smart tangible city map

promoting sustainable urban tourism with physical mobile interaction

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Abstract:

The present project sets out to investigate whether novel technology can provide persuasive incentives to promote and implement strategies towards a more sustainable urban tourism. To find answers to this problem statement, recent related research areas were reviewed, ranging from sustainable ICT to climate persuasive services, physical mobile interaction using NFC technology, and finally three state of the art projects that explored different ways of digital augmentation of tangible city maps. As a result, a prototype of a tangible, reusable city map embedded with NFC tags that allows communication with a mobile guidebook application was developed as a kind of climate persuasive service.

The prototype was evaluated based on the main problem statement which was further broken down into three evaluation goals: general usability, the users' appreciation of having both a tangible artifact and a digital application as well as the marketability of a more sustainable urban tourism. A small user study with tourists was conducted in the city center of Copenhagen. Results indicate that, apart from usability issues resulting from the "floppy" map material, the participants' overall response towards the concept was positive, regarding both the sustainability strategies it embodies as well as its hybrid tangible/digital nature.

In order to validate the problem statement, a larger study allowing proper hypothesis testing and some material improvements on the prototype will be necessary, but the current study definitely indicates great potential.

Preface

This Master's Thesis is the documentation of the work carried out as part of the 10th semester at Medialogy, Aalborg University Copenhagen.

The following report describes the conceptualization and development of the project called 'Smart Tangible City Map: Promoting Sustainable Urban Tourism with Physical Mobile Interaction'. It was chosen to explore the persuasive incentives of a digitally augmented tangible city map to promote and implement strategies towards a more sustainable urban tourism. NFC technology was used as a mean of augmentation, allowing the communication of tagged physical objects with an Android mobile application.

The source code of the Android application is attached on the CD.

The CD contains the following:

- PDF format document
- LaTex Sources
- Application source code
- Interview Audio Recordings & Transcripts

References use Chicago style citation and are presented as (Author Year). Figures and tables are numbered according to chapter and section numbers. Figures with no references are produced by the authors of this report.

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CHAPTER 1

Introduction

Is maximum 'dematerialization' the key to a sustainable modern society? In a world that is more and more inhabited by concepts like e-books and telework, the question remains of how many of all the real, tangible products that exist today humans are willing to replace completely with their digital equivalents. Maybe it's time to explore some middle ground that could lead the way to a partial dematerialization without expecting too much of a compromise from users. That way, objects do not lose their physical properties and advantages, while they can at the same time be augmented with a vast amount of digital information that is also easily updatable. To still continue pursuing a path towards a more sustainable future, it will be crucial to make those products last longer, and design them in a way they can be reused and recycled, be more energy efficient and so forth. And most importantly, it will be necessary to aim at changing people's behavior throughout all sectors of their lives.

One of those sectors is urban tourism, and it will be the main focus of this project. Tourists heavily rely on two material things in particular, i.e. the map and the guidebook. While many digital versions of both guidebook and map exist today, it is still common practice to aim straight for the local tourist office when visiting a new city, and to collect a generally free paper map. In a windy city like Copenhagen that gets 613mm of annual rainfall[1], such a paper map can have a hard time making it through the day undamaged, possibly ending up in the trash half way through the stay and being replaced by a new one. Such behavior simply cannot be the best and most sustainable practice. But if tourists are not willing to give up their tangible city maps, then what could be the solution?

Defining itself as the 'Environmental Capital of Europe' and pursuing many different initiatives with the goal of becoming 'Eco-Metropolis 2015' (City of Copenhagen 2007) and carbon-free in 2025 (City of Copenhagen 2005), the city of Copenhagen is working hard on its sustainable image. And one of the crucial means of shaping a city's image is tourism. But how can tourists be motivated to shift their focus from posing in front of the little mermaid to concerning themselves with environmental initiatives or thinking twice before they throw out yet

[1] Source: `http://www.dmi.dk/dmi/index/danmark/klimanormaler.htm`, viewed 17/05/12

another paper map during their stay in Copenhagen? Or perhaps the question should rather be how tourists can be motivated to enjoy themselves, visit all the main sights and become aware of Copenhagen's environmental initiatives all at the same time?

This project seeks an answer to the proposed question by utilizing technology as an enjoyable, novel way to explore marketing opportunities that aim at promoting and implementing a more sustainable urban tourism. At the same time it attempts to find a compromise between completely 'dematerialized' maps and guidebooks, which could possibly be the most eco-friendly but not necessarily the most 'tourist-friendly' approach, and today's practice of using paper maps and actual guidebooks.

Looking back to the ideation phase of the project, one can now say it has come a long way. Many of the considerations on sustainability were initiated by last semester's project on 'Project Unshelving'. Project Unshelving sought to be a kind of sustainable innovation framework in the sense that old, forgotten product ideas were given a second chance years after they were initially conceived, a practice that was also referred to as 'idea recycling'. This ultimately raised the question whether the notion of recycling of old ideas is really sufficient to be able to refer to the Project Unshelving framework as a sustainable innovation approach. The next section will revisit the framework in more detail, leading up to the conclusion that more needs to be considered if one aims at establishing more sustainable innovation practices.

1.1 Point of Departure: Project Unshelving

'Project unshelving' describes the process of reconsidering old, forgotten projects several years after their conception, as illustrated in Figure 1.1. The term was coined by Wilson and Hlavacek (1984) and accordingly, the strategy was applied by some companies' R&D (research and development) divisions, but underutilized by most (Wilson and Hlavacek 1984). In the previous semester project (Micheel 2011), a framework for project unshelving in the field of interactive media technologies was derived from a review of related literature, suggesting a methodology of 5 stages for successful project unshelving in the field of interactive media technologies: delimitation, screening, optimization, interaction design and business modeling as a kind of sustainable innovation approach (see Figure 1.2).

The first stage should be the delimitation of the project, or in other words, defining the scope. What will be the goal of the project, in which area or field should the product be rooted in, what kind of target group is it aiming at, i.e. what type of users should the product appeal to etc. It can be seen as a kind of requirements analysis.

The second stage is screening ideas stored in a large database to single out promising projects. The database could be an internal company or university data base, or a patent bank such as Google patents (Google 2011), as Wilson and Hlavacek (1984) suggest that patented ideas promise a higher success rate than non-patented ones. Based on their literature findings, Micheel (2011) recommend going back in time 4–7 years to limit the number of items to be screened.

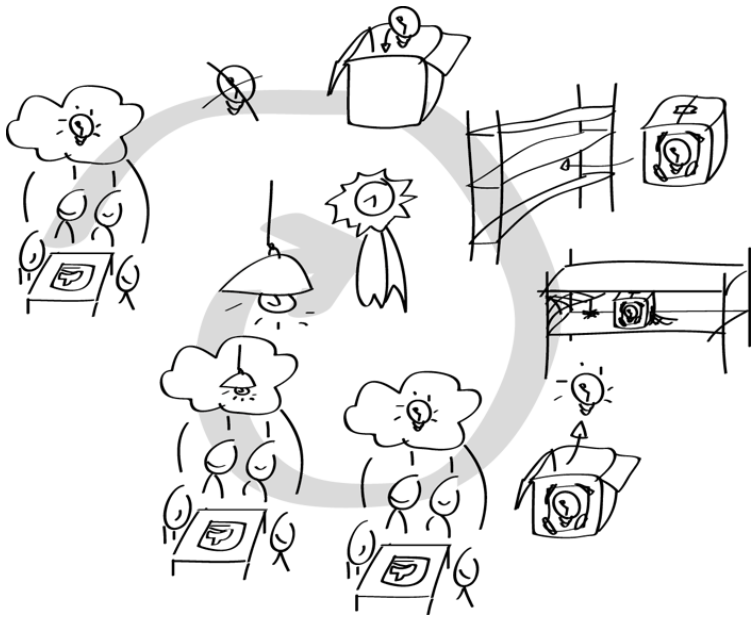


Figure 1.1: Project Unshelving Illustration: Idea is conceived, discarded, forgotten, reconsidered, refined and becomes successful after all.

Micheel (2011) developed a screening checklist which among others considers situational factors, i.e. factors that describe the setting and can mostly not be changed in the short term nor easily influenced by the project management (e.g. market potential, market competitiveness, marketing synergy and technological synergy) versus controllable factors (e.g. proficiency of predevelopment activities, proficiency of market-related activities and product advantage) (Cooper and Kleinschmidt 1987, p.182). While the latter ones should be evaluated positively both before and after shelving, observing a change in the situational factors from negative to a positive assessment is a promising indicator in terms of a project's unshelving potential.

During the idea optimization stage, creativity techniques and market research are applied to optimize or refine the idea. The Japanese Creativity Mandala can thereby be seen as the guiding scheme (Tatsuno 1990). The cycle can be repeated as many times as necessary to develop the idea to its full potential, like suggested by Tatsuno (1990, p.53), resulting in a more helix-like process. Questions like "By applying creativity techniques and market research, how can the product idea be recycled, what other ideas can be found and incorporated, how can it be refined?" can thereby provide helpful guidance.

After the idea has undergone optimization, an existing interaction design methodology can be used to further develop it towards a product that is ready for commercialization. The one suggested by Micheel (2011) is based on ISO9241, Part 10, focussing on prototyping and user evaluation. The business model should also be considered, preferably parallel to the interaction design process which complies with the approach taken by Sukaviriya et al. (2009, pp.751).

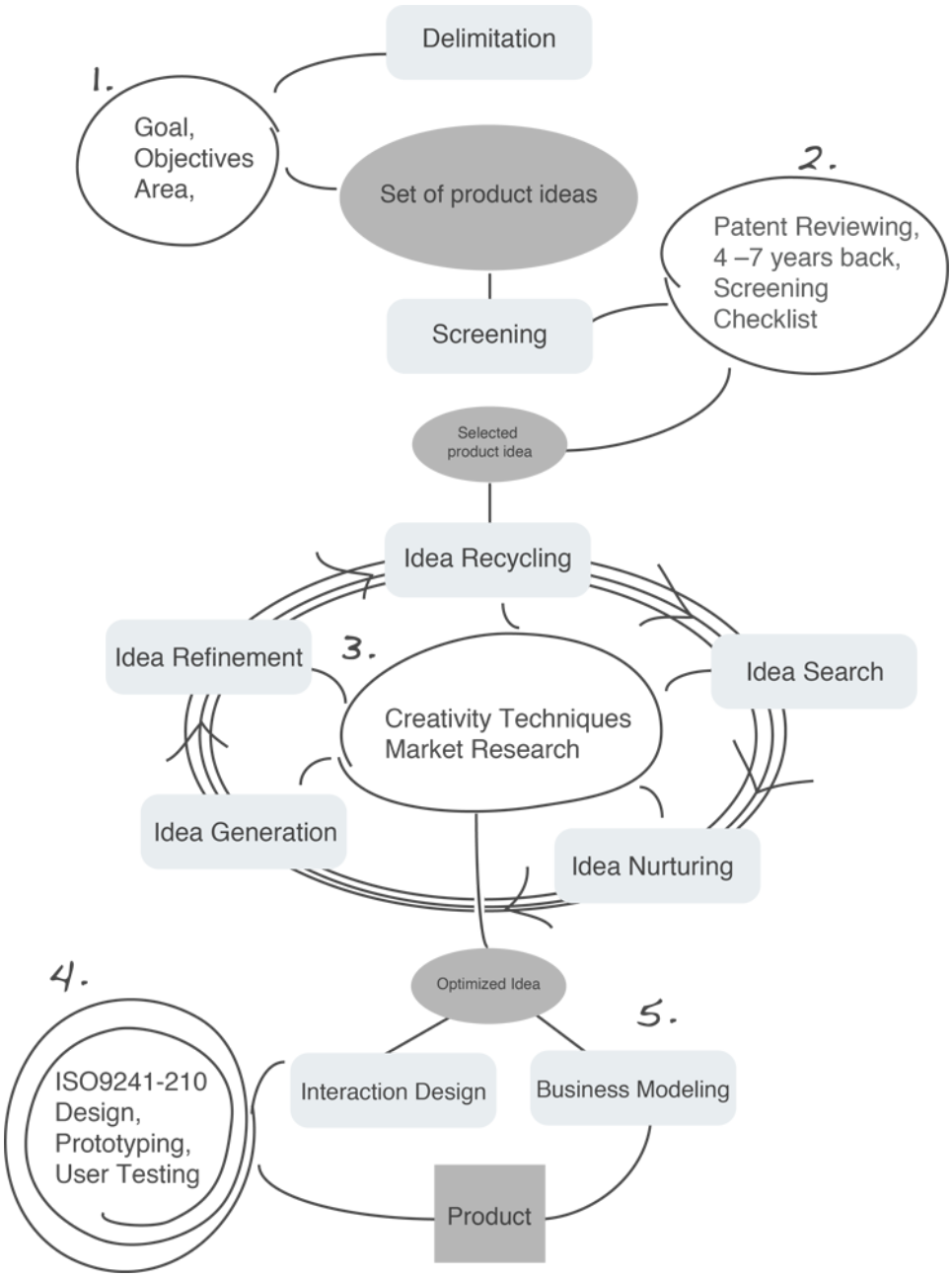


Figure 1.2: Framework for project unshelving in the field of interactive media technologies.

