed a do-it-yourself creation and configuring tool into a nursing home environment, and 2) a study that aimed at finding means for seniors to compose their memoirs. The science-fiction prototype highlights important results of both studies by emphasising the motivational aspects of configuring the environment. It further describes new interaction mechanisms afforded by future technologies and novel research opportunities for the cloud of things.

KEYWORDS

Intelligent environment (IE);
science fiction prototype (SFP);
human-computer interaction (HCI);
home for the aged;
do-it-yourself (DIY) approach;
cloud of things (COT)

Figure 1.
Hologram forest — the Cloud of Thoughts.

BACKGROUND AND SETTINGS

The objective of a science fiction prototype (SFP) in intelligent environment (IE) research context is to illustrate long-term solutions for the technology, and introduce new opportunities and designs applicable in near or distant future. The SFP of this article, 'Alice's incitements in Wonderhome', is based on two inspirational IE research studies. These studies were carried out in the EU-funded DIYSE-program, Do-It-Yourself Smart Experiences (http://dyse.org/), which aimed at enabling ordinary people to easily create, setup and control applications in their smart living environments as well as in public environments. In Do-It-Yourself (DIY) IE the hypothesis is that the smart environments are constructed piecemeal with easily available, controllable and configurable components. Users are expected to be initiative and active constructors of their living environments, who share the responsibility of constructing, configuring and maintaining the technology. The first inspirational study developed a proof-of-concept home control system and a creation and configuring tool to an intelligent nursing ecosystem for elderly [1]. The second study constructed a service for writing, publishing and sharing personal recollections — life stories — for senior citizens [2]. Both studies examined profoundly the user expectations, embedded values and usability issues in relation to the chosen technologies.

The title of this paper introduces a simple rule: IF Alice arrives THEN Wonderhome incites. The title holds privileged humour for all struggling with the philosophical underpinnings of IE research — the "unbearable lightness" of the endless possibilities to encode the ubiquitous and adaptable technology, in contrast to the "heaviness" of the real-world unpredictable and value-saturated decryption and use. The study for developing the configuration system begun by creating scenarios, short stories, to illustrate the opportunities and usage situations of a hypothetical patient of a nursing home, a persona called Alice. The very first rule that was created (relating to the Bluetooth-lock control) begun by "If Alice arrives…" Henceforth, the research group ended up creating large number of potential rules to the system that were evaluated further with users. It was soon remarked, however, that the upmost importance was to find most evocative use cases and stories that illustrated the incitements and motivations to use the systems. Yet, logically, the greatest amount of construction material was gained at the end of the project — and, by the account, the motivation for writing this science fiction prototype becomes obvious.

The SFP is constructed around most important themes of the inspirational research studies. The first study provides substance about the motivations of people configuring, customising and personifying their environments in a do-it-yourself fashion, the inspiring and supporting role of the system, the self-actualizing part of the construction process and the preference to multimodal systems, haptic interfaces and spoken language dialogue interaction. The second study provides inspiration for the configuring activity – the creation and sharing of private memories. The SFP elaborates the findings of the original studies, places them into a concrete environment, and proceeds with what was not accomplished in the projects.

Essentially, the SFP illustrates the social connection between an elder parent and an adult child facing the challenges when moving in to a nursing home. The key philosophy in the construction objective relates to Yi-Fu Tuan's concept of "topophilia", which can be defined broadly "to include all of the human being's affective ties with the material environment" [3]. Transferring Alice's experience of home to the nursing home offers an intriguing opportunity to explore the concept. Tuan's study of environmental perceptions, attitudes, and values elucidate that topophilia towards a place that is the locus of memories, i.e. home, is more permanent and less easy to express than any other perception. Furthermore, the 70's environment for the SFP has been adapted from Ellen Langer's "counterclockwise" study, in which elderly men lived for a week as though it was 1959, took more control over their lives and seemed to grow younger [4]. Evidently, an intelligent, configurable environment has manifold and specified means for the objective. The side characters' diagnoses are roughly adapted from Oliver Sacks novel "The man who mistook his wife for a hat, and other clinical tales" [5]. The purpose is to exemplify motivations for personifying the environment and define the needs for exclusive interfaces and smart products. Acknowledged by Johnson's concept of SFP [6] the novel technologies – in this case, the use for the cloud of things, advanced interaction mechanisms and new data visualisation techniques – aim to redefine what can be done and how can be interacted in future intelligent environments.

1
ALICE'S INCITEMENTS IN WONDERHOME

1.1
She's Leaving Home

During the entire trip to the home for the aged Alice was silent. Kay, her daughter, overtook that to be the final way for her mother to show discontent. But Kay was afraid after Alice had had a stroke and two serious falls with fatal consequences. Alice was afraid, too. Her condition was not getting better: she had astrocytoma, a brain cancer in the star-shaped brain cells, which could not be removed. Now that Frank, Alice's husband, had unexpectedly passed away, Kay was the only one looking after her. And Kay could not be there for Alice all the time. She had two children, husband Sam, her work in the city and a newly renovated house.

When Alice and Kay had visited Wonderhome, a compassionate nurse had introduced the settings. The apartments were furnished with most exclusive technology for monitoring inhabitants, as well as providing assistance, activities and entertainment. One important purpose of the technology, as the nurse had explained, was to encourage inhabitants to take control over their lives and perform simple but vital tasks by themselves — such as taking medicine, preparing tea and meals and dressing up — to the extent that was humanely possible due to distinct physical disorders. Alice didn't like the idea. She had a nurse visiting twice a day, and the arrangement had worked extremely well. Top off the nurse's introduction had been, when she had stressed that the wonder of the Wonderhome was not the fancy technology, but the Wonderfamily that Alice was soon going to be part. Alice didn't appreciate the idea of having housemates either. She was used living by herself — and she loved it. Besides, she had important things to do — important, *private* things — relating to something her husband has said as his last words.

1.2
Wonderhouse, Dull house and Dollhouse

Once Alice had walked into her south-wing apartment, she felt suddenly something she didn't expect. While entering in, she felt vaguely as if coming home. She anticipated that the sensation was the cause of many things: the room was furnished, as expected, with her dearest belongings, photographs and portraits — and even with the custom-made wallpapers she had at home. But also more profound elements were in their familiar places: sockets, door handles, lamps and light-switches. They even worked as accustomed. Kay saw Alice's well-hidden astonishment when she proudly presented all the configurations she had made for the apartment. She said,

'The idea is that everything in here is as close to the conditions at home, mom.'

'They don't fool me. This not my home,' Alice replied resentfully.

‘I know. But there are also so many improvements compared to home,’ Kay went on, not minding about Alice’s remark,

‘For example, if you don’t want to get up in the morning, you can just call out all things of the apartment, and they do the morning tasks for you.’

Kay said things like “turn on the TV”, “turn on the lights in the living room” and “fill the bathtub”, by causing each thing to react. Alice tried to look unimpressed, although it was getting more and more difficult. She also understood that Kay had gone through considerable efforts when making the adjustments to the apartment.

‘You may call out the things of the house wherever you are. You can ask, for example, the teakettle to be turned on in the shared kitchen.’ Kay elaborated,

‘But the most important thing is that the house is observing you, all the time. No harm will pass its surveillance. And it does things for you. The lights will softly turn on in the morning, when its time to get up. And if you wake up at night, the night-lights will turn on, so that you may find your way to the bathroom.’

Kay led Alice to the bedroom. Just when Alice thought that there were no more surprises left, she recognized a familiar dollhouse next to her bed (see Figure 2). Frank had originally made the miniature copy of Alice’s house to Kay.

‘Do you remember when I moved from home to study? Frank packed the thing with me, once he had made some configurations to it.’

‘I remember,’ Alice said quietly as she recalled the situation,

‘He connected the lights of our home to match the little lamps of the dollhouse. Whenever we turned on a lamp, the matching lamp turned on in the dollhouse. They were supposed to signal you if we were at home, if we were asleep or awake.’

‘The lights were a clever way of implying if you were available for a conversation,’ Kay said and continued,

‘I thought that you might appreciate the dollhouse in turn, Mom. I have adjusted the lamps to match our house in turn. You can see when we are at home and when I have gone to bed. It could be a way of saying “good night”.’

Then Kay pointed towards a night lamp next to Alice’s bed, and explained that it had been adjusted to Kay’s home lamp in her upstairs corridor. When Alice would turn it off, it would signify when Alice had gone to bed.

Alice watched as Kay did some final fine-tuning to the dollhouse, and thought that Kay was truly her father’s girl, all the way down the line. But Alice was careful not to show her appreciation.

Eventually, Kay left. She had said that during the first days, the apartment would learn Alice’s preferences and tune the rooms accordingly. But Alice had no preferences! She resentfully practiced with the lights of the apartment by calling each of them in turn. It was strange, but at least she felt she had some control of her environment.

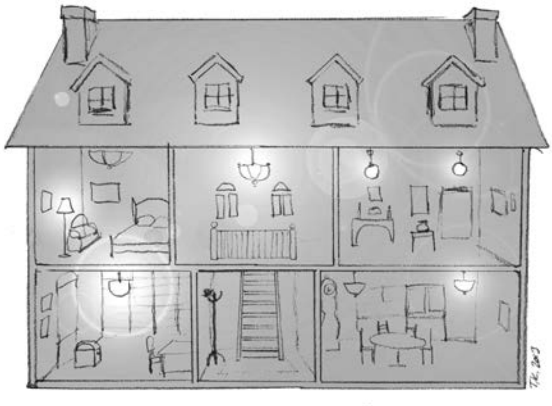

Figure 2.
The Dollhouse for subtle communication.

As the day turned into a night, Alice watched how the little lights of the dollhouse begun to turn off. When the last light faded, Alice thought bitterly how her daughter was probably sleeping more peacefully than ever, knowing that Alice was under constant surveillance and observation. And that was exactly why Alice couldn't sleep. She felt that by moving into the nursing home, nonetheless how wonderful, she had lost her integrity. Alice rebelliously left on the night lamp. She recalled that Kay could see the related corridor lamp from her bed.

Then Alice glanced at Frank's portrait in the bedroom wall. She instinctively tried to rub her wedding ring, which she had lost in the removal. She had been too ashamed to tell Kay about it, but now the situation made her feel twice as frustrated. Oh, how she missed Frank, their home and the life she had been forced to leave behind. But then she remembered Frank's harassing words, his bothering secret, which gave her another reason to stay awake. His exact last words had been,

'Do I still have time? There is the last confession I want to share with you Alice.'

Then, just before he had died, his voice had turned into mumbling,

'The key is... key is, Elise.'

All Alice could think, ever since, was: "Who the heck is Elise?"

1.3
Wicked Witch of the West

The next morning Alice was supposed to be acquainted with the other residents of the floor, but because of her poor night's sleep the circumstances were not most constructive. Still, Alice had to go to the kitchen if she wanted to have breakfast.

Alice met first Tom, the east-wing resident, who was an absentminded man in his eighties. He seemed to look somewhere above Alice while introducing himself and a weird music surrounded him once he focused on his breakfast again. Alfred, the north-wing resident, seemed to be more level headed: he had intelligent eyes, but a coarse, workman's handshake.

Fran, the west-wing resident, entered the kitchen theatrically and didn't introduce herself at all. She grasped idle looking Alice under her wing and forced her to the kitchen corner. The pompous lady pointed a statement in a smart-memo-board and harassed how important it was to encourage inhabitants to make things by themselves. The way Fran presented the goods and the kitchenware, Alice thought that she acted as if she was a nurse. Fran went on with her chattering and warned that Alice shouldn't think that because there were two men in the room, women should do all the work. Fran, herself, was doing that, but after all, she was hosting the place and, clearly, much younger than Alice. Before Alice could retort, Fran dragged her to the rest of the shared rooms and praised their modernism. The rooms were decorated in 70's style.

Fran disappeared to the hallway, as quickly as she had come, and Alice went back to the unfamiliar kitchen. Bravely she managed to make a decent breakfast for herself, with the help of her assisting avatar that appeared to the smart-memo-board. Alice had chosen the character long time ago to help in real- and virtual world situations such as this — when she did not know the way. Her avatar was a butler-rabbit.

'Such a clever avatar!' Alfred commented and went on,

'Mine resembles of my dog. Oh, how I miss the real thing! It brought such joy to my life: the way it looked at me and the way it appreciated simple things.'

Tom didn't seem to notice Alice's avatar. He replied to Alfred's statement,

'I miss my orchestra. Nothing can fulfil the experience of playing in a concert.'

Suddenly, Fran was back to the kitchen. She joined in:

'And I miss work! Not this trivial labour that I am doing here, for the time being, but my true call as an actress!' She added theatrically,

'I am waiting and waiting, but the phone never rings!'

Alfred furrowed, looked Fran and said,

'Fran, you are disturbingly starting to sound like the characters in Beckett's play "Waiting for Godot".' Then he chanced his voice and imitated,

'You divert yourself while waiting for something imaginary to happen "*if not in the evening but surely tomorrow*".'

Alice looked Alfred curiously. Clearly she had made a misjudgement regarding him, and his workman manners. Fran looked Alfred anxiously, but seemed to miss his point. Her voice turned suddenly chilly as she declared,

'Yet at this moment, in this instant, I miss most my shiny, silvery shoes. And when *the call* comes, I will *need* them.'

After a dramatic pause she turned her gaze towards Alice and continued,

'Shoes do not walk by themselves, which means that someone has taken them. Men hardly have use for ladies' shoes; and thereby the only suspect is *her*!'

Fran was pointing at Alice and accused stealing her shoes the very first time they met! Alice was appalled. She didn't know how to respond to such impulsiveness, such arrogance. And she thought she was too old for the compulsory games of defining the pecking order of a new company. She looked first at Tom, who didn't seem to realise what was going on, and then Alfred, who winked his eye to Alice. He turned to Fran and retorted, as dramatically as Fran,

'You wicked witch of the west! Why don't you use the smart-memo-board to find the lost things and stop harassing our newcomer!