So while the framework certainly embodies a notion of recycling – in the sense of idea recycling – can one really say that it therefore carries great potential to serve as a kind of sustainable innovation approach? Certainly more criteria that could lead the process in a more sustainable direction would need to be included first – simply recycling old ideas doesn't make the process sustainable yet. It should foremost be of great importance to keep real current market needs in mind as the final evaluation criterium: "Is there really a need for this product?". If a product is just developed for the sake of making great profit, neither the product itself nor the innovation process that lead up to it can be considered sustainable.

But what are the other criteria that make innovation sustainable? And which role can interactive media technologies play to help redirect human lifestyles and behavior into a more sustainable direction? These are some of the questions the present project seeks to investigate.

As the source of inspiration for this project, it was decided to make use of the idea of going through a large data base of old projects in the ideation phase as suggested by the framework. Afterwards however, instead of strictly following the framework, much attention was directed towards sustainable innovation, it's relation to ICT services and products and how these aspects could potentially enrich the initial concept.

1.2 Readers' Guide

The following Problem Analysis chapter is dedicated to the state of the art review, focusing on the areas of sustainable innovation and its relation to ICT, persuasive technologies in the role of climate persuasive services, the technological advances of Near Field Communication and its application in mobile interaction leading to the new paradigm of physical mobile interaction, and finally the presentation of three projects that concern themselves with the digital augmentation of tangible city maps.

The literature findings lead up to the final problem statement, which is followed by the Problem Solution chapter that describes the conceptualization, design and implementation of the actual prototype.

The fifth chapter presents the project evaluation based on three dimensions that were declared as central in the Problem Statement, i.e. general usability, an assessment of the tangible-digital character of the prototype as well as the marketability of sustainable tourism strategies.

The final chapter concludes on the findings of the evaluation, identifies future research and development opportunities and puts the present project into a bigger prospective.

CHAPTER 2

Problem Analysis

The starting point of this chapter will be choosing a "shelved" project, the shelf being the AAU project library, as the initial source of inspiration that is believed to carry the potential to be developed further in the process of this report.

The remainder of the chapter will guide the reader through the literature review of areas related to the problem at hand.

In order to being able to pursue a truly sustainable innovation process, the chapter seeks to give an overview of what is considered sustainable innovation, and what efforts have been made in the field of interactive media technologies, or information and communications technology (ICT), towards a more sustainable future.

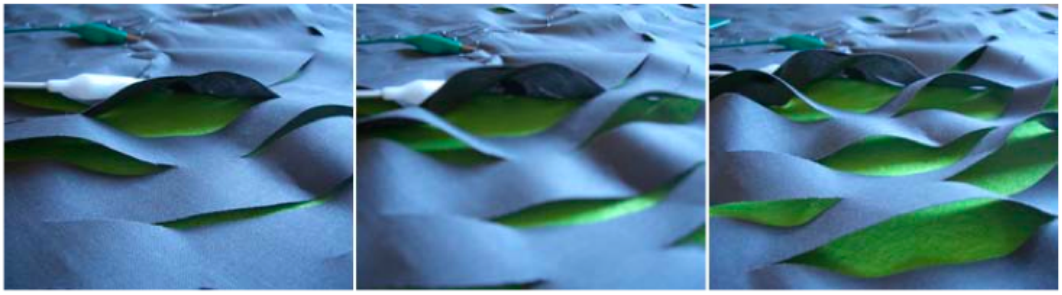
The second half of the review is concerned with different types of technologies and services that could be used to further develop the project chosen in the first screening phase, starting with persuasive technologies. Furthermore, the advantages of physical user interfaces will be studied, which allow the communication between physical objects and digital mobile applications using e.g. NFC technology. The section concludes with the presentation of three projects that are concerned with digitally augmented tangible city maps.

2.1 Going through the shelves

This section presents the 'shelved' project that was selected as a source of inspiration for this report out of a large data base, starting with a brief description of the screening process and some of the characteristics that led to choosing the project.

The projects stored in the AAU project data base were screened thoroughly to identify a possible unshelving candidate. As the majority of them only date back a few years, there weren't many projects from 4–7 years ago to be found, which led to a less strict screening criterium in terms of the initial shelving date.

The project that was chosen is a Medialogy Master's Thesis written by Marija Andonovska in 2009 with the title "E-textiles: The intersection of computation and traditional textiles. Interactive Sample Book" (Andonovska 2009). In her thesis, Andonovska (2009) explores the application possibilities of e-textiles in fashion and textile design, cooperating with fashion designers to investigate both their opinion on and experience with this type of technology. An Arduino LilyPad (Buechley et al. 2008) was used to create a few prototypes showcasing some application possibilities of e-textiles in fashion design (see textile samples in Figure 2.1).



Change in the surface of the fabric, the pictures are taken with an interval of few seconds

LilyPad Arduino with power source (left); Overview of the circuit (middle); Finished sample (right)

Figure 2.1: Two e-textile samples created using the Arduino LilyPad as part of an interactive sample book. In: Andonovska (2009)

The term e-textiles, or electronic/computational textiles, refers to textile substrates that "allow sensors or processors to be networked together within a fabric", e.g. by sewing circuits into fabrics using conductive yarns instead of wires and embedding traditional electronics such as micro controllers, light emitting diodes (LEDs) or electroluminescent (EL) materials (Andonovska 2009).

The fabric-based construction kit Arduino LilyPad has been developed especially as a mean of building e-textiles, soft wearables and the like and can be sewn into clothing and other textiles (Buechley et al. 2008). There are various sensors, actuators and other electronic elements available for the LilyPad in addition to the main board, e.g. a light sensor and LEDs (see Figure 2.2).

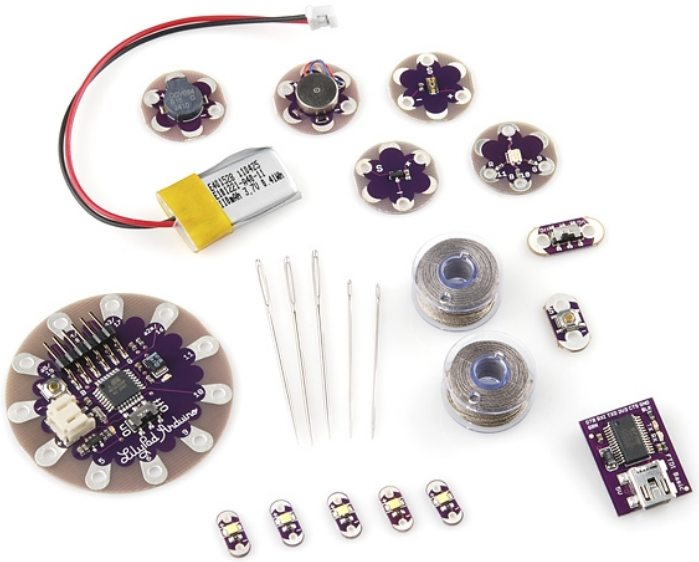


Figure 2.2: The micro-controller Arduino LilyPad Beginner's Kit with various sensors, actuators, LEDs and sewing utensils. In: Amazon (2012)

It appeared that the potential of smart textiles was not explored to its full potential with the project at hand, as it was directed towards a mostly aesthetic purpose that merely provided designers with a broader range of textiles to work with. When asking the crucial question whether this kind of application really mirrored true end-user needs, and not just the designers' interest in having yet another new material to experiment with, the answer is more likely "no". However, the technology itself and the concept of augmenting tangible textiles with a digital dimension, leaves room for much more imagination and possible application areas.

Summarizing, the e-textile sample book was chosen as the main initial source of inspiration. E-textiles seem a promising technology even beyond fashion design. How they could be used in other application areas, thus utilizing their 'smart' capabilities as actual physical user interfaces, needs to be investigated further and will be a core objective for this report. The overall goal from now on will be to explore the concept of e-textiles towards a sustainable, innovative concept. An application area that calls for more sustainable innovation needs to be identified while keeping true user needs in mind. To do so, the next step first of all requires a definition of sustainability and sustainable innovation, which will be covered in the following section.

2.2 Sustainable Innovation

In order to clarify the term sustainable innovation in the context of this report, it is necessary to take a look at existing definitions of sustainability.
In their Report of the World Commission on Environment and Development 'Our Common Future' (WCED 1987), the Brundtland Commission described sustainability as:

> *"a process of change in which the use of resources, the direction of investments, the orientation of the technological development and the institutional change are all in harmony and do not compromise both cultural and future possibilities to meet human needs and wishes."* (Jorna 2006, p.10)

Thus, in order to innovate, develop and produce in a sustainable way, one needs to consider not only how these actions affect the present, but also how they influence the future. Furthermore, sustainability concerns mainly three areas:

For Elkington (1997) as cited in Jorna (2006), sustainability means "finding the balance between the 'triple P-areas' of planet, people and profit". This concept of the triple bottom line of sustainability is also referred to as the three "interdependent and mutually reinforcing pillars" of sustainability (UN General Assembly 2005) or the sustainable development triangle (see Figure 2.3) by Munasinghe (1992) as cited in Rogers et al. (2008). Consequently, sustainability means considering not only the environment, i.e. ecological sustainability ('Planet'), but also social/cultural sustainability ('People') and economic sustainability ('Profit'). In order to reduce poverty, achieve equity and sustainability and stop climate change, all three pillars of sustainability need to be addressed equally (see Figure 2.3).

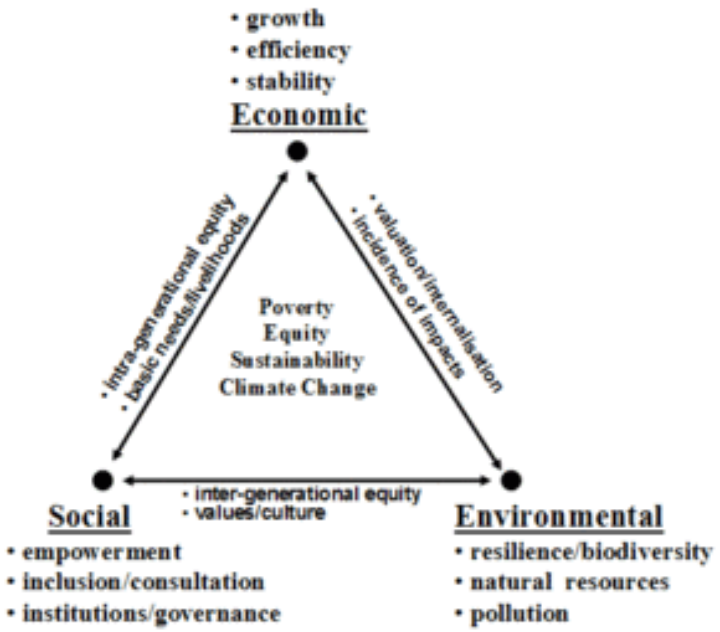


Figure 2.3: The sustainable development triangle: Key elements and interconnections. Adopted from Munasinghe (1992). In: Munasinghe and MIND (2007)

Over the last three decades, these 'triple P-areas' have shaped a new paradigm of sustainable innovation, i.e. 'innovation in economic, social and institutional structures' (WBCSD 2001) as cited in (Ryan 2004, p.29), which Ryan (2004) terms 'the Eco-Innovation Paradigm'. While this term evokes a focus shift in favor of the ecological dimension, it does refer to all three pillars, and will so throughout the rest of this report.

As Fisk (2010) states, "the best innovations respond to consumers, to their needs and aspirations". This holds true for non- and sustainable innovation alike, but according to Fisk (2010), consumers are more and more focusing on social and environmental aspects in products and services. Both when it comes to improving existing products and entering new markets, sustainability issues are gaining importance and opening up opportunities to "create new sources of competitive advantage and new drivers of profitable growth" (Fisk 2010).

Fisk (2010) describes sustainable innovation as a "disciplined yet creative process", that consists mainly of three phases: explore, design and focus. The 'explore' phase ('green field discovery' in Figure 2.4) focuses on diverging into as many scenarios and possibilities as possible, thinking really outside the box and challenging assumptions. The 'design' phase ('blue sky design' in Figure 2.4) is about improving and challenging concepts, ideas and processes involved and transforming them into profitable innovations, concentrating mainly on the consumer and their needs. In the 'focus' phase, one should converge again "down on the best in terms of their likely impact on consumers and business" by thinking about all the financial and practical specifics: "how much? – how? – is it worth it?" (Fisk 2010). These considerations then all lead up to the 'real world delivery', that is the final product or service (see Figure 2.4).

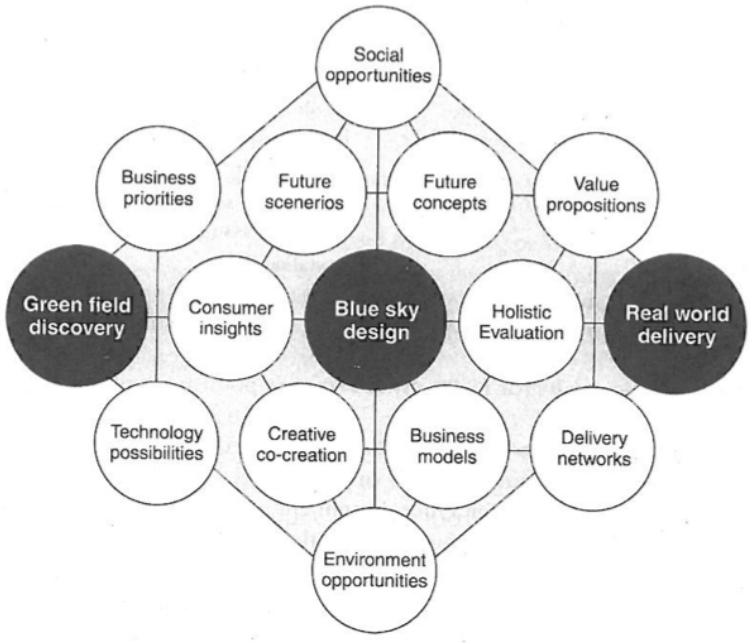


Figure 2.4: The creative and commercial process of sustainable innovation: diverge and converge. In: Fisk (2010)

Within sustainable innovation, Jorna (2006) differentiates between two related concepts: Knowledge of Sustainability (**KoS**) and Sustainability of Knowledge (**SoK**).

KoS deals with the content of knowledge, i.e. the knowledge of all three pillars of sustainability that has been accumulated before and during the innovation process (Jorna 2006, p.96). Characteristics of KoS are that it can be increased, re-used, shared and maintained (Jorna 2006, p.96).

SoK relies on innovators to use knowledge "without wasting it, preserving knowledge and structuring business processes in such a way that innovation as a process of knowledge creation continues to take place" (Jorna 2006, p.11). This means that it is important to consider how knowledge is dealt with throughout the innovation process, whether it is used efficiently, that proper knowledge management is applied in an organization and embodied in the structure of the organization, to "ensure that knowledge is distributed among the individuals who, in the future, will participate in the improvement of sustainability" (Jorna 2006, p. 325).

Summarizing, sustainable innovation considers the ecological, social and economic dimensions of an undertaking, thus contributing to improving today's world so future generations can continue to enjoy it the way we do now. As consumers are increasingly becoming aware of their role in this challenge and are more often willing to contribute by choosing the more sustainable product or service over a less sustainable one, many new market opportunities are opening up.
Finally it is not only important to consider what to deal with as an innovator (KoS), but also how to deal with it (SoK), i.e. how to manage knowledge creation and knowledge itself so it is easily accessible in an organization both in the present but also in the future. It is here, with regard to SoK, where an innovation framework like 'Project Unshelving' could contribute to a more sustainable innovation process, as it provides a mean of preserving and reconsidering knowledge that would otherwise be likely to end up discarded and forgotten in large patent, company or university databases.
After these more general considerations about sustainable innovation, the next step will be to look at sustainable solutions in interactive media technologies.

2.3 Sustainable Innovation and ICT

The first half of this section introduces terms and concepts relevant when assessing the sustainability of ICT (information and communications technology) products and services. The second half will look into some more concrete design strategies and present actual examples of sustainable interactive media technologies.

One can differentiate first-order, second-order and third-order impacts regarding the sustainable qualities of ICT products, e.g. a PC or mobile phone (Hilty 2007). First-order impacts, also known as direct effects Hilty (2007), mostly concern negative effects of ICT products themselves on the environment, such as waste residues and CO_2 emissions. In other words, they are the impacts of an ICT product on the environment during all phases of its own life cycle Hilty (2007). Countermeasures that can be undertaken include e.g. longer battery life.

Second-order impacts, or indirect effects, stand for the often positive effects an ICT product or service has on the lifecycle of other products or services. Technologies that evoke such positive effects are thusly referred to as enabling technologies. Hilty (2007) proposes a conceptual framework of the linked life cycles to illustrate the difference and dependencies of first- and second-order impacts (see Figure 2.5). The figure also illustrates the two main second-order impacts, i.e. optimization (red arrows) and substitution effects (yellow arrow).

Optimization can concern the product design whereas a change of the design can influence the other life cycle phases as well, e.g. improved re-usability at the end (Hilty 2007). Other areas that can be optimized by ICT products are the production process (e.g. improved process control), the use phase of products (e.g. improved energy management or enabling shared use of products) as well as the end-of-life treatment, e.g. in terms of the efficiency of recycling processes (Hilty 2007).

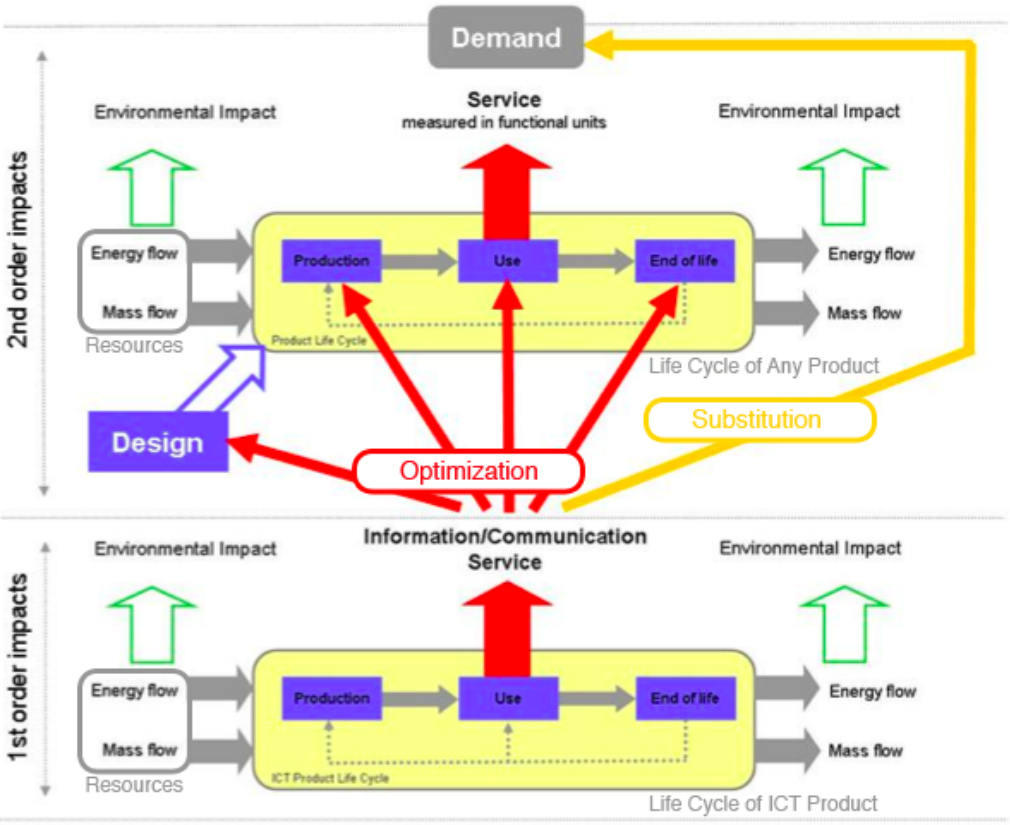


Figure 2.5: The concept of the linked life cycles: the potential first- and second-order impacts of ICT products and services. Adopted from Hilty (2007, 2009)

Substitution on the other hand means "replacing the services provided by the traditional product with ICT services" (Hilty 2007). An example could e.g. be the e-mail which substitutes the need to write traditional letters on paper or e-books substituting real books.

Third-order impacts are environmental impacts of systemic reactions to a product or service. They aim at influencing the whole system such as the market and general consumer behavior (Hilty 2009). An example by Hilty (2009) is mobile work which, if becoming more convenient, could lead to an increase in the demand for public transport since one could utilize the time on trains better.

Ryan (2004) identifies 'five domains of positive potential', all different yet interconnected, for ICT and Eco-Innovation, i.e. areas where ICT can really make a difference, mainly through their second-order and 3rd-order impacts, towards a more sustainable world:

Domain 1: Growing the Knowledge base

ICT is essential in gaining new knowledge about the environmental and social challenges ahead, in structuring that knowledge and distributing it. ICT services and products involved in this process are manifold, with application areas ranging from development of hardware and software systems of computation, data visualization, modeling and testing, to communications systems like the internet. (Ryan 2004, pp.84)

Domain 2: Increasing Pressure for Change

Since knowledge has been made much more accessible by ICT (see Domain 1), it automatically leads to a greater public awareness and interest in sustainability issues. This process can be actively supported by ICT products and services as "a way of empowering communities and stimulating behavior change." (Ryan 2004, pp.89)

Domain 3: Efficient and Effective Design and Simulation

ICT systems have revolutionized the means of designing products and processes more efficiently, e.g. through better information management processes, hardware and software systems for computer aided design, drafting and manufacture, or visualization tools (e.g. AR, 3D modeling and displays) and new collaborative design environments. Those developments allow for light-weighting of products, aero-dynamic design, smarter, eco-friendlier packaging etc. (Ryan 2004, pp.96)

Domain 4: Smarter Systems and Embedded Eco-Intelligence

More and more consumer products are equipped with so-called 'embedded intelligence' (EI), i.e. they incorporate computing systems, sensors, monitors and controls. With this newly gained intelligence, many of those products' efficiency in energy use, water consumption and resource usage has been improved. Besides standard consumer products and services, such smart systems can be mainly found in the areas of production processes and environmental management, buildings, the management of supply chains, logistics of transport and distribution waste and end-of-life. (Ryan 2004, pp.101)

Domain 5: Structural Change

Structural change means the "reshaping of physical, social, cultural and economic systems". It could be considered a combination of second-order substitution impacts and third-order impacts. The main areas that could lead to such immense, yet rather uncertain structural change are e-business and e-commerce, telecommunications and travel (including tele-working) and "new cultural values and desire for the immaterial ('hyperspace life')". (Ryan 2004, pp.112)

Ryan (2004) presents a *Digital-Eco 'design-scape'* to explore the innovative potential of bringing the digital and the domain of sustainability together. It consists of a set of vision-words, representing a kind of "landscape of design potentialities", whereas each vision-word should evoke ideas and visions about future scenarios and the role ICT could play in them (Ryan 2004, pp.133).

The vision-words describe concepts such as:

- Lightness – make dematerialized things more attractive (light weight, virtual products, services, experiences), decrease flow of resources.
- Preciousness – create objects that increase in value over time and design products that last and remain in their owners' possession their whole life.
- Distributed possession – focus on the aspect of co-ownership of joint objects.
- Modularity and cyclic reproduction – design and produce products that consist of modules that can be updated, exchanged etc. to guarantee a longer life of the product.
- Distributed production – consider a mix of both localized and mass production.