Then he was more smoothing,

'I will help you with your shoes, but before we do that, Fran dear, you might as well tell something about yourself to our Dorothy here. For example, how old are you?'

Alice's assessment of Fran's age was a bit over eighty.

'Why, you should know better than that, not to ask the age of a lady! But I might as well tell you — if you promise you don't tell my agent. I am thirty-nine.'

Alfred gave an evocative glance to Alice and continued,

'Well, for such a young person, you probably don't have any trouble in remembering what year it is?'

Fran looked baffled for a moment. Then she smiled,

'Poor old thing, you must be getting quite senile. The year is, of course, 1976!'

Alice glanced her pocket-watch-display just to make sure. In the display the butler-rabbit was proactively presenting needed information: the year was 2018. Alfred was not a bit discomfited about Fran's retort, but went on by taking a magazine from the kitchen table. He presented Fran an article of a famous actress, Meryl Streep, and asked,

'Fran, you are an actress. Can you tell me who the person in the picture is?'

'Never seen in my life! Must be some shooting star, they come and they go. Oh, she looks so skinny. A bit like Audrey, but not as sophisticated, you know what I mean.'

Then Fran stood up, collected empty cups and plates, and went by the kitchen sink. Alfred noticed Alice's confused expression. He lowered his voice and explained,

'Fran really was an actress. She has an unusual version of Korsakov syndrome, and it causes her to think that time has frozen into 1976. That is why all the rooms are decorated in 70's style, although there is more to it. It is for all our well-being; to make us feel younger. You probably noticed all the trouble that they had seen to make you feel at home, as well? But you should see Fran's apartment! Her room is an exact copy of her apartment — in 1976. There are extreme details there in place: stains in the carpet, thresholds measured of exact height, force feedback in the doors and a broken thermostat that works improperly but which has obvious logic to Fran.'

'Why?' Asked puzzled Alice.

'To make her feel comfortable. Not to confuse her. There is no time capsule to retrieve her back from the 70's, Alfred said and continued,

'But there is one thing missing from her apartment, though.'

'What is that?'

'A mirror. If she saw her reflection, that would break the illusion. She resembles Dorian Gray in that part.' Alfred quoted the play melodramatically,

'If it were I who was to be always young, and the picture that was to grow old! For that-for that-I would give everything!' Then he whispered quietly,

'So Alice, don't ever show her a mirror, unless you truly want to upset her.'

Alice saw no reason to do that. Alfred concluded by saying:

'Fran thinks that she is looking after us, but in fact, it is the other way around. The truth is Alice; that we are here looking after each other.'

After saying that Alfred went to help Fran. His assisting avatar dog led them to the lost shoes by barking louder when discovered.

1.4
BeQuest Drawer-Chest

Alice withdrew to her south-wing apartment, whilst she thought she had enough social life for a day. Alice had an important mission — a mission that required her undivided attention. Alice sat beside a huge, solid oak cabinet, which Frank had called the BeQuest drawer-chest (see Figure 3). Alice was hoping that the chest, with its forty-eight drawers, could help to reveal Frank's mysterious secret.

Frank, her philosophical handyman, had spent most of his spare time devoted in renovating Alice's house, but this new project had been his latest, his last, passion. Frank had been extremely proud of the cabinet and called it "the foundation of the human mind". According to him, it had space to hold an entire well-classified world of a person, and once one had put something in it, it could never be lost. Frank had begun the project soon after Alice's tumour had been discovered, and after, according to Frank's judgment, Alice started to forget things. Frank had said that Alice needed more memory-exercises and the drawer-chest provided plenty of those.

The significance of the drawer had become clear after an incident. Alice was a keen conserver, and she was in trouble each autumn when it was time to store the pickles. Alice noticed some large, empty drawers in Frank's cabinet, which she wouldn't ever have dreamed of using, if it hadn't been an emergency. Alice had put the pickle jars in the drawers, and thought nothing of them, until Frank had found her cache. He had been shocked and accused her of "abusing the foundation of the human mind" and "turning his reasoning cabinet into a larder".

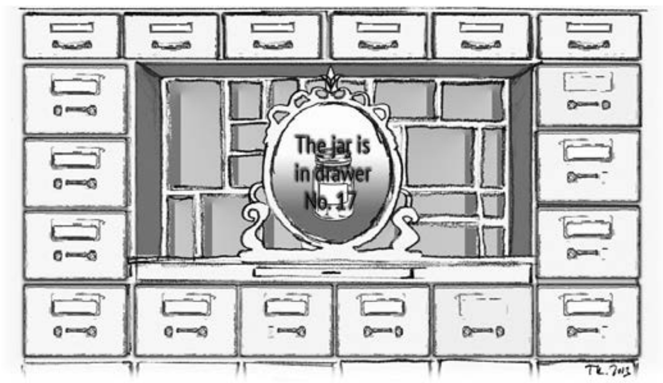

Figure 3.
BeQuest drawer-chest.

After calming down, he had used a pickle jar as an example how the cabinet worked. He enclosed a label into the jar, put it in front of a looking-glass display and asked Alice to explain the content. Confused Alice had done as asked, and Frank put the jar to one of the drawers. Then Frank smiled to her and requested for the jar. Alice witnessed how the looking glass required more specific details and Frank replied with roughly something that Alice told about the content. The looking glass revealed the number of the requested drawer. Frank put the container in front of the looking-glass reader and there was Alice's voice explaining the content with a supplementary pickle recipe drawn from the cloud.

Then Frank opened up another drawer, took his father's medal of honour and to Alice's surprise, exposed detailed wartime stories from many sources relating to the medal. From that time on, Frank stored all their most important things into the cabinet, and asked Alice to help him to save their shared recollections. Later, Frank had told that the drawer did not open up to just anyone. There were secret compartments that opened only to him, Alice and Kay — and they requested secret, articulated passwords.

Alice was convinced now that Frank's gloomy secret was encapsulated in the drawer. She said aloud "Elise", but the looking-glass display didn't react. Then Alice tried the backdoor that Frank had created in case of problems. She asked,

'Magic mirror in the chest, I request: who is Elise?'

The looking glass remained silent.

1.5 Hologram Forest

The day after, Alice decided to take another approach for finding out the secret. With a word 'forest' she asked for a hologram woods to ignite itself into her living room (see Figure 1). The hologram forest was a place for all the digital traces of Alice's life: all the things she had done, all the places she'd been, and all the communication she had ever had. In other words: the hologram forest was the outsourcing of Alice's memory. The forest emerged as a garden of diverse trees, with various shapes, colours and sizes. The trees held braches, which held leaves, which held memories and reminiscences. The information had been implanted into the forest according to Alice's preferences; a tree was bigger if it held a significant amount of memories; it was taller if it was older and a tree had a specific gloom if it had been browsed recently. Regularly, Alice mostly browsed the maples, because they held all her dearest photographs. She practically never browsed the willows that held her regularly updating medical information or sprouts of junipers that was the new sensor data of the Wonderhome.

In addition with her own part of the forest, Alice had partial access to other people's grounds. Now that Frank was dead, with his authorisation, she had inherited his entire forest. Up until this moment Alice hadn't had time to visit there.

Now Alice crossed over the border, and visited the parts she had been able to visit before. Then she came to an unfamiliar meadow. Alice had a feeling that this could be the place to start her search. She inhaled and called out "Elise". The word echoed back. At first nothing seemed to happen, but then she heard how the branches rustled, and a tiny, familiar face peeked out from the shrubbery. It was the butler-rabbit again, who gave her a rude glance, turned around, and headed deeper into Frank's forest. Alice followed him, as usual.

The rabbit led her to a tense willow growth that seemed to contain Frank's old lecturing files. It shook a tree, and dropped a leaf to Alice's hands. It was an essay from a girl named Therese, apparently tagged with label of her nickname Elise. Alice browsed the content by moving her eyes. As she was not satisfied, the rabbit led her to a non-glooming large oak and dropped some leaves that contained photographs of an old family friend, Elisabeth. Alice knew she wasn't the one she was looking for either. Then the rabbit shook his head and bounced over to Kay's forest, but Alice felt weary and did not follow. She thought she was now totally, utterly lost with the secret.

1.6
Come Together

The homecoming party for Alice was in the following evening. Alice had invited all her new roommates to see her apartment. Alfred sat next to Alice in the sofa, looked at her warmly and said:

'I am glad you moved to live with us, Alice. It is so pleasant to have someone with some sense and sensibility.'

'I admit I had some prejudice towards Wonderhome's endless observing, self-help demands and especially, the housemates. But I have swallowed my pride and know now that this was the best thing that could've had happened to me.'

Alfred was looking at Fran and Tom, who were browsing the BeQuest drawer-chest. Alice had adjusted the looking glass *not* to show the camera reflection, and there were only few drawers open to satisfy the curiosity of the occasional browsers. Accordingly, there was only the exhibit garden accessible in Alice's forest. Alfred sighed,

'Those two don't have much use for the hologram forest.'

'How come? I couldn't live without it.'

'Fran has not any digitalized recollections before 1976, and as her memory endures only about fifteen minutes, she quickly looses interest to browsing.'

'What about Tom, then?'

'He is another story. Tom has no visual memory or imagination. The world presents itself quite absurd to him. He cannot understand the hologram forest at all. In fact, he doesn't comprehend any faces, images or objects around him.'

'But he recognized me this morning, called me by the name!'

'He has a device that he carries with him for the purpose. In the device his Dormouse avatar acts as a prompter and whispers the names. It recognises people's faces, voices and walking-styles. And the labelled objects around Wonderhome obviously know Tom.'

'And is there some reason why he is surrounded by music all the time?'

'Indeed! Tom used to be a distinguished musician. Now that he does not understand things around him and what they are for, the world has been constructed according to something he understand very well — music. He has identifiable songs for every act and procedure. He has songs for dining, dressing up, even for taking a bath.'

As they were speaking, Tom came to sit next to Alice. He appraised,

'Your cabinet seems extremely interesting, Alice. But what do you do with the hologram thing, the forest? The Dormouse told me that it is for tracing back memories, but I don't understand. What kind of memories?'

Alice sighed. She was feeling too comfortable to conceive a lie to her new friends.

'I might as well tell you, since I have come to a dead-end with my investigations. For the last few days, I have been trying to solve my late husband's secret. Something he said to me in his deathbed.'

Both men leaned attentively closer to Alice. They said in unison:

'What did he say?'

'He said: "I have a last confession. And: the key is Elise." Alice said and sighed,

'I am convinced that the secret is hidden in the drawer-chest.'

To Alice's great surprise Tom chuckled and said,

'That is a catching tune! I have used it myself for remembering how to prepare tea and madeleine cookies.'

'I beg your pardon?' astounded Alice sighed.

‘I mean the most famous Elise of all: “Für Elise” by Beethoven. Now that I think of it, of course the notes could be used as a secret key. The letters that spell Elise can be decoded as the first three notes of the piece. Because an E♭ is called an Es in German and is pronounced as “S”, that makes E–(L)–(I)–S–E: E–(L)–(I)–E♭–E...’

Alice wasn’t listening anymore. Intuitively she understood that Tom had solved the mystery. She asked gingerly:

‘Could you please play it for me, with my old piano in the corner?’

Tom graciously did as asked. All listened to the scenic music that Tom played effortlessly without any hesitation or absent-mindlessness. Alice sat by the drawer-chest and observed the lockers. Then the music stopped, but nothing happened.

1.7
Last Note

After a good night’s sleep, the answer came to Alice. It came to her in a flashback memory. She had heard Frank’s last words as a mumbling: “The key is... key is, Elise”, but, in fact, she understood now, he had said: “The key is Kay’s Elise”.

When Kay had practiced the tune, as a child, she had persistently always misplayed the third note. Alice called Kay; who came and played the piece. As she hit the magical note, she simultaneously looked at her mother in a way that made Alice understand that she had plotted this whole thing with Frank. A locker opened up – not in the drawer-chest, but in the dollhouse. It notified about the event by continuing to play “Für Elise” and guiding the source of the sound to the tiny living room. Alice picked her missing wedding ring from a small chest. Intuitively, she took the ring next to the looking-glass reader of the drawer-chest. The mirror informed that the ring contained Frank’s last confession to Alice – his confession of love.

Frank’s confession was revealed as a story of the most important things in his life, spoken in his own philosophical, earthly manner. He told about the rainy day in July they had met with Alice, the marriage, Alice’s blue house, Kay’s birth and the birth of Kay’s daughters. All the happy moments came tangible to Alice as Frank led her to the drawers, one by one, which held the souvenirs of their life together. Alice was grateful of the elongated memory. There were so many things that she had forgotten, so many things buried under some ridiculous misgiving. She was also grateful that the shared chore brought her back in peace with Kay.

The first objective for the SFP was to consider what motives people would have to construct their intelligent environments and what kind of configurations they would make. These objectives were considered throughout the prototype when Alice familiarized herself with the Wonderhome and her apartment, and when she interacted with the dollhouse. The multiuse environment was augmented with referenced ubiquitous computing technology for everyday activities, such as used e.g. in the Aware Home, Easy Living and iDorm [7-9]: sensing and person tracking technologies; vision techniques, sensitive floor, and voice recognition; spatial audio cues, wearable computers and unobtrusive centralized computing services. The system for finding frequently lost objects detected Fran's silvery shoes, conceivably, with small radio-frequency tags and a long-range indoor positioning system. The smart-memoboards were touchscreens placed strategically throughout the Wonderhome, used for presenting all the smart- and context-aware services. As a side character, the prototype introduced an electronic butler [10], the white rabbit avatar, which was an autonomous, personal agent that operated on Alice's behalf in the virtual world [9].