(Ryan 2004, pp.134)

The design-scape also suggested areas of the digital dimension that display potential for eco-innovation:

- Aware-sense – incorporate sensors into 'smart' systems, e.g. eco-alert indicators, which allow real-time access to information on the system via networks.
- Intelligent feedback – provide information on the environmental impacts of actions, behavior, decisions and functions (at the product/component level, the product/user interface and macro system scale).
- Tele-presence and virtual extension – replace physical transportation with virtual transportation to another environment (e.g. tele-work).
- Virtualizing potential realities – use immersive virtual environments for simulation and modeling, to explore new systems potentials, experience future scenarios or places that cannot be safely or conveniently visited.
- Reversing the hardware/software balance – focus innovation on upgradeable software rather than material resource intense hardware in order to extend product life ('eternally yours, but ever changing').
- Eco-logistics – make use new eco-efficient logistics by tracking resources, products and components, reducing transport impacts, and supporting remanufacturing.

(Ryan 2004, p.135)

This concludes the section on sustainable innovation in ICT. Essential was the categorization of impacts of ICT on the environment into first-, second- and third-order impacts. Furthermore, the Digital-Eco Design Scape could be good design strategy for bringing sustainable innovation and ICT together. As a mean of possibly achieving significant behavior change of individuals or user groups that could eventually lead to third-order impacts, i.e. systemic effects, the following section takes a look at persuasive technology.

2.4 Persuasive Technology

This section introduces the terms 'persuasive technology' and 'Captology', the study of persuasive technology. It further investigates how persuasive technology could be used to persuade users to change their behavior towards a more sustainable lifestyle.

> *"We have entered an era of persuasive technology, of interactive computing systems designed to change people's attitudes and behaviors."* (Fogg 2003)

Fogg (2003) defines persuasive technologies as interactive computing systems "designed to change people's attitudes and behaviors". It is essential to stress the importance of the word "designed", as computers never act on their own intent, but rather on their designers' (Atkinson 2006). Atkinson (2006) thus suggests that instead of referring to 'computers as persuasive technology', the relation between computing and persuasion should be described as 'computer-mediated persuasion', keeping in mind that the computer is a tool of the designer, or in other words the "mechanism for conveying, or mediating, its designer's intent".
Common types of persuasive technologies are web sites, but they can take many other forms as well, ranging from mobile phone applications to embedded, nearly invisible computing (Fogg 2003).

The study of persuasive technologies is often referred to as 'Captology' (based on the phrase "computers as persuasive technologies"), a term which was coined by Fogg (2003). Captology thus focuses on the "design, research, and analysis of interactive computing products created for the purpose of changing people's attitudes or behaviors" (see Figure 2.6).

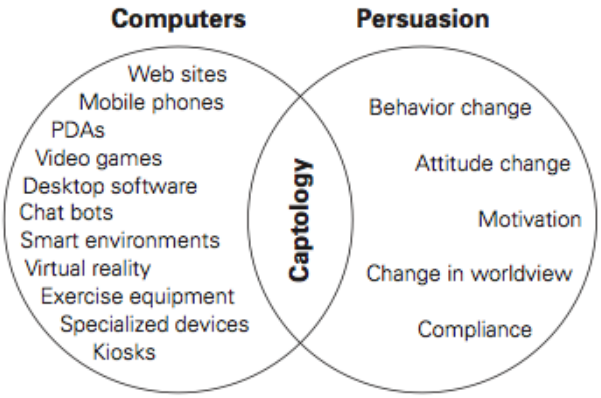


Figure 2.6: Captology: "area where computing technology and persuasion overlap." In: Fogg (2003)

Within the field of Captology, Fogg (2003) differentiates between 'macrosuasion' and 'microsuasion'. With the term 'macrosuasion', he describes "the overall persuasive intent of the product, in other words, the specific behavioral or attitudinal change intended by the designers", whereas 'microsuasion' refers to "smaller persuasive techniques to achieve the macro-goal (such as the rewards used to help users stay on a site, or with a task, longer)" (Atkinson 2006).

2.4.1 Climate Persuasive Services

Zapico et al. (2009) suggest, that the "persuasive power of ICT can be oriented towards climate change" and that "changing behavior is a prerequisite for reaching sustainability and mitigating climate change". Their term 'climate persuasive services' seeks to refer to all those ICT applications that "change behavior towards reducing greenhouse gas emissions" (Zapico et al. 2009).

As the main drivers of climate persuasive services, Zapico et al. (2009) identify three key technology domains, i.e. mobile phones, pervasive sensors and social media (see Figure 2.7). According to Zapico et al. (2009), mobile phones are convenient since they are widely spread, yet at the same time have a comparatively small impact on climate change.
Having become very small and low-cost, pervasive sensors allow different kinds of data, e.g. on certain environmental and social impacts, to be integrated into actual products, buildings etc. (Zapico et al. 2009). They could for example be used to make carbon footprints visible throughout a city, or to measure different types of geographical information.
Social media provides various social influence tools, or persuasion principles, such as "reciprocation, social proof, commitment, consistency, authority, liking, and scarcity" (Zapico et al. 2009). This means that by conveying competition amongst users and enabling them to share goals, users are likely to influence each other with their actions and opinions, and ultimately promote a more carbon-friendly lifestyle among themselves. In other words, persuasive applications can "promote collaboration for a common good" (e.g. climate, atmosphere), which is otherwise "misused for the individual sake" (e.g. driving, flying or eating fruit transported from the other side of the world) (Zapico et al. 2009).

Figure 2.7: Key technologies that act as drivers of climate persuasive services: mobile phones, pervasive sensors and social media. In: Zapico et al. (2009)

Most of the existing applications thereby focus on tracking the user's carbon footprint, sharing sustainability goals and making green behavior easier (Zapico et al. 2009). One example of such an application is PEIR (Personal Environmental Impact Report), which is being developed by UCLA (2008). PEIR enables the individual to use their mobile phone to explore and share both their own impact on the environment and the environment's impacts on them (Zapico et al. 2009; UCLA 2008):

"PEIR uses location data that is regularly and securely uploaded from your mobile phone to create a dynamic and personalized report about your environmental impact and exposure" (UCLA 2008). The exposure and impact estimates include 'Smog Exposure', 'Fast Food Exposure', 'Carbon Impact' and 'Sensitive Site Impact' (impact on sensitive sites such as schools and hospitals), and while PEIR mainly focuses on the principle of 'self-monitoring', it also provides the option to share that information, e.g. through Facebook (Zapico et al. 2009; UCLA 2008). Figure 2.8 shows screenshots taken from the PEIR application demonstrating how the user's movements are tracked and their carbon footprint is calculated.

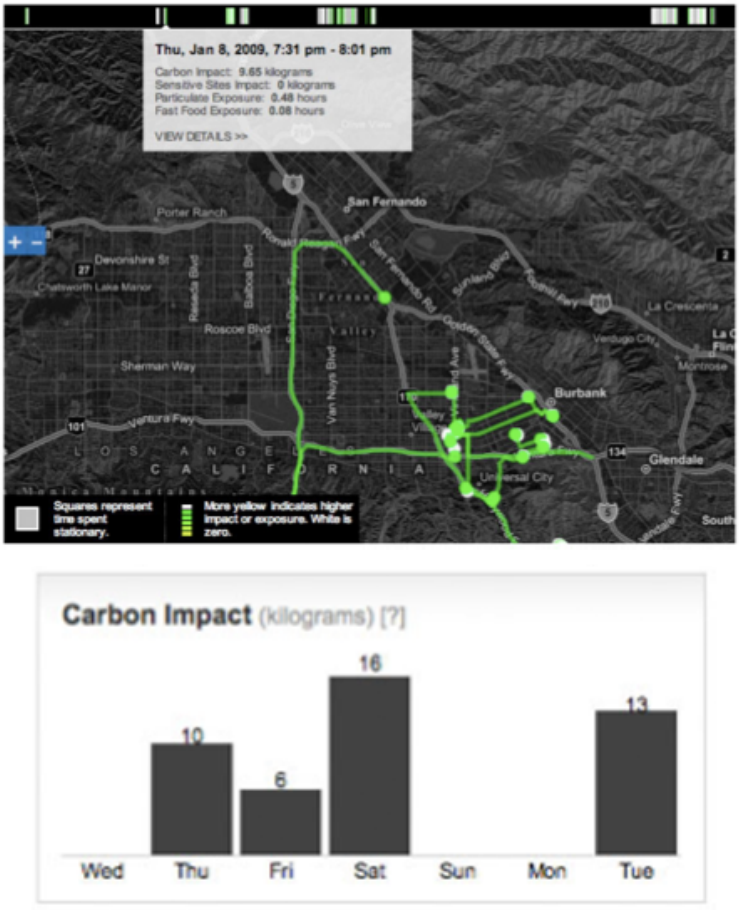


Figure 2.8: Screenshots of the PEIR web application. In: Zapico et al. (2009)

Finally, as important features and improvements for 'climate persuasive services', Zapico et al. (2009) suggest the following:

- Effortless, accurate, individual CO_2 data.
- Feedback for more responsibility: Augment the credibility of the data, by using sensing technologies to feed real behavioral data into the system.
- Normative influence: "Make the green behavior look normal, not the normal behavior look green."
- Exploit a mass principle of cause and effect: Link cause and effect between individual behavior and emissions and enhance this with the social media tools.
- Make it fun: Introduce more "game-like functionality", to trigger the principles of "competition, cooperation and recognition".
- Make it mobile.

It becomes apparent at the end of this section that persuasive technology could be a promising way of trying to change people's behavior towards a low-carbon and generally more sustainable lifestyle. Zapico et al. (2009) provide guidelines for the design of what they termed 'climate persuasive services', that shall be applied for the concept development of the present report. With the mentioned key technologies in mind, i.e. mobile applications and sensing technology, it is now important to explore the technological possibilities that could be used for designing such a climate persuasive service. The next section will therefore look into a new and promising data exchange standard: Near Field Communication.

2.5 NFC – Near Field Communication

This section investigates the relatively new communication standard of Near Field Communication (NFC) and its areas of application. Juniper Research (2011) predict in their market forecasts, that by 2014, 20% of all smartphones worldwide will support NFC contactless functionality. They furthermore assume that "North America will account for half of all NFC smartphones in 2014, followed by Western Europe".

2.5.1 The Technology

Near Field Communication is an emerging technology for the short-range, contact-less exchange of data, often between two mobile devices or a mobile device and passive wireless tags (Broll and Hausen 2010; Hang et al. 2010). NFC is based on existing RFID (radio frequency identification) technology, especially ISO 14443 based Mifare (Philips) and FeliCa (Sony) (Tuikka 2009). It was brought forth by an alliance formed in 2004 by major companies[1] referred to as the NFC forum with the aim to integrate RFID technology into portable consumer devices, e.g. mobile phones (NFC Forum 2012d; Tuikka 2009).

[1] Nokia, Philips and Sony, later joined by others such as Visa, MasterCard, Samsung, Microsoft and Motorola. The NFC Forum is now comprised of ca. 150 members (Tuikka 2009; NFC Forum 2012b)

With NFC, two devices ('peer-to-peer' mode, e.g. to share virtual business cards) or a device and a passive NFC tag ('reader/writer' mode, e.g. to read an NFC Smartposter tag) need to be brought within only few centimeters of one another to establish an NFC connection and exchange data (Tuikka 2009). A third mode is called 'NFC card emulation' mode, where a phone can emulate an RFID tag, e.g. so it can be used like a credit card for contact-less payment (Tuikka 2009). To assure security in applications such as payments, a secure element (chip) can be included in the NFC hardware. As documented in Rhelimi et al. (2009); NFC Forum (2012c), each mode of operation is based on a different set of protocol stacks (see Figure 2.9).

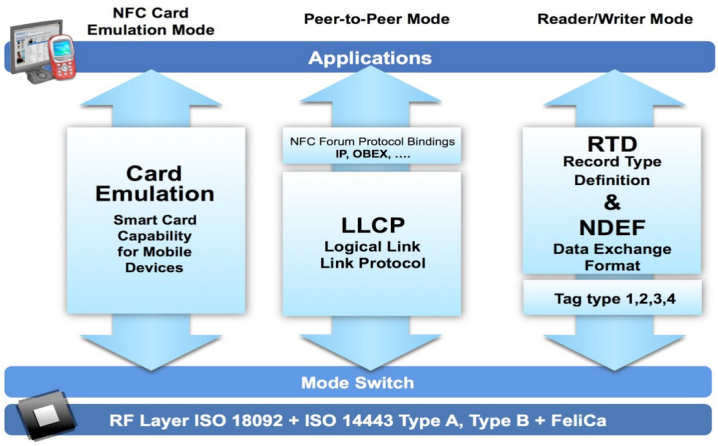


Figure 2.9: Detailed description of the different components of the technical architecture of NFC. In: NFC Forum (2012c)

As part of the standardized technology architecture introduced by the NFC Forum in 2006, a common Data Exchange Format (NDEF) was established, as well as three initial Record Type Definition (RTD) specifications for smart poster, text and Internet resource reading applications (Tuikka 2009).

Furthermore, four existing tag formats, until now mostly used for non-NFC applications such as mass transit and access control, must be supported by all NFC Forum-compliant devices. They are based on ISO 14443 Types A and B (the international standards for contactless smartcards) and FeliCa (conformant with the ISO 18092, passive communication mode, standard) (Tuikka 2009). Each tag type comes with different memory capacity and data rate, whereas Tag Type 1 (96-byte memory) and 2 (48-byte memory) differ greatly from Type 3 (variable memory, theoretical limit is 1MByte per service) and 4 (variable memory, up to 32 KBytes per service) which means their application areas are barely overlapping (Tuikka 2009; NFC Forum 2012e).

There are various application areas for NFC, ranging from, as already indicated, mobile payment or ticketing to access control or information retrieval (see Figure 2.10 for more examples). The most interesting for this report, and according to Broll and Hausen (2010) possibly the most neglected application area are tagged objects and physical UIs with multiple tags, e.g smart posters, menus for home delivery or control panels for multimedia players, which the rest of this section is dedicated to.

Figure 2.10: Example applications of NFC. In: Tuikka (2009)

2.5.2 Physical Mobile Interaction

'Physical mobile interaction' refers to a relatively new paradigm for "mobile interaction that uses mobile devices for physical interaction with (tagged) everyday objects" (Broll and Hausen 2010). Both NFC and RFID are technologies with a great application potential for this type of interaction, especially in the context of the Internet of Things (Broll and Hausen 2010; ITU 2005). In the Internet of Things, "real-world objects get digital identities and can then be integrated into a network and associated with digital information or services" (Broll et al. 2009). This enables both communication between objects and interaction between humans and objects (see 'Any Thing Connection'-dimension in Figure 2.11), whereas the latter can be facilitated through mobile devices equipped with the hardware necessary to access the information from the tagged objects.

Many research oriented projects are exploring means of interaction, usability and learnability of actual RFID/NFC User Interfaces. Projects such as PERCI (Broll et al. 2009) are e.g. dedicated to developing smart posters with multiple tags, which can link to URLs, or guide through ticketing processes. Another project was presented by Reilly et al. (2005), who designed a home care service for elderly people using a tagged menu that aims at simplifying the process of ordering meals. Results of a study on physical mobile interaction by Broll et al. (2009) indicate that "a dedicated start-tag facilitates the first step in NFC-based mobile interactions and that users preferred an implicit guidance through the interaction process."

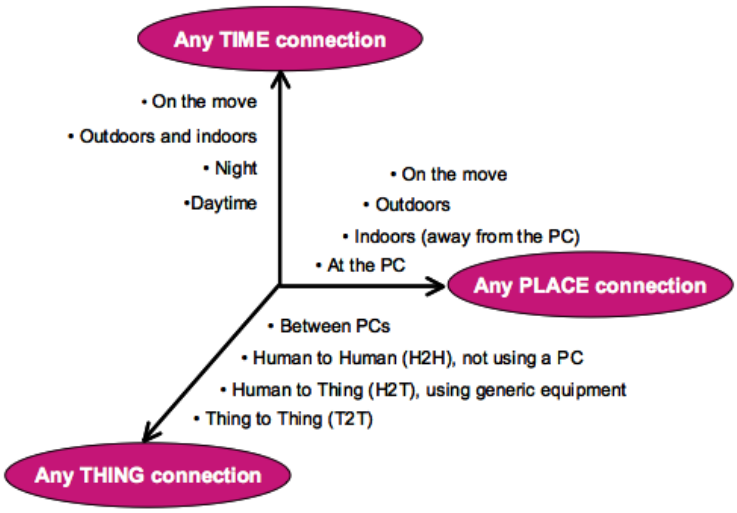


Figure 2.11: The three dimensions of the Internet of Things. In: ITU (2005)

In a project by Reilly et al. (2005), paper maps for tourists are augmented with RFID tags so users can select various actions and apply them to different areas of the map with a PDA (see Figure 2.12). Their aim was to identify the most preferred interaction/selection method but while users thought they would prefer point and click over other means, the study showed that after trying a functional prototype, users didn't have a clear preference but accepted all the suggested selection methods.

Figure 2.12: Users interacting with paper map prototypes augmented with RFID tags by selecting regions and actions with a handheld computer. In: Reilly et al. (2005)

Overall, NFC seems to be a promising, easy-to-use method of interaction between physical, real-world objects and mobile devices, especially as more and more devices will be equipped with NFC hardware in the near future. Physical UIs still leave a lot of room for further studies and applications, but one area that has already been explored to some extent is the combination of tagged, physical city maps and mobile tourist guides. Keeping those projects in mind, the next section will look further into advantages of physical, tagged map UIs over both all-digital map applications and non-augmented, traditional maps.

2.6 Augmenting Physical Maps

This section presents two more state of the art projects with augmented physical maps and discusses the advantages and shortcomings of physical over all-digital maps, focusing on the area of city tourism.

A recent study investigating tagged paper maps similar to the study shortly presented in the previous section was conducted by Broll and Hausen (2010). They focus on evaluating "different configurations of mobile and physical UIs for the combination of different kinds of items - actions and objects - through physical interaction", i.e. with which UI (physical or digital) users preferred to perform which types of interaction. Figure 2.13 displays the digital mobile UI screens for different tasks in their application.

Figure 2.13: Mobile UI screens for selecting objects on the mobile device (left), highlighting selected objects (center) and actions (right). In: Broll and Hausen (2010)

Examples of the physical UIs used are shown in Figure 2.14. The study showed that "interactions with multi-tagged physical UIs worked best for the selection of items and the accomplishment of more complex tasks" and that "users preferred to carry out most parts of navigation and the selection of items on the physical UI" (Broll and Hausen 2010).

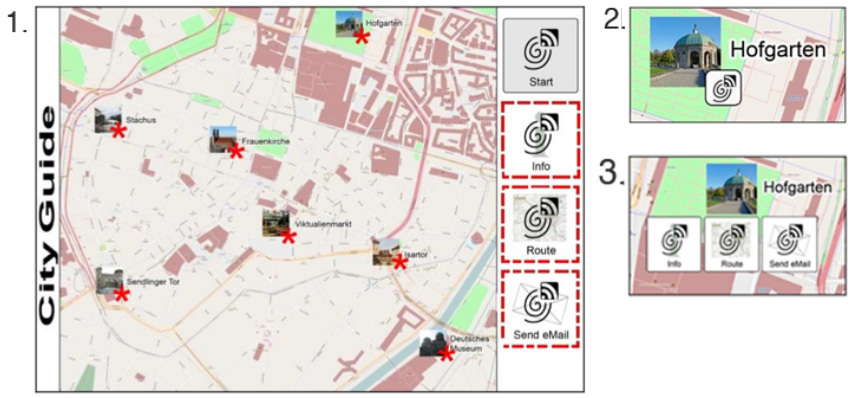


Figure 2.14: Three versions of a physical map UI (1. version only initiates the mobile interaction with one tag, 2. version allows single interaction with each sight, 3. version allows three different action types for each sight). In: Broll and Hausen (2010)

The 'MapLens' project on the other hand uses a sophisticated AR (augmented reality) application to augment paper maps for tourists "by superimposing registered icons and labels onto live video stream on the phone." (Morrison et al. 2011). In other words, a mobile phone application displays additional information about sights and locations with the use of the built-in camera of the mobile device and an algorithm, that detects which area on the map the user focuses on (see Figure 2.15).

Figure 2.15: The 'MapLens' application displays additional information when hovering about paper map areas. In: Morrison et al. (2011)

In a comparative study with one group testing MapLens on a single phone paired with a paper map versus the other group using a digital equivalent similar to google maps individually with a phone for each member of the group, they found that MapLens strongly facilitated a collaborative use of the physical map and mobile device (Morrison et al. 2011). The MapLens group tended to cluster around the physical map, "negotiating and establishing common ground to solve tasks", referred to by Morrison et al. (2011) as the 'honeypot-effect' (see Figure 2.16). That way, the group was able to focus on the task as a team. In the other group, tasks were usually divided up and solved individually (Morrison et al. 2011).

Figure 2.16: MapLens group using a physical map paired with a single mobile device clustering around the map. In: Morrison et al. (2011)

In a trial with the augmented map and multiple mobile devices, collaborative behavior and common ground establishment was also observed, but rather facilitated "through the system" vs. the group with only one device collaborating "around the system" (Morrison et al. 2011). They further observed a kind of place-making with the physical map, whereby the map "acts as a place where joint understanding can be reached, and the players can collaborate".

Brown and Chalmers (2003) conducted an ethnographic study of city tourists' practices regarding their use of mobile technology while visiting new places. Among other things, they investigated how tourists work together in groups or collaborate around maps and guidebooks (Brown and Chalmers 2003). They observed that while there exist various digital versions of both the map and the guidebook, they were hardly used by tourists in their study.

According to Brown and Chalmers (2003), both the physical map and the guidebook are important utensils for tourists and often used in combination, with the guidebook informing about what there is to do and the map showing where such points of interests are located. The physical guidebook was identified as a "collaborative artifact", with conversations between tourists as well as between tourists and locals taking place around it: "tourists pointing at the guidebook, and then pointing either at a map or in a direction, so as to link together the establishments being discussed with their position" (Brown and Chalmers 2003). This act of combining map and guidebook is of central importance for the urban tourist, i.e. the need to simultaneously focus on a point of interest on a map and in a guidebook (Brown and Chalmers 2003).

The importance of the physical guidebook and map as collaborative artifacts becomes very obvious in a scenario where tourists interact with locals or staff at visitor centers (see Figure 2.17), as both guidebook and map in a way mediate the conversation: it is easy to go through or over them, pointing out the requested locations and attractions (Brown and Chalmers 2003).

Figure 2.17: Maps laid out at the counter of a tourist information center as a collaborative artifact between tourist and staff. In: Brown and Chalmers (2003)

In terms of the in their opinion needed improvement for the design of mobile technology for urban tourists, Brown and Chalmers (2003) suggest to use electronic guides to support making "connections between where attractions are and what they are", also allowing quick and easy comparison between different points of interest. With the limited screen size of today's mobile phones and many mobile browsers only being able to display one page at a time, it could be good to look at some alternative solution to an all-digital guidebook and map combination (Brown and Chalmers 2003). Brown and Chalmers (2003) suggest the combination of paper maps and mobile guidebooks, which "would remove some of the disadvantages of the small screen by allowing users to juxtapose the PDA and the map in their visual field". These are therefore some of the considerations the present project attempts to address.

Overall, there seems to be a need for an alternative solution to the all-digital map-guidebook combination to better suit tourists' needs. It was found that physical maps and guidebooks act as collaborative artifacts for tourists in their process of exploring a new city. Both maps and guidebooks can further mediate the interaction between tourists and locals or tourist information center staff, as points of interest and other information can easily be pointed out. User studies conducted on the matter showed that tourists in most cases preferred interacting with a physical map (Broll and Hausen 2010) as compared to the all-digital equivalent.

2.7 Summary

This concludes the state of the art review, in which several areas and projects were identified as relevant to the present work. It was found that ICT products and services can have a great impact on people's habits and behavior and the sustainable qualities of other products and services, e.g. as a substitute for a less sustainable product, as a mean of managing energy consumption of different devices smarter using a range of sensors, or as a climate persuasive service.

NFC was identified as a rather novel, RFID based technology with the potential to become a big mobile communication trend. It is predicted that within the next few years, NFC readers will be integrated in many of the mobile devices. While one major application area is e.g. mobile payment and ticketing, NFC also allows for new kind of user interfaces to be developed, leading to what has been termed "physical mobile interaction". There, physical objects and artifacts are given additional functionalities using multiple NFC tags, turning them into actual user interfaces for mobile application. This allows the augmentation of the physical world with a vast amount of additional digital information.