The second objective of the prototype related to the storing, retrieval and sharing of personal recollections. The BeQuest drawer-chest (exploiting the Cloud of Things) and the Hologram forest (organizing the Cloud of Thoughts) exemplified innovations that could be applicable in (near or distant) future for organizing and augmenting private data and memories. The idea for the BeQuest drawer-chest came from a personal heritage cupboard and had further inspiration from a novel by Henri Bosco written in 1947 [11]. The prototype deliberately neglected to specify in detail what the technology behind the "looking-glass reader" and the "labeling" were, as in the case, the presently available magnetic and optical data storage technologies could easily be replaced, for example, by future holographic data storage technology [12]. In that case, the "looking-glass" would play more important role in creating and reading through the hologram. In essence, the drawer-chest was a computational artefact on top of which anyone can build their life stories, complemented creatively with rhymes and chords.

The hologram forest was inspired by Mark Weiser's concluding statement in his widely quoted article [13]: "Machines that fit the human environment instead of forcing humans to enter theirs will make using a computer as refreshing as taking a walk in the woods". Essentially, the hologram forest was a personal map of all the digital things traceable in Alice's life. The forest introduced a novel data visualization technique to present the ambiguous, personal digital data stored in the cloud. Another novelty was the haptic feedback and the use of gaze-contingent technique for browsing the holographic projection.

The core testimony of the prototype was that in ubiquitous world the language has enormous significance. It defines how people interact with the technology, how devices communicate between themselves, but also how the information is retrieved. Humans are successful at communicating complex ideas to each other, but there is still a lot of work to be done with the human-computer interaction. Animated characters were mentioned by Chin et al. [14] as one option for the interaction. In the home control system evaluations, the prominence of the spoken language dialogue became evident, and hence it was chosen as the key interaction mechanism in the SFP for triggering actions and subtly securing private information.

The prototype 'Alice's incitements in Wonderhome' used narrative means in bridging the gap between "the unbearable lightness" of encoding ubiquitous technology and relating "heaviness" of nondeterministic users decrypting the code. It introduced enchanting technology that aging Alice would presumably be motivated to use in an intelligent nursing home. As technology becomes physical, the motivations and values, such as creativity and control [14], are fundamentally things that have the utmost importance. The quest for the IE opportunities is an on-going cycle; this SFP aimed at ending one cycle and, hopefully, provide incitements to begin another.

1 T. M. Kymäläinen, J. Heinilä, T. Tuomisto, J. C. Plomp and T. Urhemaa, Co-design Process and Evaluations of a Home Control System, in the Context of Intelligent Nursing Environment. In The Proceedings of 8th International Conference on Intelligent Environments (2012), 87-94.

2 T. M. Kymäläinen and J. C. Plomp, Life Story – Constructing a Memoir Writing Service, In Proceeding of the 16th International Academic MindTrek Conference (2012), 147-153.

3 Y-F. Tuan, Topophilia: A Study of Environmental Perception, Attitudes, and Values, Englewood Cliffs, NJ: Prentice-Hall, 1974.

4 E. J. Langer, Counterclockwise: Mindful health and the power of possibility, Ballantine Books, New York, 2009.

5 O. W. Sacks, The man who mistook his wife for a hat, and other clinical tales, Summit Books, 1985.

6 B. D. Johnson, Science fiction prototyping: designing the future with science fiction, Synthesis Lectures on Computer Science, Morgan Claypool, 2011.

7 C. D. Kidd, et al. The aware home: A living laboratory for ubiquitous computing research, Cooperative buildings. Integrating information, organizations, and architecture, Springer Berlin Heidelberg (1999), 191-198.

8 B. Brumitt, B. Meyers, J. Krumm, A. Kern and S. Shafer, Easyliving: Technologies for intelligent environments. Handheld and ubiquitous computing, Springer Berlin Heidelberg (2000), 12-29.

9 H. A. Hagras, V. Callaghan, M. Colley, G. Clarke, A. Pounds-Cornish, and H. Duman, Creating an ambient-intelligence environment using embedded agents, Intelligent Systems, IEEE, 19 (6): (2004), 12-20.

10 D. J. Cook, J.C. Augusto and V. R. Jakkula, Ambient intelligence: Technologies, applications, and opportunities, Pervasive and Mobile Computing, 5 (4) (2009) 277-298.

11 H. Bosco, Monsieur Carre-Benoît in the Country, Staples Press Ltd., (First English Edition) 1956.

12 V. Sainov and E. Stoykova, Display Holography—Status and Future, In Optical Imaging and Metrology: Advanced Technologies, Wiley-VCH Verlag, Weinheim, Germany, 2012.

13 M. Weiser, The Computer for the Twenty-First Century, Scientific American 265 (3): (1991), 94–104.

14 J. Chin, V. Callaghan, and G. Clarke, Soft-appliances: A vision for user created networked appliances in digital homes, Journal of Ambient Intelligence and Smart Environments, 1(1) (2009), 69-75.

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DREAMNESTING

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CO-CREATED FUTURE VISION OF AN INTELLIGENT INTERIOR DESIGN EXPERIENCE

ABSTRACT

This article, and subsequent science-fiction prototype, finds its premise in two different foundations: the human-centred design of new technology development, and the co-creation methodologies of business sciences. The connection between these two research fields arises from the emerging need to find means of constructing complex service experiences with multidisciplinary approach. By leaning on both perspectives, the aim of the article is to construct a science-fiction prototype 'Dreamnesting'. The prototype presents a new service enterprise that engages a user-customer deeply in the co-creation experience and introduces a new technology platform for the interior design task: augmented reality (AR) technology in an intelligent service environment. The prototype has its foundations, at first, in a front-end co-design user study, which aimed at creating novel interior design service concepts that were thought to be used virtually, and to exploit 3D modelling and AR technology. Then, the article converses on relevant building blocks that come to the fore from the economy and business theories, namely: co-creation of value, customer experience and human assets of the firm.

KEYWORDS

Customer/user experience;
co-creation;
service design;
augmented reality (AR)
intelligent environment (IE);
human-technology interaction (HTI)

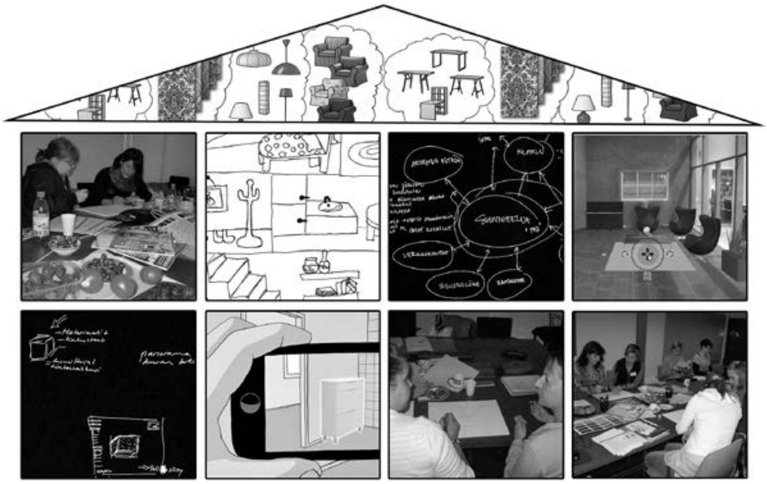

Illustration 1.
Co-designing a novel interior design service.

1 Introduction

The science-fiction prototype introduced in this article was inspired by a research study, “User-created new service concepts and interfaces for interior design – introducing augmented reality features” [1, 2]. The study was part of a research programme that aimed at studying the use of new technologies and applications – social media services, augmented reality features and location awareness – in the field of interior design, and at finding new revenue models for media. The study was carried out by VTT Technical Research Centre of Finland within the Adfeed project, which was supported by TEKES as part of the next Media programme of TIVIT (Finnish Strategic Centre for Science, Technology and Innovation in the field of ICT). The framework for the preliminary research study was twofold. The human-centred design aim was to study users’ innovation capability in the early phase of a complex design process by utilising participatory design methods [3]. The technological aim was to create interior design concepts that exploited augmented reality (AR) and 3D models [4]. The study was carried out in workshops with the critical users [5] – interior designers, bloggers and serious amateurs – who co-created service ecosystem descriptions and requirements with project- and business partners.

Engaging customers in technology-driven service processes is a relatively new approach in the human-centred design field, whereas co-created services have been studied much longer in economics and business research [6]. For example, in service-dominant logic, service is perceived as the fundamental basis for all exchange and value, with the assumption that all economies are service economies [7]. Central to service-dominant (S-D) logic is the proposition that the customer becomes a co-creator of value [8]. To implement this idea in technological design processes would require services to be seen as the entry point for technological development. Lusch and Vargo explain that physical goods, such as devices or applications, which often are the research subjects also in technological development processes, may be seen as a delivery channel or transmitter for the service [7]. Correspondingly, Pine and Gilmore perceive service and tangible elements as a single customer experience, from the customer point of view [9]. As technological development has evolved to cover much larger systems – technology-embedded intelligent environments [10], for example – the focus has started to shift towards services and customer experiences. Human-centred design part of the development has been concentrated more on the front-end design processes and usability research. Since economic sciences are more interested in “how they (the set of assumptions) correspond with the real world” [11] – in other words, the interest is skewed also towards the end of the process – we may assume that these two approaches offer complementary pathways for studying service-oriented technological ecosystems. In this article we shall use the science-fiction prototype to speculate how the

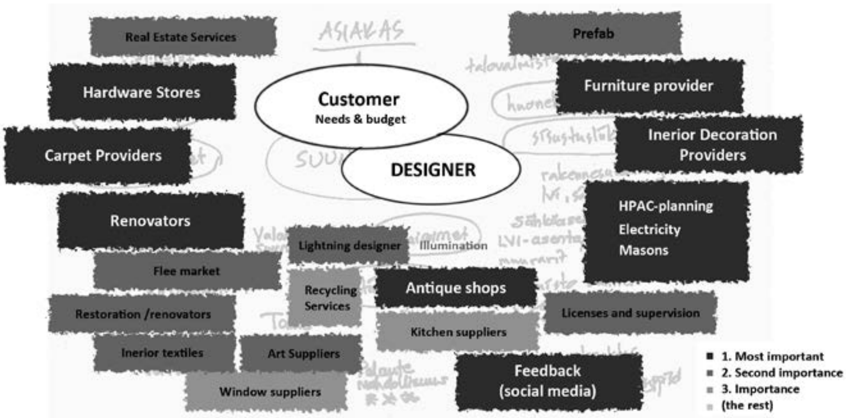

Illustration 2.
An example of a service ecosystem made by interior designers, (reconstructed).

user-created service concepts, powered with co-creation theory, may evolve into a new kind of service model. Through future modes of co-creation, we are potentially influencing revenue generation models, and this could be leading to a whole new definition of the theory.

How, then, is it best to approach the question of constructing service-centered experiences? Suitable theory from the business perspective is the co-creation paradigm, presented by Ramaswamy and Gouillart, which explains the emerging relationship between customers and companies [12]. In short, co-creation is about putting the human experience at the centre of the enterprise's design.

2
CO-CREATING A PLATFORM BY UTILISING THE RESULTS OF THE INSPIRATIONAL HUMAN-CENTRED FRONT-END USER STUDY

"Co-creation starts with a focus on the entire ecosystem, and aims to imagine a new value chain that benefits all players, including of course, the enterprise [12]." Conveniently, Ramaswamy and Guillard provide a framework for co-creating experiences, which will provide practical structure for creating a science-fiction prototype, as well. The first task in the framework is to identify all stakeholders touched by the process. Second task is to understand and map out current interactions among stakeholders, and the third task is to organise workshops in which the stakeholders share experiences and imagine ways of improving them. These three tasks have been carried out in the front-end user study [1] that will provide the crucial information necessary for constructing the science-fiction prototype. The most valuable material was the co-created ecosystem descriptions (see Illustration 2).

As the fourth step, Ramaswamy and Guillard suggest building platforms for implementing the ideas for new interactions, and for continuing the dialogue among the stakeholders to generate further ideas. In this case, the platform will be the science-fiction prototype constructed for this article.

2.1
Settings for the prototype – the firm

We will construct the prototype by first concentrating on the ecosystem that presents itself as the firm, Dreamnesting. When considering establishing an enterprise, even fictional one, three levels of analysis, by Oliver Williamson [13], may be applied. The first level considers the overall structure of the firm: how the operational parts are related one to another. The second level deals with the operating parts: which activities should be performed within the enterprise, which outside, and why; in other words, defining "efficient boundaries" for the enterprise. The third level responds to the question of how human assets are organised [14]. In the prototype, Dreamnesting

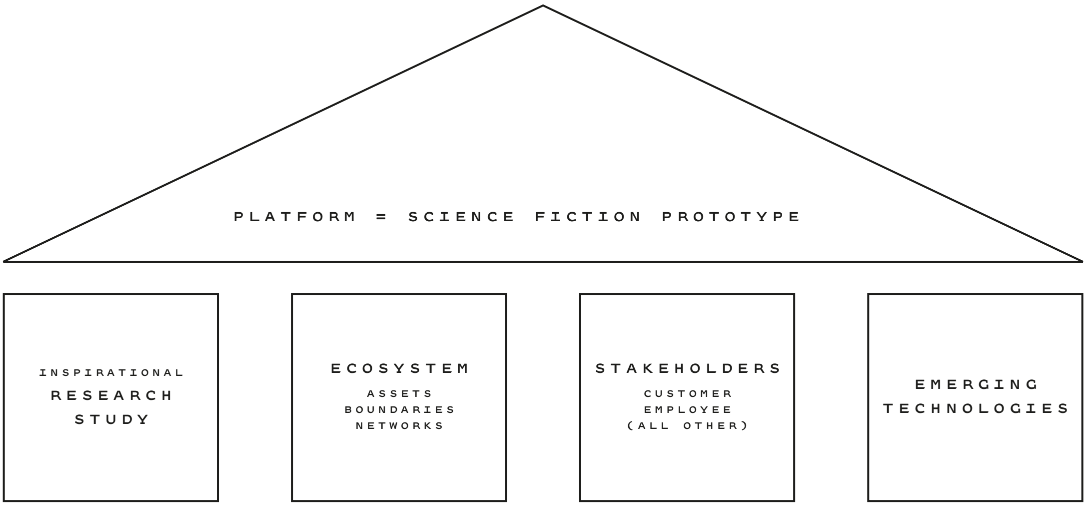

Illustration 3.
Building blocks for the science fiction prototype.

will mainly focus on the third level: it will show itself as an organisation of human assets, namely the assets that are gained learning by doing. Also, the assets such as e.g. continuing supply of services and site specificity are somewhat considered [15].