Three different physical mobile interaction projects were presented, two using NFC and one using image processing of streamed footage as a mean for augmentation. They explored ways to augment physical city maps with additional digital information that can be displayed on a mobile device. The need for a physical map was backed up by a study by Brown and Chalmers (2003) which identified maps and guidebooks as important collaborative artifacts for tourists that cannot easily be substituted by their digital equivalents.

However, when aiming at a more sustainable approach, dematerialization is often the key. The present project will therefore explore the opportunities that lie in physical mobile interaction towards a compromise between all-digital map and guidebook applications, which would mean maximum dematerialization and potentially maximum sustainability, and the tourists' needs of physical maps that e.g. act as collaborative artifacts, with the goal to promote a more sustainable approach to urban tourism. A multi-tag map interface much like the project examples identified in this chapter is therefore to be developed to incorporate both the tangible component of a physical map and partial dematerialization regarding the guidebook, which is substituted by a digital mobile application that can provide large quantities of up-to-date information.

CHAPTER 3

Problem Statement

After reviewing literature and research areas relating to sustainability, climate persuasive services, physical mobile interaction and the importance of the city map as a tangible artifact, the following final problem statement was derived for this project:

Novel technology can provide persuasive incentives to promote and implement strategies towards a more sustainable urban tourism.

The aim of this project shall therefore be the design and evaluation of a physical mobile interaction prototype consisting of a digital tourist guide application paired with a tangible city map as the NFC-augmented user interface. The prototype is to be evaluated on three different dimensions:

1. Its general usability, e.g. its visual appeal, functionality, overall performance or the cohesiveness of its navigation.
2. The users' appreciation of having both a tangible artifact and a digital application that allows the augmentation of physical objects with a vast, always up-to-date stream of information.
3. The marketability of a more sustainable urban tourism, i.e. the effectiveness of using novel technology such physical mobile interaction as a playful mean for promoting behavior change such as participating in green activities or using reusable, tangible maps.

With the formulated problem statement in mind, the rest of this report documents the implementation of the prototype and its evaluation based on the aforementioned criteria through a qualitative user study.

CHAPTER 4

Problem Solution

In this chapter, the process of designing and implementing the prototype will be described. With the point of departure being the e-textiles project by Andonovska (2009), the initial idea was focussing on using the Arduino LilyPad as a key technology for a possible textile prototype making use of soft switches and LEDs sewn into a textile to create a physical UI. Further research revealed the growing importance and sophistication of NFC-enabled mobile devices (see Section 2.5) that could potentially introduce a whole new dimension for 'smart' textiles and other physical objects and materials. As part of refining the initial idea, the direction was not only changed towards NFC, but a lot of thoughts went into the sustainability criteria set in the Problem Analysis chapter. Therefore, this thought-process as well as the final concept are presented here.

The first section will describe the initial idea, followed by a section on the final concept evolving around an interactive physical and reusable city map with its special focus on sustainable city tourism. Afterwards, the UI-design, the system design and a description of how the actual prototype was assembled are presented.

4.1 Idea-Refinement Process

This section documents the process of refining the initial idea. The point of departure was set to be the e-textile sample book by Andonovska (2009), and the refinement process should lead to the goal of incorporating the aspect of sustainability as a core attribute of the new smart textile product or concept.

The Unshelving-framework as described in the introduction as well as the 'creative and commercial process of sustainable innovation' described by Fisk (2010) suggest the application of creativity techniques to broaden the idea-horizon and take a product or concept to the next level. Thus, as a first step, a mindmap was created to get an overview of different domains and to be able to make connections between those domains. Figure 4.1 displays the mindmap with its three domain nodes 'textiles', 'technologies' and 'sustainability' as the roots branching out into the various sub-categories of each domain.

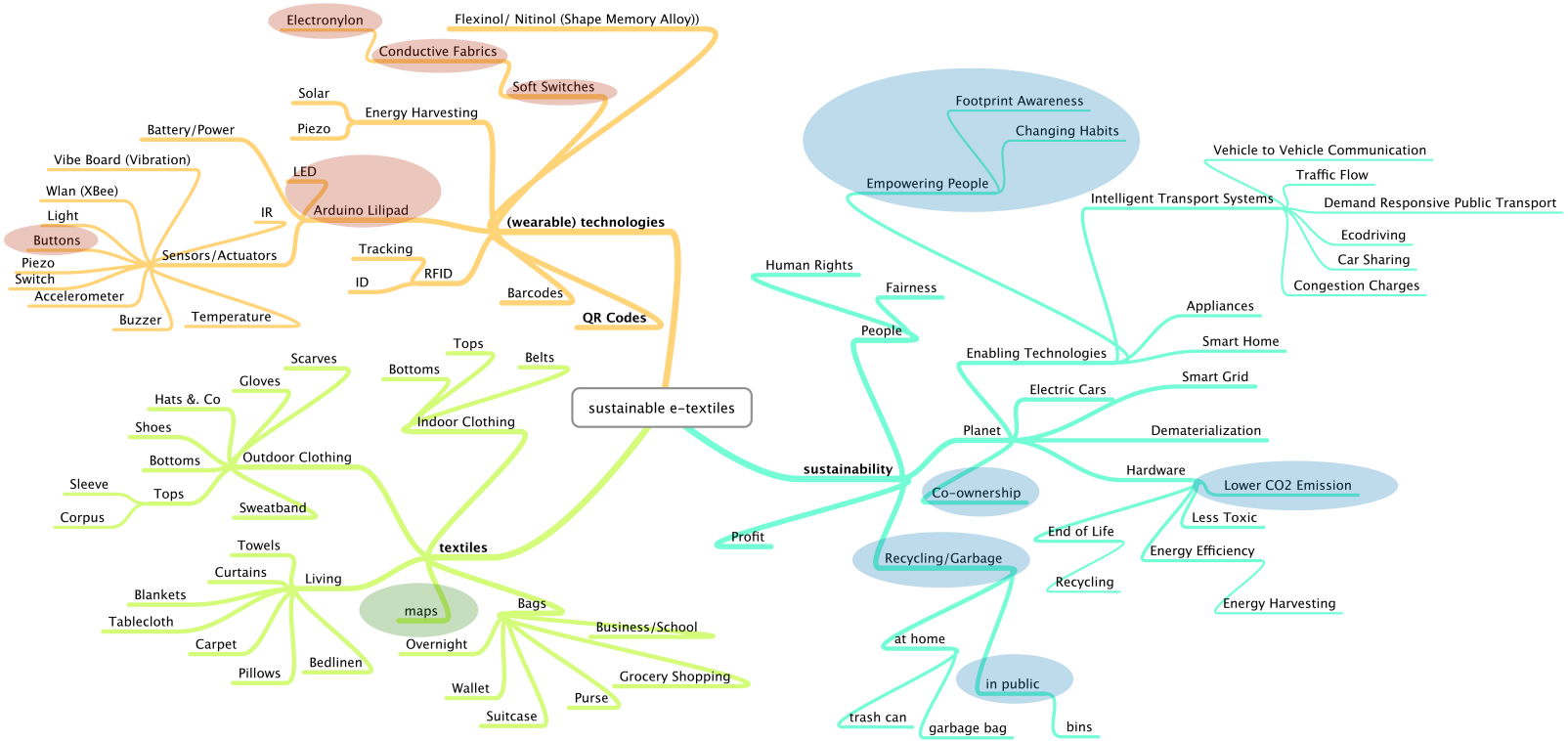


Figure 4.1: Mindmap exploring the domains of 'textiles', 'technologies' and 'sustainability'.

The highlighted nodes in figure 4.1 were identified as promising elements within the different domains and after some additional considerations led to the next step of the concept design.

The idea of a textile map is based on a fairly new product called "Crumpled City™ maps" by Italian designer Emanuele Pizzolorusso (Pizzolorusso 2012). Available for various big cities worldwide, they are printed on the light-weight fabric-like material Tyvek® (DuPont 2012), so that they can be "easily crammed into your pocket, backpack or the carrying pouch provided without having to worry about refolding it along the original creases" (Pizzolorusso 2012). Figure 4.2 shows the London version of the map.

Key properties of Tyvek® include: a higher strength-to-weight ratio than paper, little moisture absorption, a "distinctive look and feel that enhances graphic images" and it's made of 100% recyclable material (DuPont 2012).

Figure 4.2: Crumpled City™ map of London. In: Pizzolorusso (2012)

But how can a map made of textile-like material contribute to facilitating a more sustainable lifestyle, possibly functioning as a mean of empowering people to change their behavior?

City maps play a key role in urban tourism, so tourists were identified as the main target group of such a product. To gain insight into some of the tourists' main needs, a short interview with an employee at the Visitor Centre[1] in Copenhagen was conducted. When asked about the most common inquiries of tourists approaching the Visitor Centre's information desk, there was no hesitation in the employee's answer:

> *"Tourists coming here have one main question: "What is there to see and do in Copenhagen?" This is what we design our free city maps for, which display the inner city's main attractions and a a self-guided walk route that takes them there."*

[1] The Copenhagen Visitor Centre is situated at Vesterbrogade 4A, 1620 København V, DK

Figure 4.3 shows the city map provided by the Copenhagen Visitor Centre. The maps, available in English and Danish, are laid out in the entrance area and can be collected free of charge.

Figure 4.3: Official Copenhagen Map provided by the Copenhagen Visitor Center.

A more detailed excerpt of the official Copenhagen Map is depicted in Figure 4.4, showing the self-guided walk and the main attractions on the map, as well as the descriptive paragraph that provides some more details on the walk, and which can be found on the back of the map.

Figure 4.4: Inner-city excerpt of the Copenhagen Map with self-guided walk and main attractions.

The interview further revealed that the circulation number of annually printed copies of the official city paper maps provided by Wonderful Copenhagen is 1,5 mio (1,1 mio. in English and 400.000 in Danish). These numbers can also be found on each individual map. The maps are made of environmentally friendly, recyclable paper. However, how many maps are disposed of properly so that they can be recycled highly depends on the behavior of the individual tourist.

In Section 2.3, a set of vision words was presented as the core of a 'Digital-Eco Design-Scape' (Ryan 2004), including: Lightness, Distributed possession and Modularity. These vision words were applied to the concept to identify, describe and further develop its possible sustainable qualities.

Since textile maps such as the Crumpled City™ map are made of a more durable and liquid-resistant material than paper (Tyvek®), they last much longer than traditional paper maps such as the ones distributed at the tourist office. This opens up the possibility of map co-ownership (Distributed possession), as maps could be rented out multiple times to different tourists e.g. by the tourist office. Thus, to cover the demand for textile city maps, only a fraction of the amount of paper map copies would have to be produced each year.

Such a decrease in the flow of resources is also reflected by the principle of Lightness. Often, complete dematerialization is the key to the lightness of products and thus to their sustainability. Dematerialization means physical products are replaced by their digital, non-material equivalent. In the case of paper maps, the most obvious step would therefore be the complete digitalization of the city map, meaning that people should start using services like Google Maps (Google 2012). However, the review of literature revealed that physical maps are an important collaborative artifact for tourists and that the small screensize of current mobile devices is neither sufficient to give a good overview nor to display both the map view and matching information from a digital guidebook in a way that suits the average urban tourist (see Section 2.6). This calls for a compromise between an all-digital service and an environmentally friendly all-physical map and guidebook solution.

If physical maps are augmented with additional digital content, a certain degree of Modularity can be achieved despite their material nature. Digital content is upgradable, and a good way to display additional information about sights and activities. Thus, the guidebook functionality could be implemented e.g. as a mobile application, while the map still acts as a collaborative physical artifact for tourists. Both can be used in unison, leading to less attention shifts from one item to the other than if the tourist had to switch between different tabs in a mobile application to see the map and the additional information (Brown and Chalmers 2003).

These considerations lead to a first visualization of a possible prototype consisting of a mobile application and a tangible map UI made of the textile-like material Tyvek® as well as augmented using the Arduino LilyPad. The idea was to use LEDs to mark points of interests so that they can light up when selected on the map, marking their position clearly to the user. Additionally, soft buttons could be used to enable two-way communication: Pressing a button would trigger the mobile application to open a page with information about the selected sight (see Figure 4.5).