2.2 Characters for the prototype – the stakeholders

According to Mrs. Robinnson, "Any economic system requires a set of rules, an ideology to justify them and *a conscience in the individual which makes (her) strive to carry them out* [11]." On our task of building a platform, the focus will be next, as suggested also by Ramaswamy and Guillard [16], on the experiences of a few key stakeholders. The participants of the front-end user study have determined explicitly the characters for the prototype: their needs, time of use and the settings. According to the results of the study, the critical users for the service would be a young couple that have just bought an apartment, and who were waiting, for a month or two, for permission to move in. The young couple in the prototype, Abby and Elvin, will thus have the legitimate main roles in the prototype. Sam is a character who will provide the employee's perspective as a manager.

2.3 Experience Environment

Prahalad and Ramaswamy [17] suggest further a framework for an experience environment — a framework that allows the firm to facilitate a variety of co-creation experiences with lots of consumers (with varying interests, skill levels, needs and desires). The mind-sets of this framework will be a continuum to the construction of the platform. If we broaden the science-fiction prototype to an experience environment, important requirements are the following: 1. The experience environment should offer opportunities for consumers to co-construct their own experiences on demand, in a specific context of space and time. 2. Personal meaning will be the knowledge, insights, enjoyment, satisfaction and excitement that the individual derives from the event. 3. The involvement of the consumer communities engages the consumer emotionally and intellectually. 4. New opportunities afforded by the evolution of emerging technologies should be offered for the stakeholders.

2.4 Emerging technologies

In the front-end user study, a web-based augmented reality (AR) interior design service was the technological research subject. The usefulness of the technology for the field of interior design was seen to be the fact that AR provides a practical visualization method for purposes where there is a need to enhance the user's perception [18]. Interior design, in particular, is an application field where the combination of real and virtual benefits the user. The participants of the user study raised three important topics, concerning the technology, above others: realistic lighting, number and variety of furniture models available (including 3D reconstruction of existing furniture), and smart database search. We will thus consider these key requirements in the prototype. In the study, it was presumed that users would augment digital images and operate the system by using a PC or a mobile device. The science fiction prototype will further accelerate the technological evolution of the interior service system by placing the events to an intelligent (design) environment [19].

2.5 Aesthetic qualities

Finally, to make the task of constructing a prototype more challenging, the aim is to create value for the service by adding aesthetic qualities to the platform. The attempt is acknowledged by reference to French philosopher Gaston Bachelard's thoughts on home, house and space, envisioned in his work "Poetics of space"[20]. To quote: "The house is one of the greatest powers of integration for the thoughts, memories and dreams of mankind." The reference suits well for the purpose of an invitation to share the experience of the science-fiction prototype.

3
SCIENCE-FICTION PROTOTYPE: DREAMNESTING

3.1
The house

Abby squinted in the sharp spring sun to watch a swift flying over the eves. She followed how skilfully it grabbed at a piece of fluff floating in the air and carried it to a nearby nest. The nest was atop a tall oak — certainly a safe place for any anticipated little swifts, thought Abby.

'Come on!' said Elvin, her fiancé, his voice tense.

Abby looked at him and smiled calmingly. 'I think she can wait one more minute.'

Elvin growled. 'I don't think she can. We're finally going to talk about money; every real estate agent's favourite subject!'

As soon as Elvin had spoken, the door opened, and a pair of enthusiastic eyes, an over-enthusiastic smile and a mismatching headscarf greeted the couple.

'There you are, you little lovebirds!' said the honeyed, lively tone. 'Welcome to the not-so-modest hut that will soon be yours!'

Entering the house for the second time, Abby had the feeling she was coming home. The feeling endured as she sat next to Elvin on a soft, flowery, worn-out sofa, which was located in the living room — in the heart of their forthcoming home.

The reason for their visit was the down payment. They were to discuss it with the present owner, a woman they hadn't met during their earlier visit. Hope introduced the couple to Alice. She seemed a warm, kind old lady; a little sad, somehow, but that was to be expected. She was selling her home, after all.

'I am glad that it's you two buying the house. You seem such a sweet young couple!' said a delighted Alice. 'You look just like Frank and me when we moved here!' Alice's eyes sparkled as she recalled the event. Then a furrow came to her brow as she continued, 'It would have been terrible to sell this house to some *speculator*. This house has seen so many happy moments. It holds all my dearest memories!'

Abby felt sympathy for Alice, but was soon overtaken by excitement and curiosity. When Alice gazed out of the window, Abby stood up and walked around the room admiring all the details of her forthcoming home. She felt compelled to try to make a mental note of everything, knowing it would be a torturing two months before they could move in.

Elvin was equally examining the room from his vantage point on the sofa. All around, the traces of Alice's past memories were clearly evident: faded wallpaper, ancient flooring, dog-nail scratches, and rather too many dark corners... things that eventually would need to be renovated and repaired.

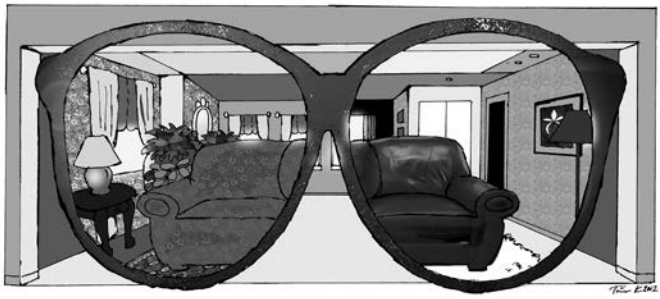

Illustration 4.
Interface space and smart glasses.

'Hmm,' Elvin began. 'We sorted out the loan with the bank, and will have the money ready on September 1st as was suggested.'

Hope was back in business, conscious of her duty to avoid embarrassing her employer with such mundane matters. She quickly took the envelope containing the deposit and returned a chip to Elvin's side of the table. Elvin took the chip, which resembled a key fob with a house-shaped cover.

'All the necessary information concerning the house is in there,' Hope said, and repeated the list she had memorised: 'All the floor-, garden- and renovation plans, plus all the plans for lighting, electricity, heating, plumbing and air-conditioning. Then there are full contact details for all the contractors who have carried out renovations over the last decade.'

'I'll leave you some of the furniture, as a housewarming gift,' said Alice. 'My late husband made models of all our furniture for the insurance company, and I think they're also in that thing you've got there.' Alice pointed to the chip.

'Oh God!' thought Elvin, 'I hope she doesn't mean the sofa! That'll be the first thing to go.'

Alice was looking at Elvin intensely. Abby had also caught his expression, and was sure Alice was reading his mind when she continued:

'But you can do what ever you like with the furniture. I can't take it all with me to the nursing home.'

Abby, who was almost qualified artisan in furniture refurbishment, thanked her warmly. She was convinced she would find use for the furniture, including the sofa.

Elvin stood up to take leave, and the others followed. As Abby was stepping over the threshold, Hope grabbed her shoulder, familiar enthusiasm once again filling her eyes.

‘You’ve come this far,’ she whispered. ‘You’ve got your dream house! But as you see, it’s anything but perfect. It’ll be two months before you can move in, but there are plenty of things you can do before that. And it’ll be worth all the effort, as you’ll be living here till the end of your days!’ Hope slipped a card into Abby’s hand. ‘It *is* your dream house,’ she said. ‘I have a hunch for these things, you know!’

Abby glanced at the card. A word in gold lettering glistened on a cloud-blue background: “Dreamnesting”.

‘What did she want?’ Elvin asked as they were walking away from the house. Abby showed him the card.

‘Hope is right, you know,’ she said. ‘There are plenty of things we *should* do before we move in. I have heard that this “Dreamnesting” has all interior and renovation services gathered under one roof. They’ll help us to fit in the old furniture, think about the new kitchen.’

‘I don’t know,’ mumbled Elvin. ‘Smells like money burning. And since we have just moved to town and I am the only one with a job.’

‘Actually,’ said Abby, in an attempt to make her pleading more effective, ‘I heard of this place first from Sarah, Jim’s wife. She shared some magnificent pictures of her under-construction living room in Facebook.’

‘Sarah and Jim are lucky because of Sarah’s inheritance,’ said Elvin. ‘And Jim — well, as my new boss, he obviously makes more money than I do.’

Though Elvin continued in the same vein, Abby could sense that the ice was melting.

‘Couldn’t we just settle in and do the renovations one by one?’ Elvin persisted. ‘Once we’ve started to pay off the loan we’ll have more money for the renovations.’

‘But we’ll have more money now that you’ve got the promotion! And getting promoted means you won’t have time to plan or do anything by yourself.’

‘Well, *you’ll* have plenty of time! Couldn’t you just Google a few options and send them to me at work? I’ll then just pick the cheapest one!’

This was Elvin’s peculiar brand of sarcasm talking, but Abby wasn’t going to let him, or anything, spoil her good mood. She stopped, and said, rather spicily:

‘No! I want us to do this properly. I want to fulfil my dearest dream and build the perfect home for us to live in happily ever after!’

3.2 Dreamnesting

Abby had contacted Dreamnesting and sent them the chip in advance, as was requested. She had also answered to a questionnaire about her preferences concerning the interior design and followed some conversations about the many ways to plan designs with the help of the firm and its networks. Then a company representative, a manager, as they seemed to call them, contacted Abby and presented himself. When Abby agreed to meet him, he replied that she would need a full day for the design plans. The day would cost her nothing, except her valuable time.

Abby entered the company's lobby, sat down and waited. Soon an older man – in his sixties, she guessed – came in and called her:

'Miss Kindle?'

'Yes,' said Abby, getting up.

'I am Sam,' the man said, shaking Abby's hand. 'I've been assigned to help you on this journey towards your dream home.' Sam had kind eyes, and Abby found him immediately reassuring. 'Actually,' Sam continued, 'after seeing the profile of your three-storey house I was convinced I am the right person to assist you. I am a philosopher by profession, you see, specialising in the works of a French philosopher Gaston Bachelard.'

This caused Abby to raise her eyebrows, but Sam went on to explain the strategy:

'Our policy at Dreamnesting is to provide tailored options for our customers, or "artists", as I prefer to call them – artists designing their dream homes. We are using the most sophisticated technology in the design process, but our most sincere aim is to put our experience in the hands of the customer to create an aesthetic and comfortable home. A dream home come true, you might say.'

As if to add further impact to his words, Sam touched a screen behind the desk and revealed the following text:

"An artist does not create the way he lives, he lives the way he creates. – Jean Lescure [21]."

'I'll be here all day to provide any assistance. If you will need me, that is.'

'Of course I'll need you!' Abby huffed. 'I haven't a clue how to design a home, much less how to operate your sophisticated systems! I've not done this before. I've never bought a home before!'

Sam smiled. 'You'll get plenty of help, Miss Kindle. Cybil can help you much better than anyone else.'

'Cybil?'

'Cybil is the artificial intelligence that will guide you through the process. Let me give you a proper introduction. This can only be done at the location. Shall we go there, to the white space? Your empty canvas, on which to paint your dream nest?'

Sam led Abby down long corridors towards a door bearing the number 42. Behind the door was an empty hall in white; it was the size of a warehouse. It had the appearance, and echo, of a clean and sterile laboratory; it was a true non-place, thought Abby.

‘This space is the *interface* of the interior design programme,’ Sam began. ‘It will adapt perfectly to your dream home.’ He walked to a side table that Abby had only just noticed, for it was as white as the rest of the hall. Sam took two objects from the table: a tablet, which was transparent as if made of glass, and a pair of very light eyeglasses.

‘This is your artist’s palette, *the cloud palette*,’ Sam said, handing over the tablet, ‘and only by wearing these magic glasses you are able to see your artwork.’

Abby put on the glasses and took hold of the palette.

‘Cybil!’ Sam called out. ‘May I present you the artist, Miss Abby Kindle?’

A soft, comforting voice replied.

‘*How do you do, Miss Abby Kindle. I am Cybil, your humble assistant.*’

‘How do you do,’ Abby replied, somewhat indecisively.

Sam moved to the door and said, ‘Now that you two have been introduced, I’ll leave you to your work. If you will need anything, just press this button by the door. We’ll bring you tea and sandwiches between breaks, whenever you please.’

Then he left, and Abby was alone in an empty room with a faceless voice called Cybil. It spoke again.

‘*Miss Abby Kindle, we are now going to start reconstructing your dream home. First, I am going to put the first floor, ceiling and walls into place according to the floor plans.*’

The walls and ceiling started to move, and all Abby could do was to stare. First, wall elements descended from the ceiling. Soon Abby stood by the entrance door in the outer hall of her future home. Windows and doorways appeared, and the ceiling began to lower. When it “clunked” into place, Cybil announced:

‘*You may walk around.*’

Abby walked from the hall into the living room. The walls and doorways seemed to be in their exact places, just as she remembered.

‘Wow!’ she exclaimed as she entered the room, ‘Even the windows look just like real ones!’

‘*Luckily the window information was stored using version 3.0.*’

Abby thought she noticed pride in Cybil’s voice, but laughed at the thought. She was talking to an artificial intelligence, to a *computer*.

‘*Shall we continue, Miss Abby Kindle?*’ said Cybil. ‘*We will need the glasses and the cloud palette now.*’

Abby was already wearing the glasses, but took hold of the palette. Seven colour buttons appeared on its surface.

‘*Those colours are for seven interior styles I have programmed in advance. You may toggle between them.*’

Abby pressed the first, purple button, and the white room was suddenly filled with colour! Rose ornamented wallpapers covered the living room walls, while the flooring was coated in the shade known as madder red. There was also some new furniture.

'*Style is called "Old English Manor",*' said Cybil, and encouraged Abby to try the other styles. Abby walked around the living room and kitchen, toggling between "*Scandinavia Minimalism*" and "*Feng Shui*". She found "*Monet*" much too extreme, and changed the room around her to match "*New, Borrowed and Blue*".

It was only after pressing the yellow button, a style that coloured the surfaces in yellow, crème and fresh green that she knew "*Spring Primrose*" was the name of her true style.

'The designs you are experiencing were created by independent designers, for houses much similar to yours, Miss Abby Kindle. These designs are copyright protected, and if you decide to use the plans there will be compensation payable to the designer and her network. If you choose one of the ready-made styles, however, you will be able to create all the interior design plans of your home during only few days.'

Abby was so overwhelmed by what she was experiencing that she just had to call Elvin. Elvin was about to take his lunch hour, and reluctantly agreed to come and see what the fuss was all about. While waiting for him, Abby decided to play a practical joke on her fiancé.

'The previous owner stored furniture models on the chip,' she said to Cybil. 'Could we browse those and see if there is a certain flower-patterned sofa in there?'

Elvin had brought sandwiches to eat, but he could barely swallow when he saw the place. Even the joke with the sofa failed to bring him back to earth; so convincing was the virtual version of their future home. Abby explained in detail what she had learned so far. Elvin went to stand over by the living room wall.

'I was thinking of removing this wall to give straight access to the kitchen,' he said.

He thought he was speaking to himself, until Cybil replied:

'A new customer? Please identify.'

'Oh, Elvin Hall,' said Elvin, slightly confused.

'Mr Elvin Hall, you may not move the wall entirely, because underneath there is a supportive structure. But you could replace it with a column. I will demonstrate.'

The wall withdrew into the ceiling, a column descending in its place. Elvin was speechless. Eventually, with a wrinkle of his eyebrows, he speculated:

'What would this all cost?'

This was his way of finding a reason in an unreasonable situation. Cybil responded:

'You can see all the costs for every purchase, acquisition and labour on the cloud palette.'

Abby handed the palette to Elvin. He pressed the coin -button, and suddenly the view displayed all the prices for renovation, wallpaper, paint, materials and furniture, with the total cost set clearly underneath.

'Hmm. This would help in negotiating a suitable loan,' he murmured, and, to Abby's surprise, seemed to be following through with the scheme. 'We should probably do the renovations right away, and include the costs in the loan since the interests are lower for a mortgage than for a renovation loan.'

'For some people, *seeing* is believing!' thought Abby.

Later Sam convinced Elvin that the prices showing on the cloud palette were only the estimations. If they wanted to spend time on negotiating, they would obtain lower prices from the distributors. They could also do some of the work themselves – the currently obligatory sustainability plans and demolition work, for example – and that would lower costs further.

Abby and Elvin decided to make a contract for the two forthcoming months, during which Abby would design their entire house with Cybil. Abby was convinced she didn't want to use the ready-made designs, as appealing as they seemed. She was convinced she wanted to rebuild and decorate her new home *her way*. And since that would significantly lower the costs, Elvin agreed.

3.3
Steinway Model B

On the following day, Abby was standing in the virtual living room, surrounded by the colours she had picked and improved from the "Spring Primrose" collection. Cybil demonstrated more of her magic by placing a virtual, but time-bound sun shining in through the windows. The view from the windows was of the garden (generated from the garden plans on the chip) on an early morning in July, just like the real world. They were about to furnish the first floor, and Cybil adjusted the buttons of the cloud palette to bring up seven different furniture categories.

'Today we are going to start the true design, Miss Abby Kindle,' said Cybil. *'Is there some piece of furniture that is of great significance to you or Mr Hall? An ancestral cupboard, for example?'*

Abby didn't need to think twice. She had brought along her weighty, but treasured piano whenever she had moved.

'What is the brand of the piano? Or who is the manufacturer?'

'It's a Steinway Model B,' Abby answered without hesitation.

'And where do you want to place it?'

Abby thought for a while, but there was really only one place for it – near to the window so she could see into the garden, but protected from harsh sunlight. She pointed out the spot by keeping the palette over the place for a while, and stepped aside when Cybil asked her to. The piano models began to flash before her eyes through the glasses, and stopped when Cybil had found the exact model from her library. The hallucination seemed so real that Abby felt she could reach out and start playing. She suddenly felt the urge to remove the glasses. But as she did, the illusion was gone: the design had disappeared and there was only the bare, white space. Abby quickly put the glasses back on.

'I will remove the article from the shopping cart since you have it already, Miss Abby Kindle,' said Cybil. *'Shall we continue? We might proceed by taking the colour from the article and applying it to the surroundings, or try to find matching furniture.'*

'My piano stool is quite old and unsteady,' Abby said. 'Is there a new one available, not too expensive?' Cybil replied that she would look for one from her database, and fed in the criteria for matching style, price, size and colour. She found several suitable alternatives and displayed them. Abby browsed through them all, and soon reached a decision on her first furniture purchase.

'Do you want to set the delivery date for the 1st of September? Is the delivery address the dream home, 149, Bloom Street?'

Abby, relishing the thought, agreed.

It took almost three weeks for Abby and Cybil to complete the design of the first floor. It was hard work finding the genuine Italian wallpapers, the low-cost imitations of oriental plaques, the matching set of interior textiles, and the special furniture. Because Abby spend time on negotiating about the prices and various ways to deliver the articles, she was able to have discount for the total price. But Abby's appetite and ambition grew when she involved herself more deeply in design task, and Elvin soon noticed, that his bride's taste was not most cost-effective one.

3.4
From cellar to garret

Abby met Sam in the lobby. As usual, he was delighted to see her.

'Today is going to be a particularly exciting day for you, Miss Kindle!' he said. 'You are about to enter the next level!' Sam escorted Abby to her design space, talking of the philosophy that concerns home.

'According to Bachelard, once we are in the new home, memories of all other places we have lived in come back.' He turned to Abby and asked, 'Have you thought of that while constructing the house?' Abby shook her head. Sam smiled encouragingly.

'Today,' he suggested, 'you might try to fit into the design Bachelard's most important thought, that the first home shapes all later spaces."

Then he turned towards door number 42 and gestured Abby to step through.

'Good morning, Miss Kindle,' said Cybil. *'We have already designed the first floor of the three-storey house. Now we are about to concentrate on the other two: the cellar and the upper floor.'*

Abby agreed.

'Miss Abby Kindle,' Cybil said suddenly, *'May I ask you something personal?'*

Abby was startled. She had almost forgotten about talking to a computer, but the thought once again entered her mind. As creepy as the situation was, Abby replied, 'Sure.'

'Does this house remind you of something? Your childhood home, perhaps?'

Abby remembered Sam's counsel. She was now curious how her past experiences could be exploited in this simulated design.

'My new house doesn't remind me of my childhood at all. My parents were students and we lived in a block of flats.' Abby sank into her thoughts, but was astonished when she suddenly remembered something. 'But it *does* remind me a lot of my grandparents' house. It was *just* the same kind of three-storey house.' Abby said and sank into her thoughts. 'I spent most of my summers there,' she whispered, 'and have *very* pleasant memories.'

'If I may suggest, we could integrate your pleasant memories when designing these, more personal, homely floors. Do you agree, Miss Kindle?'

Abby willingly agreed.

'Which will you choose first: the cellar or the garret?'

Abby wasn't sure. In the absence of an answer, Cybil applied some rational thinking.

'The upper floor is for the bedroom, and the bedroom bears the mark of intimacy. I would suggest that you design the second floor together with Mr Hall.'

'We'll start with the cellar, then,' said Abby.

Sam knocked on the door and stepped in, wheeling a tea trolley.

'Which one of the two floors did you choose, Miss Kindle, if I might ask?'

'The cellar,' said Abby.

'It will take some time for Cybil to reconstruct the floor, so let me take advantage of the time to illustrate some common notions about cellars.'

Over their many discussions, Sam had come to learn that Abby drank tea without milk or lemon. He passed the cup to Abby and lowered his voice to a whisper.

'The cellar is the dark entity of the house. There is plenty of evidence of this. For example, my favourite novelist, Edgar Allan Poe, places his darkest plots in the cellar [22,23]. Even admired psychologists, such as C. G. Jung [24], admit that the unconscious operates down there. You may also recall the many films and TV-series in which the cellar is the preferred setting of the most horrible mass murderer.'

Abby laughed.

‘It’s an interesting thought, but I think I’ll settle for designing a comfortable bathroom and a practical utility room!’

‘Exactly, Miss Kindle!’ said Sam, straightening up. He continued, however, with what was apparently one of his favourite subjects. ‘But there are always different layers in every decent artwork. An artist might try to find other uses for the cellar. With a cellar, an artist might try to do more than just rationalise it.’ Sam got up and moved towards the door. Before leaving, he whispered, ‘Sometimes it is best to leave some corners dark, some rooms not so... *inhabited*!’

Abby smiled at Sam’s mystifying thoughts.

By the time Abby had finished her tea, Cybil was ready. Abby was now standing underneath the stairs leading to the first floor. They began the task by browsing all the rooms. Cybil asked questions that referred to Abby’s grandparents’ house, questions such as *“Was the cellar cluttered?”, “Was the room large or small?” and “How was the room illuminated?”* Abby was thrilled to find another aspect for the design – to design by recalling her past experiences. Her stress, however, was on convenience. Despite this, Sam’s thoughts on the mysteries of the cellar had struck a chord in her, a fact she acknowledged by leaving some corners as they were.

That night, Abby searched through her belongings for evidence of her grand-parents’ house, finding two chairs, and a drawing she had made when she was ten. The drawing showed a three-storey house. Her grandparents’ house was sold many years ago, and it made her sad to think that the two chairs and her memories were all that was left. There was no return to her roots, to where she came from. She realised that this was probably how Alice was feeling at this very moment. When Abby looked at the drawing, the many things she thought she had forgotten now came flooding back.

Abby decided to take full advantage of the opportunity revealed by the memory lane. The next day she asked for 3D-models of the two chairs, and, with her long-slumbering inclination for furniture refurbishment fully reactivated, poured all her childhood memories into creating a variety of fabric designs until finally, she was satisfied with the results.

When Sam saw the designs he was thrilled. He confessed having recognised immediately that Abby’s interest would not be limited to superficial decorating – that she was *a true artist*. Sam revealed that few customers spent as much time as Abby on designing interior plans, let alone creating their own designs. As she would easily pass the qualification level set by Dreamnesting’s service department, Sam felt that Abby’s designs should be made public. He said that he would launch the process of congregating Abby’s personal network. With her consent, the fabric designs could be linked to the design library, and she would have her share of profit as a discount of the total sum if she preferred. Abby smiled, as she knew that Sam suggested that because he knew Elvin’s attitude towards the cost of making the designs.

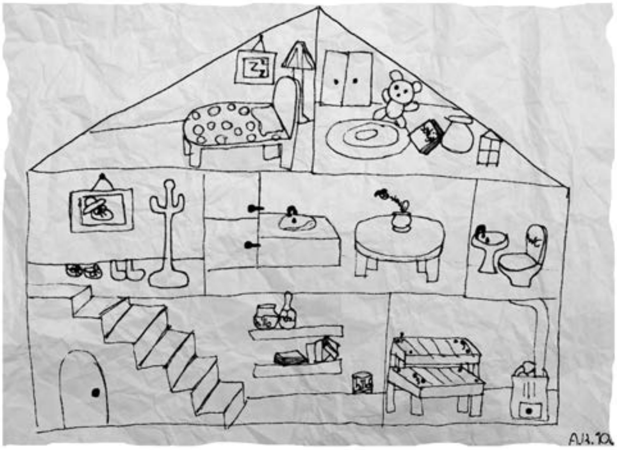

Illustration 5.
Abby's drawing of a three-storey house, at the age of ten.

3.5
House and universe

The two months passed quickly. Various suppliers, furniture companies, interior architects, renovators, electricity consultants, gardening- and lighting designers and logistics made their best putting all the pieces together before Abby and Elvin moved into their home. Once, while they were signing their contracts, ordering last accessories and furniture and calling the last bids for contractors, Sam said:

'Now the time has come to stop dreaming and start building your dream.'

'Or then we could just move in here,' Elvin replied. 'I mean, we will never be able to keep things as tidy as in this virtual place!'

Sam cited Bachelard one last time:

'Inhabited space transcends any virtual, geometrical place.'

On September 1st, Elvin carried Abby over the threshold of their new home. They looked around, excited in the knowledge that they were finally allowed to enter the house in the role of new owners. They wandered around the house, admiring their entire interior dream come true.

Finally, they were able to sit on the sofa that Alice had left them, now refurbished with Abby's fabric design. Abby found a card from Dreamnesting on the side table, it held congratulations and the words: “Your house is your corner of the world.” A handbill was attached to the card, specifying all bought services and supplies. Elvin looked stunned.