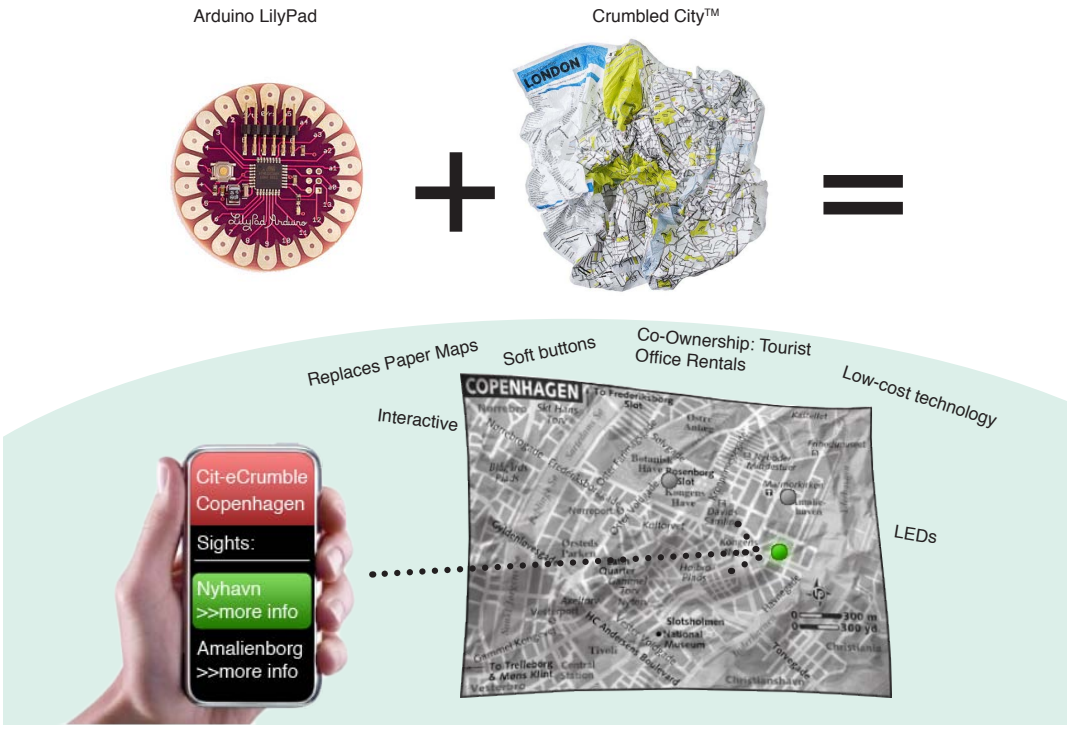


Figure 4.5: Illustration of the initial concept idea that meant to combine the Arduino LilyPad and a textile map into a physical UI that could communicate with a mobile application. Sources: Pizzolorusso (2012); Buechley (2012); Free Stock Photography (2012); OM Air Travel (2012)

While the concept already includes sustainable attributes, it's still missing true persuasive aspects that could lead to a long-term change in behavior of its users, i.e. urban tourists. The next section describes the final, refined concept. Not only was the choice of technology for the prototype reconsidered, but more thought went into its sustainable dimension to characterize the product as an actual persuasive technology.

4.2 The Refined Concept

This section describes the refined concept in detail, including specifics about the use of technology as well as how different aspects of sustainability are introduced and envisioned. The outcome is a kind of climate persuasive service based on physical mobile interaction.

The initial idea of using the Arduino LilyPad as a prototyping tool would require to sew a lot of small electronic elements into the textile map, possibly resulting in a rather heavy and awkward-to-use prototype. Also, setting up a connection with a mobile device through Arduino would have been difficult.

RFID based NFC readers on the other hand are already integrated in some mobile devices. As identified in the literature review in Section 2.5, they can communicate with small, very

light-weight physical NFC tags that come in many shapes and materials and that can easily be integrated into physical products. One of the most common tag versions for non-commercial use are NFC tag stickers (see Figure 4.6), which guarantee a straight-forward way of creating rapid, functional prototypes.

Figure 4.6: NFC tags as stickers. In: Chandler (2012)

Looking further into the future in regard to textile products, there have already been efforts e.g. by Austrian research teams at Seibersdorf Laboratories and Austrian Institute of Technology to develop a woven, washable NFC tag consisting of a standard NFC RFID chip and a copper wire antenna (see Figure 4.7), that can be sewn into garments (Clark 2011).

Figure 4.7: Woven NFC tag that can be sewn into garments, washed, spin-dried and ironed. In: Clark (2011)

NFC technology, or more generally RFID, also allows for detailed, real behavioral data about products to be made visible to its users and consumers. This possibility was identified by Zapico et al. (2009) as a key feature of 'climate persuasive services', as it is a way to provide credible feedback about the various effects behavior can have on the environment.

Therefore, and since NFC is both the more reliable and less complex prototyping tool compared to Arduino LilyPad, it was decided to go in different direction using NFC as the key technology instead of Arduino LilyPad.

As a second major step towards the final prototype as a climate persuasive service, more sustainability characteristics were incorporated into the concept, such as:

- raising awareness among tourists about the various climate initiatives by the Copenhagen municipal.
- promoting 'greener' activities among tourists.
- discouraging careless, wasteful use of paper maps.
- encouraging more responsible resource handling in general.

To help meet these 'macrosuasion' goals, various 'microsuasion' features were added to the prototype, some of which were possible to implement whereas others are thought as features that could be incorporated in future versions (see Section 2.4 for differentiation between 'macrosuasion' and 'microsuasion').

Copenhagen is involved in several climate and sustainabilty initiatives. In their vision as "Eco-Metropolis", they state that in 2015, they want to be "rightly known as the capital city in the world with the best urban environment" (City of Copenhagen 2007). They thrive to become an inspirational example to other capitals and demonstrate to them "how a greener urban environment can enhance the quality of life in practical terms" (City of Copenhagen 2007). Their visions and goals can be divided into four main areas, i.e. become 'World's best city for cycles', 'Climate Capital', 'A green and blue capital city' and a 'clean and healthy big city'. They are further specified e.g. in the Municipal plan and the UN's Agenda 21 Plan (City of Copenhagen 2007; United Nations 1992; City of Copenhagen 2011). The more specific goals for 2015 on Copenhagen's "Eco-Metropolis"-vision are listed in a table that can be found in Appendix A.1. Two of the goals are e.g. "the air should be so clean that Copenhageners' health will not be damaged" or "A reduction of Copenhagen's CO_2 emissions of at least 20% compared to today" (2005: 4.9 tonnes per inhabitant) (City of Copenhagen 2007).

Copenhagen municipal has also formulated a Climate Plan that states those goals and that furthermore stresses their aim that Copenhagen is to become CO_2 neutral in 2025 (see Figure 4.8).

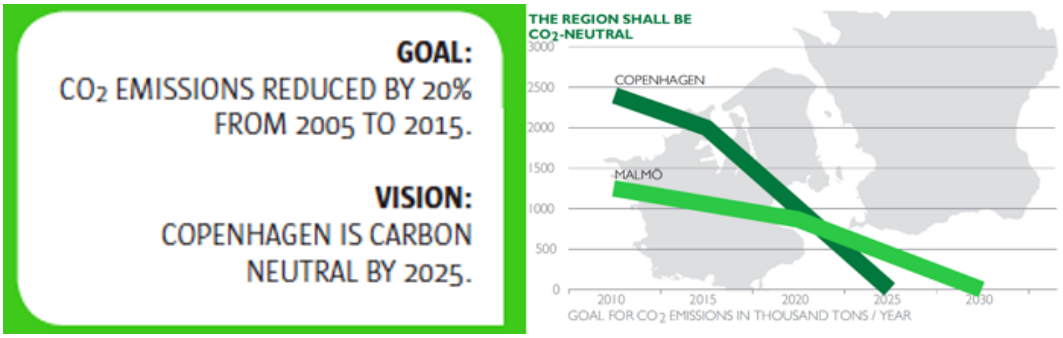


Figure 4.8: Copenhagen's goal to reduce CO_2 emissions by 20% in 2015 and become CO_2 neutral in 2025. In: City of Copenhagen (2011, 2005)

The map can be used to promote these initiatives among tourists, for example by printing a short, informative, advertisement-like text on the back of the map. The mobile app can also be used to inform about the initiatives and link to their home-pages with more detailed explanation. Additionally, with NFC technology, the physical map can link to the tab in the app and/or straight to the various webpages.

To encourage "green" tourism, the official tourist office agency Wonderful Copenhagen has gathered and published many green activities and opportunities online under the category "ECOpenhagen" for tourists visiting the city (Wonderful Copenhagen 2012b). Those activities are further divided into several categories: 'Green Copenhagen', 'Climate-friendly hostels', 'Organic restaurants', 'Vegetarian restaurants', 'Bike City Copenhagen', 'Climate-friendly transport', 'Christiania', 'Gardens and parks' and 'Baths and beaches'. Thus, to promote these 'green activities' more, they will to some extent be incorporated into the city map in addition to but clearly distinguished from regular sights.

Since Zapico et al. (2009) argue that a 'climate persuasive service' should be a fun and almost "game-like" experience to trigger principles of "competition, cooperation and recognition" (see also Section 2.5), a kind of "scavenger hunt feature" or "geocashing feature"[2] is introduced. Tourists can collect 'green credits' by participating in a green activity. Credits are stored on one of the NFC tags on the physical map and can be used to receive discounts for various attractions and activities all over the city, similar to and possibly cooperating with the 'cOPENhagen Card' (**?**). This would require involving the green business owners more actively, but since such a campaign has great marketing potential for each of them, it is expected to receive high acceptance and willingness to cooperate.

It would be ideal to provide the functionality of calculating and displaying the carbon footprint of the individual tourist or group of tourists in the application using GPS and other data, similar to the 'PEIR' project developed by UCLA (2008) and presented in detail in Section 2.4. This would enable linking cause and effect between individual behavior and emissions, another very important characteristic of 'climate persuasive services'. The calculated individual CO_2 data further opens up the possibility of sharing one's footprint with other tourists and users of the map with the help of social media tools. These features require unfortunately a much longer development phase, so they will not be incorporated into the first version of the prototype presented here. They are however important to keep in mind and to be considered in the future, as they carry a lot of potential for further development.

With the concept in place, the following section describes the design process of the UIs, i.e. both the physical map UI as well as the mobile app GUI.

[2] Geocaching: "Geocaching is a real-world outdoor treasure hunting game. Players try to locate hidden containers, called geocaches, using GPS-enabled devices and then share their experiences online." Source: `http://www.geocaching.com/`, viewed 22/05/2012.

4.3 UI Design

In this section, the design process that lead up to the two user interfaces, i.e. the physical map UI and the application GUI, is described. The first step was to design the icons or symbols that should incorporate both an indication of their general as well as their NFC functionality.

4.3.1 Physical Map UI

The design of the icons for the physical map UI was to some extent based on the work of Hang et al. (2010). In their study, they looked at various aspects of the visual design of NFC-augmented physical user interfaces, i.e. mainly smart posters, and evaluated different symbols designed to represent different phases of the interaction process (Hang et al. 2010). They identified five main interaction phases: 'Awareness', 'Approach', 'First Contact and Selection', 'Completion' and 'Dropout'.

Their symbol designs mainly concentrate on the first three phases as they are the most crucial ones, with *Adhesive Symbols* aiming at the users' awareness of the poster and its NFC-features, *Explanatory Symbols* communicating the method of interaction, i.e. touching the tags with the mobile phone, during the first contact phase, and finally *Action Symbols* for the selection phase representing the available functionalities (Hang et al. 2010). Figure 4.9 displays examples of the symbol types.

Figure 4.9: Combination of Adhesive Symbol and Explanatory Symbol (left) and different Action Symbols (right). In: Hang et al. (2010)

Similar to the approach by Hang et al. (2010), the underlaying symbol for the icons was the Nokia 3220 NFC symbol shown in Figure 4.10. It is incorporated into each of the *Action Symbols* and the *Explanatory Symbol*.

Figure 4.10: Nokia 3220 NFC symbol. Adapted from Fraser (2012); Hang et al. (2010)

The *Action Symbols* can be divided into two subcategories: menu-bar icons and point-of-interest indicators. The latter underwent three main design iterations as shown in Figure 4.11.