‘The charge is far less than my estimate,’ he said in wonder.

‘That’s because I’m now an independent contractor of Dreamnesting,’ Abby replied with a grin. ‘You can actually thank the sofa and the two chairs beside it, since they’re my main articles in the firm’s virtual supply. I have a contract that allows me to design articles and renovate old furniture whenever I find the time.’

Elvin grinned and hugged Abby proudly. Abby bounced up and down happily and ran to her piano. Joyfully, she played their song: “As time goes by”. After she had finished, they shared Casablanca-type kisses. And then Abby found the courage to pour out her heart, saying with a smile:

‘I think I’ll have to go back to Dreamnesting once more though, as in the role of a customer.’

Elvin looked puzzled.

‘We’ll have to decorate the other bedroom again. I’m pregnant!’

4
REFLECTION

The enterprise in the science-fiction prototype, Dreamnesting, was truly not an organisation but an organism [15], as Coase has elucidated when defining the nature of a firm. Dreamnesting was obviously a collective organization that benefitted from the fact that indivisible physical assets were owned and utilised by some form of peer group association [25]. An inclusive network contained autonomous networks in which each member was connected with the centre. The employees of Dreamnesting, first Sam and then Abby, were independent contractors – in carrying out the work of effecting the services [15].

Reflecting on the three levels of analysis, provided by Oliver Williamson [13], we may summarise that the strategic objective of Dreamnesting was to provide interior-design-related products and services in a technology-advanced, computer-augmented environment. Internal structure of the firm was thus a collection of independent networks that were organized and managed by the enterprise. The human assets were chosen to be the level to be studied more carefully, for those are expected to be particularly important in a future enterprise that is specialised in providing services [14]. Human assets can be described to the degree in which they are enterprise-specific and the ease with which productivity can be measured [13]. Undeniably, there were various kinds of customer and employee relationships at Dreamnesting, but according to what was revealed; the human assets were very specific to the enterprise (Abby was learning by doing) and very difficult to measure (as one would presume when key personnel is experienced in philosophy). Apparently, the most highly valued skills were acquired in a learning-by-doing fashion, in which case they become enterprise-specific and imperfectly transferable [26]. Skills deepen through work experience, and then these non-transferable skills become a source of added value [13]. And mostly, valued skills lead to greater compensation.

When considering the relationship between Abby and the enterprise, one could say that they operate in a bilateral exchange relation [13]. Once an investment was made, buyer (Abby) and seller (the firm) were effectively operating in this relation for a considerable time. The supplier (the firm) was effectively "locked into" the transaction, and Abby was equally committed to the transaction as she could not turn to alternative sources. Where asset specificity is great, buyer and seller will make special efforts to design an exchange that has good continuity properties [26]. All the more if the enterprise sees every customer as a potential employee.

Sam has an interesting role in the network: he acts as the manager, but is yet an independent actor. In such a novel enterprise as Dreamnesting, managers need the capacity to react quickly and continuously based on events, along with the capacity to reconfigure resources flexibly and quickly [17]. For creating an optimal customer experience, according to Prahalad and Ramaswamy, managers must understand and intervene selectively in individual consumer events even as they manage the overall operation. Managers must thus get real-time event-centric data regarding consumer experiences. Appropriate teatime brake, just when critical events were about to take place, illustrated this argument in the prototype.

4.1
Technological feasibility: augmented reality (AR) and intelligent environment (IE)

When considering about the technological feasibility of the prototype, it can be said that at the moment, AR technology is mature enough so that the service could be build – as a 3D -service, with AR functionalities, operating through Internet. Photorealistic rendering [27], relating to the user requirements, is computationally demanding, but in the presented prototype, still images [28] would have suit for the purpose. The prototype illustrated a large object library that supports creativity, together with (far too) advanced AI search functionalities. The prototype speculated about the advantages of an intelligent interior design environment, which in this context was pure fiction. The topic, *interior design* however tempted to place the events into the real environment; i.e. to envisage that *the space is the interface*. The settings were most suitable for exploring the prospects of embedded, aesthetic intelligence that is perceived with all senses.

5 CONCLUSION

"Economics is the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses [29]." The stress is on the terms "ends" and "means". We desire something concretely either "for its own sake" or as a means of achieving something else [30], which is very much the situation with service experiences. Hopefully, this prototype has offered thought-provoking insights of the "means, which have alternative uses" that may be speculated on through both economic- and technological glasses.

The article will end with Bachelard's most appropriate words: "Thought and experience are not the only things that sanction human values. The values that belong to daydreaming mark humanity in its depths. [20]" Thus, daydreaming, in this context, applies to all activities: interior design, service design, dreaming about co-created business models and future service ecosystems, and most of all, in the mans of using science-fiction prototyping [31] for demonstrating the activities.

1 T. Kymäläinen, S. Siltanen, Co-designing Novel Interior Design Service That Utilizes Augmented Reality, a Case Study, Second International Symposium on Communicability, Computer Graphics and Innovative Design for Interactive Systems (CCGIDIS 2012) Valle d'Aosta, Italy (2012) In press.
2 T. Kymäläinen, S. Siltanen, User-created New Service Concepts and Interfaces for Interior Design – Introducing Augmented Reality Features, Emerging Software for Interactive Interfaces, Database, Computer Graphics and Animation: Pixels and the New Excellence in Communicability, Cloud Computing and Augmented Reality. 2012. Blue Herons Edition. In Press.
3 D. Schuler, A. Namioka, Participatory Design: Principles and Practices, Lawrence Erlbaum Associates, Inc., Hillsdale, New Jersey, 1993.
4 W. E. Mackay, Augmented reality: linking real and virtual worlds: a new paradigm for interacting with computers, In Proceedings of the working conference on Advanced visual interfaces (AVI '98), ACM, New York, NY, USA, (1998) pp. 13-21.
5 J. Cassim, H. Dong, Critical users in design innovation, In: P.J. Clarkson, R. Coleman, S. Keates, C. Lebbon, (Eds.) Inclusive Design: Design for the Whole Population, Springer-Verlag, London, 2003, pp. 532-553.
6 E. Kaasinen, M. Ainasoja, E. Vulli, H. Paavola, R. Hautala, P. Lehtonen, E. Reunanen, User involvement in service innovations, VTT Research Notes 2552, Espoo, Finland, 2010.
7 R. F. Lusch, S.L. Vargo, The service-dominant logic of marketing: dialog, debate, and directions, M.E. Sharpe, Armonk, N.Y., 2006.
8 C. Grönroos, Service management and marketing: a customer relationship management approach, Chichester, Wiley, 2000.
9 J. Pine, J.H. Gilmore, The experience economy: work is theatre & every business a stage, Harvard Business School Press, Boston (Mass.), 1999.
10 K. Edwards, R. Grinter, At Home with Ubiquitous Computing: Seven Challenges, in: Proceedings of Ubicomp 2001, Springer-Verlag (2001) pp. 256-272.
11 J. Robinnson, Economic Philosophy, Aldine Publishing Company, Illinois, USA, 1963.
12 V. Ramaswamy, F. Gouillart, The Power of Co-Creation: Build It with Them To Boost Growth, Productivity, and Profits, Free Press, 2010.
13 O. E. Williamson, The Economics of Organization: The Transaction Cost Approach, The American Journal of Sociology, 87(3) (1981) pp. 548-577.
14 P. Garrouste, S. Saussier, Looking for a theory of the firm: Future challenges, Journal of economic behaviour & Organization, vol. 58 (2005) 178-199.
15 R. Coase, The Nature of the Firm, Economica, 4 (16) (1937) 386–405.
16 V. Ramaswamy, F. Gouillart, Building the Co-creative Enterprise, Harvard Business Review, Harward Business School publishing corporation, 2010.
17 C.K. Prahalad, V. Ramaswamy, The future of competition: co-creating unique value with customers, Harvard Business School Press, Boston (Mass.), 2004.
18 S. Siltanen, Theory and applications of marker-based augmented reality, VTT Science 3, Espoo, Finland, 2012.
19 K. Edwards, R. Grinter R, At Home with Ubiquitous Computing: Seven Challenges in Proceedings of Ubicomp, pp. 256-272, (2001) Springer-Verlag.
20 G. Bachelard, Poetics of space (in French: La Poétique de l'Espace), Presses Universitaires de France, 1958. Orior press Inc., 1964.
21 J. Lescure, Lapicque, Galanis, Paris, France, Editions Galanis, 1956.
22 E. A. Poe, The Black Cat, in: Tales, Wiley and Putnam, New-York, 1845.
23 E. A. Poe, The cask of Amontillado, in: Godey's Lady's Book, vol. XXXIII, no. 5, (1846) 33:216-218.
24 C.G. Jung. Modern man in search of a soul. Harcourt, Brace and World, New York, 1933.
25 O. E. Williamson, Markets and Hierarchies: Analysis and antitrust Implications, New York, Free Press, 1975.
26 O.E. Williamson, The Theory of the Firm as Governance Structure: From Choice to Contract, Journal of Economic Perspectives, 16(3), 2002, pp. 171-195.
27 M. Aittala, Inverse lighting and photorealistic rendering for augmented reality, The Visual Computer, Vol. 26, No. 6, (2010) pp. 669-678.
28 S. Siltanen, C. Woodward, Augmented Interiors with Digital Camera Images, W. Piekarski (ed.) In proc. Seventh Australasian user interface conference (AUIC2006) ACS. Vol. 50: 33 (2006).
29 L. Robbins, The nature and significance of economic science, Macmillan, London, 1932, pp. 16.
30 D.M. Hausman (ed.), The philosophy of Economics, An anthology, Cambridge University Press, 1984.
31 B.D. Johnson, Science Fiction Prototyping: Designing the Future with Science Fiction, Synthesis Lectures on Computer Science, Morganclaypool, vol. 3:1, 2011, pp. 1-190.

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SONG OF ILIAD

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ABSTRACT

The short story "Song of Iliad" describes a future music therapy "performance space" in which children around the globe create music together, form a band and perform for others. The story encapsulates the human-driven design approach and presents an example of how future design processes might exploit emotion-driven design in creating highly personified products and services.

KEYWORDS

Smart Spaces;
Do-it-yourself experiences;
User-Centred Design (UCD);
Human-Technology Interaction (HTI);
Design for All (DfA);
Music Therapy.

Figure 1.
Song of Iliad.

INTRODUCTION

The “Song of Iliad” (Figure 1) describes the world of a twelve-year-old boy who is isolated, and looking for a friend — an idea not too far-fetched, perhaps, as the starting point of a story or study. The story illustrates a novel smart-space concept that twines around a magical music box, the box revealing a hidden world that unfurls slowly through music. In describing a long-term use of currently non-existent technology, and allowing the reader to imagine the details, the story’s science fiction prototyping method further stretches the means of early-phase, user-centred design methods [1]. The story also broadens the perspective of current technological achievements to embrace emotion-driven design, acknowledging that emotions are expected to be an important research subject in future design of highly personified products and services [2, 3].

DO-IT-YOURSELF SMART ENVIRONMENTS

“Song of Iliad”, a sci-fi short story, is inspired by a research project that has developed the “DIYSE Music Creation Tool”, aimed at people with intellectual learning disabilities [1][4]. The tool is part of the Eureka/ITEA2 DIYSE (Do It Yourself Smart Experiences) project[2]. The general aim of the project is to enable ordinary people to create setup and control applications in their smart living environments, and in the public Internet-of-Things space. This is achieved by allowing them to take advantage of aware services and smart objects in order to obtain highly personalised, social, interactive, flowing experiences at home and in other environments. The development of the “DIYSE Music Creation Tool”, the user studies and the evaluation of the tool were all aimed at studying the needs and expectations of new technologies in the context of music therapy. The actual prototype consisted of software and physical guitar controllers. The software allowed the music therapist to personalise interaction mapping between physical and digital instrument components. By means of the guitars, the study’s users — people with intellectual learning disabilities — were able to play prepared musical compositions without extensive training. The observations and evaluations of the tool were carried out in a natural music therapy situation, allowing the gathering of information on adaption and usability of the software and instruments. All music therapy sessions were video-recorded and later analysed using an interaction analysis method [5, 6]. According to the evaluations, the study participants considered performing on stage, publishing music and training for a performance to be important. “Song of Iliad” attempts to highlight the issues that emerged and stretch the

1
People who have a mild or moderate (Diagnosis ICD-10) intellectual learning disability

2
http://www.dyse.org

idea further, beyond the limitations of current technology.

The music therapy case was nevertheless only one example of the human-driven means of developing a smart space concept. One endeavour of the DIYSE project has been to research and develop the overall architectural structure of smart spaces – consisting, for example, of all the physical building blocks, applications, sensors and sensor data – and, furthermore, how the users interact with the technology and how the information is presented [7]. The paradigm lies in the question 'what are the means for the users to interact with the smart space system?' The story also commits on evaluation methodologies by offering a method for performing the evaluation in situ, i.e. where the users are [8]. In its illustration of a specific smart space concept, the story's general value for science lies in its focusing attention on human behaviour, rather than on novel technology, and in doing so, signposting an alternative path in the field of human-technology interaction.

SONG OF ILIAD

Iliad was a crippled boy raised by his uncle Nestor and aunt Alice in the depressing landscape of Upper Sandusky, Ohio. Iliad had been born with legs and hands shorter than his body, at least shorter than extremities should be in a twelve-year-old boy. Because of his disabilities, and his forsaken dwelling place, Iliad lived an isolated life and felt alienated. Luckily, Iliad had an old white shepherd dog Pris, his sole source of happiness.

One ordinary morning, or what at first seemed to be an ordinary morning, Iliad was surprised by his Aunt Alice. Even though it was not his birthday, Alice took Iliad to the upper attic, where she gave him a special gift box. Later, Iliad thought that Alice could have been more talkative while giving him the present, but there was apparently a good reason why she only said:

'This is no ordinary gift box. I received it from your music therapist, Paula, and she instructed me to leave you alone to figure out its mystery by yourself.'

Iliad observed the box from close to and from a distance. The box was an ornamented package, covered in purple velvet, a very intriguing thing indeed. As Iliad heard his aunt leave — and ignoring Pris, who was barking a warning — he opened the box and heard a purring sound. Soon after, he saw a holographic image appearing into the thin air. The image was blurred and it quivered at first, before focusing and revealing the head of an odd-looking woman, with a tight topknot, strange glasses and a resentful expression. The woman sighed, and said with a machine-like voice:

<Hello, my name is Ellen Blaise and I am from the Music Therapy Research Group. I am your wizard and evaluator in the Muzic box application. I will ask you a few questions and I want you to reply as truthfully as you can. After the background research, there will be a decision on how the experiment is to continue.>

Iliad said nothing, just gulped.

<Respond: name, age, address, gender and occupation.>

'Err... I am Iliad. I am twelve. I live in Upper Sandusky, Ohio, United States, and I am a boy, so I do nothing... except go to school, play and do some errands on the farm and... do... nothing. This is Pris. She is a dog, and she is nine years old.'

<Recorded. Do you have a disability?>

'How did you know about that?' said Iliad, surprised. He was also a little annoyed when he added: "I do have twisted legs and hands, so you might call me a cripple."

<Recorded. What makes you happy? What is your greatest wish?>

Iliad hesitated. He was not sure of Ellen Blaise's purpose in asking these questions; what was she driving at? Nevertheless, Iliad decided that if this was a game, he didn't have too much to lose by it. He responded to his formal-sounding questioner by revealing his deepest desire:

'I wish that I had friends.'

‹Recorded. Have you ever played music? Any instruments?›

'No, I guess I've never played, except in therapy classes. My uncle has a flute, though, but he never allows me to touch it.'

The ethereal but inflexible Ellen Blaise seemed satisfied, when she said:

‹Background research completed. You may start exploring the material. Try to build a musical instrument of your own choice. Take your time. End of phase one.›

The hologram vanished inside the box, a tiny red light began to flash, and instead of purring, the box now hummed. Iliad placed it carefully on the ground and looked around. What had the woman meant by saying he should built an instrument? Iliad noticed that under the box was a much larger trunk, a trunk he had never seen before. He opened it, in turn to discover strange-looking items that seemed vaguely like musical instruments. The objects were fascinating. Iliad began to piece them together, and soon the whole attic was filled with outlandish devices. The parts connected easily to one another, providing countless options. Pris helped Iliad by bringing him parts that were lying around the trunk. By late afternoon Iliad had built a dozen combinations that, at least in his mind, were reminiscent of musical instruments. He pressed the ones that invited pressing, beat the ones that called for beating, and blew the ones that demanded blowing. Through simple expressions he was able to generate sounds; sometimes even a single press or light blow brought complex tones. Iliad felt a strange obsession and passion in creating music — music that floated so easily and filled the air. Time lost meaning, and before Iliad noticed, it was late. That night, Iliad climbed into bed with Pris and, for the first time in years, felt a slight tingling in his chest.

The next day, Iliad ran back to the attic and opened the magic music box with enthusiasm. Once again, Ellen Blaise appeared from the box. Her evident restraint, in contrast with the boy's eagerness, gave the impression that she had got out on the wrong side of bed.

‹Phase one analysed. Do you wish to continue?›

'Yes!'

‹Pick an instrument of your choice and say 'Done' when you are ready.›

Iliad looked at the devices he had built yesterday. They all seemed as inspiring as they had seemed last night, but which one did he like the most? Intuitively, he picked up a flute-like, silver instrument. Deciding that it was in need of fine-tuning, he experimented and changed some parts. Iliad chose the flute to be exactly the size that matched the length of his short arms. Because his fingers were small, he added a few keys to the middle of the flute, and because he had strong lungs, he added a bagpipe-like extension. Finally, he was satisfied.

'Done!' he said, proudly. Ellen Blaise responded accordingly:

‹Play something with your instrument: recording begins in ten seconds.›

Ellen counted down from ten and, on reaching zero, remarked sharply:

‹Recording begins!›

Iliad was composed when he put the mouthpiece to his lips and let the sweet music fill the attic. The magic of the instrument was that it generated harmonious tunes. There was no need to know anything of music theory or notes, and it was impossible to make a mistake while playing. His music was quickly improvised, but it filled him with pride and joy. When Iliad had finished, Ellen Blaise said, in a standoffish tone:

‹Music recorded. What is the name of the song?›

Iliad hesitated, but replied contentedly:

'The Song of Iliad.'

‹Recorded. This is your calling song. Inside the music box you will find a ring. When the ring changes colour, you have made a contact: then you must return. End of phase two.›

Iliad was puzzled when he looked for the ring from the music box, and found nothing. After careful and persistent inspection, he came across a hidden secret compartment and, consequently, the mysterious ring. The cover of the ring, was made of some unknown material, stone or glass perhaps, and was coloured matte blue. Iliad put the ring on his finger and went out of the attic. He felt excited, although a little uncertain about what was going to happen next. Yet the mystery of the game made it twice as exciting!

Iliad's uncle had a farm, and the following morning Iliad was milking cows. Pris helped him as well as she could by following him, and avoiding the milking robot. Iliad was just about to put the milking robot into the stall, when his ring changed to a shiny green. Iliad toppled a chair over as he rushed out and headed for the attic, with Pris on his heels. He opened the music box with trembling hands. He was breathing heavily, because he didn't know what awaited him. Iliad was in for a surprise. Instead of Ellen Blaise, the pop-up hologram showed a young girl, about the same age as Iliad.

'How do you do?' said Iliad, shyly.

The girl made no response. She shrugged, and tried to speak, but no words came from her lips. Then the girl picked up a violin-like instrument that in some way resembled a melodica. She started playing, and Iliad was fascinated. He could hear the music loud and clear, as if the girl had been it the attic too. He listened to her play, recovering from the spell only when the girl finally finished her song. Then she gestured Iliad to play for her. After Iliad had played for a while, the mystery girl joined him. They found a common tune immediately, and soon their playing began to resemble a conversation. A conversation in which the two parties were trying to influence each other's performance, occasionally losing the common melody, then gradually finding their way back. There was a point when Iliad played too slowly and the girl tried to match her timing according to his playing. Iliad tried to improvise and when he began playing to his heart's content, the girl laughed hysterically. Before they knew, morning had become noon, and they found they had whiled away several hours in simply playing together. The girl signed that she had to leave, she bent over the music box and her hologram disappeared. Her sudden absence left the attic dismal and empty.

Two days had passed since Iliad had played with the girl. The day before, he had climbed up to the attic and played alone on his strange instrument. Then he had built more instruments, and created new sounds. But somehow the joy of creating music by himself, without a friend, was no longer so fascinating: not now that he had experienced the joy of playing with someone else. The activity kept him busy, though, and all the time he was learning something new. Iliad tried to concentrate on his duties at school and on the farm, but he kept a continual watch on his finger, out of the corner of his eye, in case it glowed green again. When Iliad was slowly climbing the ladder to the attic, he felt a slight tickle in his finger, and saw the ring shining. But now it was glowing red instead of green! Iliad opened the music box, holding his breath. This time the holographic image showed a young boy. He was very pale and skinny and it was hard to say how old he was. He might have looked older than he really was. Iliad raised his hand but said nothing, not being sure if the boy would turn out as quiet as the girl had been. Iliad waited for the other boy to introduce himself, which he did. Unfortunately, Iliad was unable to understand a word he said. When the pale boy noticed this, he repeated very slowly:

'Minä olen Aki, kuka sinä olet?' He pressed his hand over his chest and then pointed towards Iliad.

'Oh, I am Iliad. Hi Aki.'

Iliad picked up his fine-tuned flute, and the other boy drew out something that appeared to be a round-shaped harmonica. Aki played very fast and changed the tune unexpectedly. Iliad found it very hard to keep up with him, and saw that he could not play as well together with Aki as he had with the girl. Aki noticed this, too, and after a while they began to take turns. Iliad played his calling song, and Aki played his fast and anxious music piece. Slowly, Iliad began to understand the logic of Aki's music, and every once in a while he played a note during Aki's turn. This experience turned out to be very different to Iliad's experience with the girl, but in the end, it was almost even more enjoyable, as it has taken some effort to learn to play together.

For the next three days, Iliad came to the attic and played with Aki. After an exceptionally enjoyable music session, Aki had to leave early. Iliad felt discontent when the image disappeared, but his dissatisfaction did not last long. Soon his ring began to glow green, and the image of the girl appeared from the open box. The girl waved happily to Iliad, but before Iliad could wave back, the girl's hologram moved to the left, and another image appeared. Iliad saw a new boy, who introduced himself:

‘Hello. I am Victor. I live in Bedford, England.’

‘Hi. My name is Iliad.’

‘I heard from Nina that you two had met. She lives in East Germany, by the way. She told me you’re new, but that you play well.’

Iliad was surprised.

‘Oh, has she? I mean, I thought she doesn’t speak.’

‘She doesn’t,’ said Victor. ‘She has damage to her brain that has made her deaf. It also gives her severe headaches that last for days, and that’s why she hasn’t been able to play with you lately.’ He continued, ’And we talk to each other by our wizards.’

‘Wizards! You mean Ellen Blaise, the top-knot lady?’

Victor laughed.

‘You really are new! We all have different wizards. Mine looks like a hairy slob, with a beard and a belly. He calls himself Archibald Butler. And I understand that Nina’s wizard is a proper punk rocker.’

Nina laughed and nodded. Iliad was confused.

‘I haven’t seen Ellen Blaise for days. I’ve only played with a boy called Aki.’

Victor smiled and took on an educational tone as he explained,

‘You call your wizard if you need guidance. It seems your wizard is not as talkative as mine. If you want to make a call you have to press the button, the one that sort of asks to be pressed, if you know what I mean.’

Iliad bent over and saw the button. Of course, he had seen it before. He just didn’t like the idea of pressing buttons if he didn’t know what they did. Victor continued.

‘You can leave a message for your wizard if you want to know something, and the wizard contacts you later.’

‘Thanks, but I don’t have anything in mind at the moment. Shall we play instead?’

‘Sure,’ said Victor, and Nina nodded.

It seemed Victor had chosen to play the drums, if that was the right word for his instrument. It was difficult to distinguish anything by a hologram, since Victor had spread the various bits and pieces all around him. Iliad concentrated on listening while Victor and Nina played a song they had apparently rehearsed well beforehand. After a while, Victor asked Iliad to play his calling song. Victor and Nina both smiled as they listened to it, and seemed to enjoy. Victor began to provide a rhythm, and as Nina joined, she became so wrapped up in the music that she continued into a tremendous solo with her violin-like instrument, and the boys had to stop what they were doing and just listen to her play. When they had finished Iliad’s song, Victor suddenly remembered.

‘You said you’d been playing with a boy called Aki. Was he any good?’

Iliad became excited.

‘Well, at first you could only listen to him as he played so fast. But it was fun to follow his playing and learn from him.’

‘We could try to contact him. If you call your wizard, you can ask if all four of us can play together. Let’s say, tomorrow? Is that OK with you, Nina?’

Nina nodded, and Iliad inquired,

‘So, I just press the button?’

‘Just press the button. I have to go now.’

‘Wait!’ Iliad exclaimed. He wanted to know something about Victor.

‘What’s your disability?’ Iliad showed his arms and continued,

‘We all seem to have something. I guess that’s why we have been chosen for this experiment, or whatever you call it.’

Victor smiled, and then became serious.

‘I don’t have anything, I just like to play. Well, I am a bit shy. I like to be by myself. It certainly seems to be a disability nowadays.’

Victor was more serious than he had been all day and he wanted to reassure Iliad.

‘Disabilities can be a state of mind. They can truly trouble you in real life, but there are no disabilities in this world. Just plain music. You are a great musician, Iliad. And that goes for you, too, Nina!’

Nina smiled and waved, and her hologram vanished, then Victor nodded, and his hologram disappeared too. Iliad savoured Victor’s words, and found them comforting. He drew the box closer and gazed at the alluring calling button. When he finally pressed it, Ellen Blaise appeared quickly. She was tense, as usual.

<You have a request. What do you wish?>

‘I was wondering, could all four of us play together? Aki, Victor, Nina and me?’

<Request recorded.>

Ellen Blaise vanished. Iliad rose up and stretched his legs. That night, when Iliad came down the stairs, his steps were lighter, and looking through his bedroom window, the night sky seemed a degree brighter. Pris climbed on to the foot of the bed, and was pleased when her owner finally paid her some attention, too.

The next day, Iliad once again experienced a strange tingling in his chest. Anticipation made him feel tense and insecure. When he walked towards the attic, he knew what to expect, as during breakfast his ring had changed from green to red, and then from red to yellow. This time, on opening the magic box, all his new friends emerged. No time was wasted on talking, as all knew Iliad and Victor were the only ones who could communicate with words. They began by playing their calling songs. Victor and Nina appeared to find Aki’s way of playing very strange. His manner was quite frantic and his music fast. After a while, all became used to his ways. They seemed to enjoy that Aki brought a surprise element into playing music, and invited others to expand their boundaries. The four musicians played until nightfall. At the end of the day, Victor seemed to radiate.

‘I think this is it! I think I have finally found myself a band!’

Nina and Aki looked approvingly at each other, but Iliad couldn't work out why Victor was making such a fuss.

'What do you mean by a band? Isn't it just great to play together?'

The others looked at Iliad enthusiastically, and Victor expressed their common thoughts in words,

'With a band, we can record music and perform!'

This was a new idea for Iliad, a curious and intrusive thought. Iliad asked,

'Who'll listen to the recordings? And who will we perform to?'

Victor smiled.

'To everyone! There's a great cloud site called "His Mastermind's Voice" broadcasting selected music sent to their site via Muzic Box. Top ten bands can perform live once a month. They broadcast the holographic performance all over the world!'

Strangely enough, Aki seemed to understand what Victor was saying, as he added,

'His Mastermind's Voice! Top Ten! Olen nähnyt sen Tampereella!'

Victor was glad that Aki also knew about the performance space. Then he remembered something else.

'But I think we need a singer. All the best bands have a singer.'

He glanced at Aki and Nina. Nina shrugged her shoulders. Aki shook his head.

'I can't sing. I don't want to sing. But I could write lyrics,' said Iliad.

Victor seemed to approve.

'Could you write lyrics to Iliad's song? When you have something ready, we can figure out who sings it.'

Iliad nodded. He was actually quite happy with this assignment, because he enjoyed writing poems. This was something he had not told anyone, ever. Writing lyrics for a band certainly sounded like a step up. Victor was pleased.

'After we have the song, we can send it to "His Mastermind's Voice"!'

The following week turned was busy for Iliad. He reviewed all his poems and found bits here and there that matched the music. Yet the task was by no means a simple one. Iliad was tormented by sentences, words and syntax, and the task of writing lyrics followed him wherever he went. When he was milking the cows, the rhythm of the milking machine mixed with the song and he ended up having to change the melody, too. Nina had been absent the whole week, and Victor suspected it was because of her headaches. Most of the time, Iliad had played separately with Aki and Victor, and they soon learned not to rush him, or even to ask him how he was getting on. That suited Iliad fine, and by the end of the week he was ready to share his thoughts with the band. Iliad's hands were sweating as he held the paper in front of him. He had played the newly composed tune, and the others fumbled for the melody. While they were playing in the background, Iliad was enunciating the words rather than singing them. The others listened pensively while Iliad told them a tale about the wizard of Oz [10], a scarecrow who wanted to have a brain, a tin woodman who wanted a heart, and a cowardly lion, who needed to be brave. Then he told of himself, how he wanted nothing more than to have friends. He went on to describe the silver flute that made his dream come true, the wizard with many faces, and the yellow-brick road they all walked along towards the sunrise. He ended the tale with the words "We are not alone". While Iliad had been reading the lyrics to the band, he had not once glanced at his audience. Now he raised his gaze and met an overwhelming silence. Even Victor seemed speechless. Suddenly, all began to applaud, and Victor recovered his voice.

'Unbelievable! You have really stuck your neck out with this... this masterpiece!'

Aki nodded his head, and Nina kept clapping her hands. Iliad had never been so proud in all his life. Pris, sensing this, waved her tail and pressed her nose in his lap.

The band began to practice. After a few days, Victor succeeded in finding a suitable melody for the lyrics, and gave a distinctive rendering of its message. He had mentioned earlier that he was uncomfortable about being in the limelight, and especially about being the lead singer of the band. Now that the band had its own song, a message to the world, he didn't feel uncomfortable at all. Iliad, happy with Victor's adaptation, concentrated on the song's intonation. There was a reason for this, since Aki developed such rich and complex rhythm patterns that he had to be restrained and slowed down. One day Nina was practising another melody on her own. It was obvious by now that Nina had a real talent for music, and she could invent melodies and create compositions in a different way from the rest of the band. The others ceased to listen to her music in terms of the main song, and, after a little tuning, the new melody fitted in nicely as the song's solo part. Once the band had polished the "Song of Iliad" to perfection, they began to contemplate the recording and sharing of the song.

'I think the song is ready. What should we do next?' asked Iliad.

'Well, we'll have to make a recording first. We'll have to play the song as well as we can and then sent it to a wizard. Perhaps, it should be your wizard, as you composed the song.'

Iliad shrugged, and wondered what Ellen Blaise would think when she heard it. Probably nothing. Victor was suddenly troubled.

'Before we can send the song to "His Mastermind's Voice", our band will have to have a name. Does anyone have any suggestions?'

The task of inventing a name proved difficult. Iliad had no suggestion of his own. Aki had a dozen, but no one understood them. While Victor was trying to fathom Aki's suggestions and find one of his own, Nina began drawing something on a piece of paper. When she had finished, she showed the drawing to the others.

'Green spectacles!' Victor and Iliad cried out together.

'Why not?' said Iliad, and all were agreed.

'Right. Is it OK for everyone if we record the song tomorrow?' Victor asked, and all nodded.

The next day Victor showed Iliad how to record the song on his music box. It was very simple; all he had to do was press another button. The band had to play the piece almost fifty times, however, before Iliad was satisfied. After an exhausting day, the others left Iliad alone so that he could call Ellen Blaise. When Ellen's hologram appeared from the box, she looked different, somehow, although Iliad couldn't pinpoint what the difference was. Seeing that Ellen wasn't going to speak first, Iliad began by saying,

'I have a new song for sending to "His Mastermind's Voice".'

It seemed, for once, that Ellen was meeting Iliad on-line. There were no prescribed questions, and she seemed more sensitive than her formal, pre-recorded self.

'So soon! You and your musical friends must blend well together if you have already recorded a song.'

'Do you want to hear it?'

'Of course! Play it for me.'

Iliad pressed the button, and "Song of Iliad" was unleashed to fill the air. Iliad observed Ellen's reactions and at one point, during the chorus, he thought he saw a tear running down her cheek. It could have been a holographic mirage, though. Nevertheless, Ellen's voice trembled when she said,

'That was a beautiful song! I will send it to "His Mastermind's Voice" right away.'

When Ellen was about to set off, Iliad said,

'I want to thank you, Ellen Blaise, for all that you've done for me.'

Ellen looked at Iliad and smiled for the first time.

'You did it all yourself, Iliad. I and the Music Therapy Research Group, we just offered the tools for you.'

The rest is history: "Song of Iliad" became the most popular song on Muzic Box and stayed on top for 24 weeks. The band, Green Spectacles, performed the song once a month, although, since their holographic images were projected on to specially created stages, they didn't need to go on tour. Green spectacles, worn for every performance, became the band's trademark. Finally, the last line of the lyrics became a popular slogan for the Music Therapy Research Group and "His Mastermind's Voice" performance space: "We are not alone"[3].

3 Quotation from the movie "Close Encounters of the Third Kind", 1977

2.1
Epilogue

Ellen Blaise was sipping tea with Iliad's uncle Nestor and aunt Alice in their comfortable living room. Aunt Alice sat with her back straight, too tense to drink anything. Uncle Nestor sat quietly opposite his wife while he observed the proud-looking, strange woman on their sofa. Ellen Blaise cleared her throat and said,

'The experiment exceeded my all expectations.'

'Amazingly!' Alice burst out, and continued, 'Iliad has never been so enthusiastic about anything. The boy has certainly changed, I can tell you that much.'

Ellen flinched when Pris put her nose in her lap, but then began stroking its neck. Uncle Nestor straightened his back and said,

'When I was young, there used to be singing competitions. That was really something, when thousands of gifted singers queued up for the trial contest, and only a handful were selected to perform. One by one, the competitors were eliminated, until there was only the most talented one left.'

Aunt Alice knew exactly where this conversation was leading. She had heard it a thousand times before. Nestor cleared his throat and said proudly,

'I took part in a song contest myself. I was selected for the finals, and I was voted sixth, but then...'

'An ear for music runs in the family,' said Aunt Alice, interrupting, and looked at Ellen regretfully. Nestor had picked up a framed photograph and was admiring a younger version of himself, waving a flower bouquet. The picture was evidently a snapshot from the contest he had just been describing. With some annoyance, he continued,

'Nowadays anyone can perform and publish music. There are no stars and idols to admire. Everything is just one grey mass, doing this and that, performing and publishing. A dog barking at its own tail, that's what it is!'

Ellen Blaise, looking a little harassed, smiled and said,

'I am sorry you feel that way, Mr Tyrell. We at the Music Therapy Research Group think that the progress has been remarkable since those days, now that the joy of making music and playing together has become the main objective. These children don't have to compete if they don't want to. But competition, of course, sets goals in playing music. I thought you would have been prouder of Iliad's achievements. After all, his accomplishments are beyond dispute. His band has performed worldwide, not just in a national song contest.'

Uncle Nestor seemed shocked by Ellen's sharp-sighted reply, but held his tongue. Ellen looked at Pris and continued,

'Iliad's initial motive for playing music was not in competing, or even in playing his music. His main objective was to gain friends.'

'Those trivial ghosts,' snorted Uncle Nestor.

‘Well, we tried using avatars at first, because we thought some of our customers might prefer to remain anonymous. That didn’t work at all. Even though Iliad’s friends are not actually present, and they have the ghostly appearance, they are as real for him as this dog is. I believe Pris is your name, isn’t it?’ said Ellen, and looked Pris in the eyes. ‘The most exclusive part of their friendship is that they don’t even have to speak the same language. They can express their thoughts through looks and expressions, just as Pris does.’ Ellen Blaise raised her head and looked first at Uncle Nestor and then at aunt Alice, and said, ‘But Iliad and his friends have something this dog doesn’t have — and that is music. Music is a common language that binds people together.’

The short story "Song of Iliad" describes a somewhat sugar-frosted, perfect music therapy situation. Here, the definitive advantage of a science fiction prototyping technique lies in not being restricted by prevailing conditions, imperfect technology *or* unpredictable users. The authentic evaluations and observations of the "DIYSE Music Creation Tool" revealed that, in reality, people with intellectual learning disabilities have very different variations in their skills and learning capability. With contemporary technology, it would be extremely difficult to construct a "music performance space" such as this that would be flexible and adaptive enough to truly satisfy all needs. In contrast, the users of the tool in the story — the children who used the magic music box — were highly independent and learned to use the system quickly and intuitively.

Though "Song of Iliad" contains little illustration, the story's design — the outward appearance of the science fiction innovations that were described — was important. The self-made instruments that the reader could build in his or her mind in fact constituted one of the key elements of the story. As to the rest of the imaginary mock-up set, such as the mysterious music box with its buttons and secret compartments, could be seen as being almost irresistible to a child through its semantic meaning and appearance. The ghost-like genies reinforce the magical atmosphere of the box, while the chameleon ring is something one would proudly carry around as a token of membership of some secret society. Novel approach for emotional design was infiltrated effortlessly into the story, as the current tendency is to create highly personated products and services that are designed from the premises of the needs and wants of the individual users.

The advantage of this story's science fiction prototyping method lay in describing the usage situation of a forthcoming technology over the long run. By way of contrast, many early phase evaluation methods, such as short scenarios of prototypes, are tantamount to snapshots of the usage situation, thereby limiting also the evaluation results. In addition, current early phase development methods usually attempt to describe technological inventions in detail, sometimes even using detailed images, which has the effect of restricting the imagination of the users. Science fiction stories may easily be viewed as tools for stimulating conversation among users and developers on the usage situations at the fuzzy front end of design processes.

1 H. Strömberg, V.Pirttilä & V.Ikonen, Interactive scenarios – building ubiquitous computing concepts in the spirit of participatory design. *Personal and Ubiquitous Computing* (2004), 8 (3), 200-207.

2 P.M.A. Desmet, J.C. Ortiz Nicolas & J.P.L. Schoormans, Personality in physical human/product interaction, *Design Studies* (2008), 29(5), 458-477.

3 D. Norman, D. *The Design of Everyday Things,* Doubleday, New York, 1990.

4 M. Luhtala & T. Kymäläinen & J. Plomp, *Designing a Music Performance Space for Persons with Intellectual Learning Disabilities,* NIME: New Interfaces for Musical Expression (2011), Oslo, Norway.

5 B. Jordan & A. Henderson, Interaction analysis: Foundations and practice, *The journal of the learning sciences* 4 (1995/1), 39-103.

6 S. Ylirisku & J. Buur, *Designing with video: Focusing the User-centred design process,* Springer, 2007.

7 P. Saariluoma (Eds.), T. Kujala, S. Kuuva, T. Kymäläinen, J. Leikas, L. Liikkanen & A. Oulasvirta, Ihminen ja teknologia – Hyvän vuorovaikutuksen suunnittelu (In Finnish). Teknologiateollisuus, Helsinki (2010), 160-180.

8 V. Ikonen, J. Hakulinen, T. Kivinen, M. Aloja, L. Hokkanen, P. Ruutikainen, T. Kymäläinen, M. Nelimarkka & A. Harrela, IHME = Miracle – Make, Imagine and Research Applications for Computerised Living Environments. *Proceedings of the 14th International Academic MindTrek Conference: Envisioning Future Media Environments.* The MindTrek Association in co-operation with ACM SIGMM; ACM SIGCHI. Tampere, FI (2010), 3 – 6.

9 F.L. Baum, *The Annotated Wizard of Oz*, Clarkson N. Potter, 1973. Revised New York, W.W. Norton, 2000.

The dissertation portrays how experience design findings of emerging technology research may be harnessed for the construction of future-oriented science fiction short stories. As evidence the dissertation introduces four case studies and three reflecting science fiction publications. The case studies have investigated how to encourage people to employ Internet of Things technologies in a do-it-yourself fashion, by the means of design-oriented research.

As a research-oriented design outcome the dissertation presents science fiction stories as reflecting experience design artefacts. The dissertation claims that the introduced artefacts have the potential to contribute more than plain science fiction stories or customary science fact outcomes, such as academic publications and proof-of-concept prototypes. The particularities of the presented science fiction prototypes relate to the manner by how they engage experience design findings profoundly to the process, and how they illustrate the aesthetic, positive experiences – the latter being recently remarked to be a quality severely neglected by the entire genre of science fiction.

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