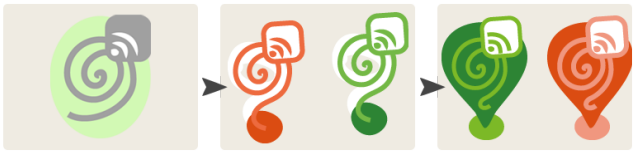


Figure 4.11: Point-of-Interest Action Symbols: red symbols refer to main sights and green symbols to 'green activities'.

The menu-bar icons that were developed parallel to the first point of interest indicator are displayed in Figure 4.12 as part of the first, low-fidelity map UI iteration. The actions they represent are (left to right) a directly into the map incorporated Copenhagen Card which, when purchased in addition to the map, functions like the actual version of the card. The next symbol links to some general information about the tourist office, e.g. opening hours. The middle symbol initiates the download of the corresponding guidebook application, followed by a symbol that refers to a page with information about the concept and the various initiatives copenhagen is involved. The symbol on the right holds the current green credit score.

Figure 4.12: First iteration of the map UI with the menu-bar displayed on the bottom of the map. Sources: Wonderful Copenhagen (2012a); Google (2012)

The design of the map UI was further refined and the final UI iteration is shown in Figure 4.13. The menu-bar was simplified and now includes only three items, as the info pages were combined into one and the virtual Copenhagen Card taken out of the design. It can still be considered for future projects as a possible additional feature, but at this stage it could distract the user evaluating the first prototype since no functionality can be attached to it yet.

Even though the same holds true for the 'download' symbol, the latter was included as it represents a core application functionality. Only a limited number of sight and green activity icons are visible on the map since the prototype will only demonstrate the functionality rather than representing a fully developed product. Each icon is associated with a number that corresponds to the number displayed with the sight or activity in the mobile application, so users have a mean of verification if they are unsure whether the right information is displayed. It also enables users to locate sights and activities they discovered in the application on the physical map.

Figure 4.13: Final iteration of the map UI with the menu-bar displayed on the left side of the map. Sources: (Google 2012)

Additionally, a 'How it works' box describing how to operate the map was included in the menu-bar (as compared to the upper right corner in the first iteration). This box also contains the *Explanatory Symbol* showing how a mobile phone is to touch or be hovered over icons to operate the system (see Figure 4.14). As for the *Adhesive Symbol*, the official NFC Forum N-Mark Trademark (NFC Forum 2012a) was placed in the upper right corner. Since the NFC Forum is probably the largest forum of influential companies joining forces to promote and advance NFC technology, it is believed that their trademark will eventually be the strongest symbol associated with NFC. Thus it was decided to incorporate it into the map. In order to being allowed to do so, an official license, which is available online and free of charge, was acquired. A copy of the Trademark License Agreement is attached in Appendix B.3.

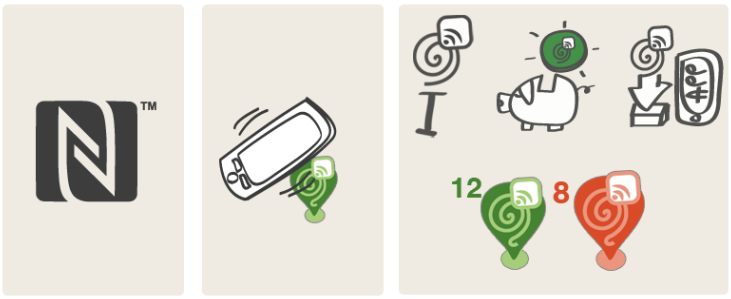


Figure 4.14: Final symbols designed for the map UI.

The logo (see Figure 4.15) incorporates the green credit coin, the lower-case 'e' refers to the 'smart' electronic component, as e.g. also included in eTextiles, while the unison coloring of the word eCO directs the focus towards the eco-dimension of the concept. It also establishes a connection to the official Visit Copenhagen program promoting green tourism called ECOpenhagen (Wonderful Copenhagen 2012b).

Figure 4.15: eCOpenhagen Logo.

Also, the color scheme was developed as part of this process (see Figure 4.16). To achieve a cohesive, unified look for both the guidebook app and the map UI, the same color scheme will be applied in the design of the app GUI. Different shades of green dominate the overall look, to communicate the main 'message' of sustainable, eco-friendly tourism.

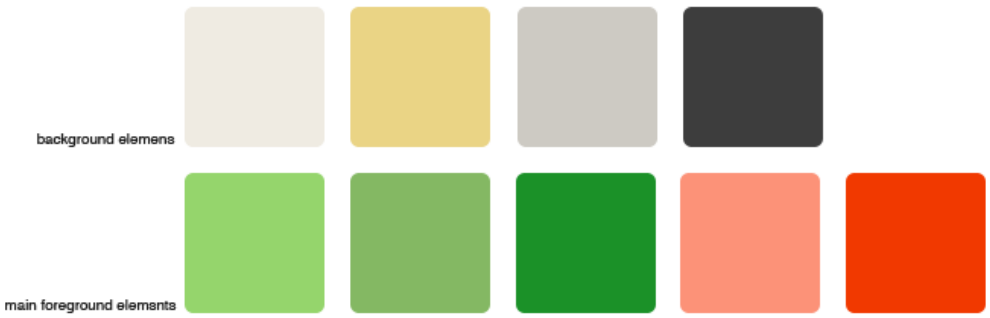


Figure 4.16: Color scheme with brigther foreground colors and earth-tone background colors.

Red as the complimentary color to green was chosen as the second dominant foreground color to clearly set the sights and green activities apart from each other. Red is furthermore often used in combination with tourist information logos (see Figure 4.17) and strongly associated with Denmark.

Figure 4.17: Different Tourist Information logos. Sources: `http://www.hopsten.de/index.php?id=87`, `http://www.northcoastni.com/places-to-stay/`, `http://www.gemeentenoordenveld.nl/vrije_tijd/recreatie__en__toerisme/tourist_info`, `http://www.worms.de/englisch/tourismus/Service_Kontakt/index.php`, viewed 13/05/12

4.3.2 Application GUI

The GUI of the Android mobile application was designed using the color schemes and most of the symbols developed for the physical UI to achieve a strong, visually unison connection between them.

The navigation icons are very similar to the map UI symbols, but a 'Home'-icon to navigate back to the home screen was added as well as a 'Find route'-icon that directs the user to Google Maps and displays the route leading them from their current position to the sight or green activity they are interested in. All the icons used in the application are displayed in Figure 4.18.

Figure 4.18: Mobile application icons used as navigation symbols linking to (left to right): info, points of interest, credit score, home menu, route-finder on Google Maps

Figure 4.19 shows a kind of sitemap of the application structure using screenshots of each application activity. The actual application implementation is documented in the next section.

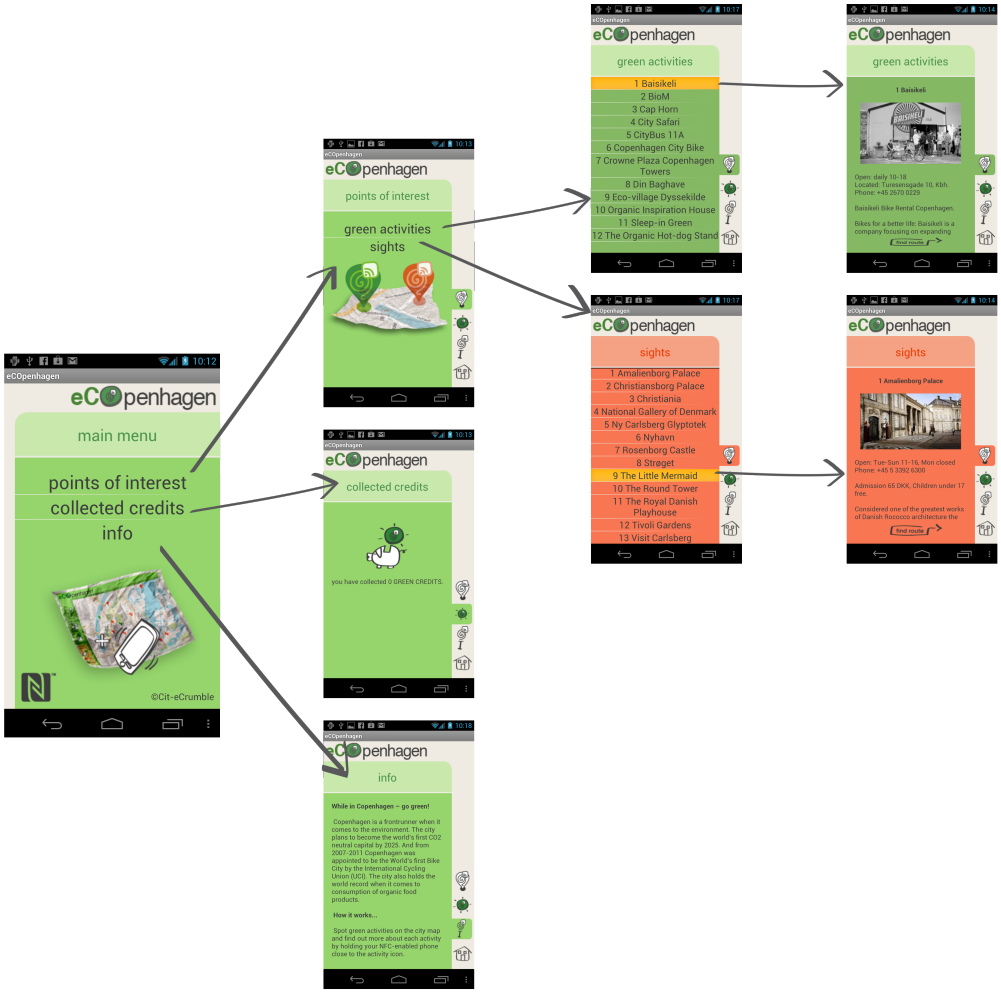


Figure 4.19: Application structure consisting of screenshots.

4.4 Implementation

This section describes both the development of the Android mobile application as well as the process of assembling the physical map prototype. There are not many NFC enabled phones on the market yet, but one of them is the Samsung Galaxy Nexus Android smartphone which was used for this project (see Figure 4.20).

Figure 4.20: Samsung Galaxy Nexus smartphone equipped with an NFC reader (reader position is indicated on the picture but not on the actual smartphone case). In: McHugh (2011)

4.4.1 Application Development

The Android application was developed using the Android SDK and ADT (Android Development Tools) plugin for Eclipse (Android Developers 2012):

> *"Android is a software stack for mobile devices that includes an operating system, middleware and key applications. The Android SDK provides the tools and APIs necessary to begin developing applications on the Android platform using the Java programming language."* (Android Developers 2012)

A basic exercise on how to create a multi-menu application structure in Android by Lynggaard (2012c) was used as the starting point for the application development. It consists of three different screens (see Figure 4.21), whereas each screen is based on the Android *Activity* class. An *Activity* is one of the four basic application components, or essential building blocks, in Android. The four component groups are listed in Figure 4.22. In Android Developers (2012), an *Activity* is described as follows using concrete examples:

"An activity represents a single screen with a user interface. For example, an email application might have one activity that shows a list of new emails, another activity to compose an email, and another activity for reading emails. Although the activities work together to form a cohesive user experience in the email application, each one is independent of the others. As such, a different application can start any one of these activities (if the email application allows it). For example, a camera application can start the activity in the email application that composes new mail, in order for the user to share a picture."

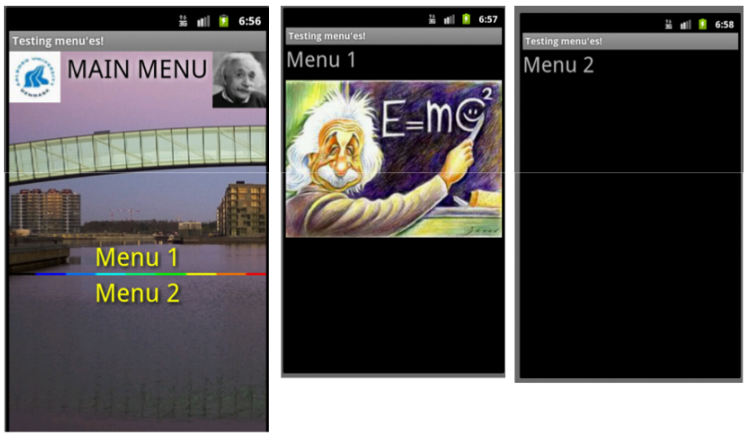


Figure 4.21: Simple multi-menus application with three UI screens. In: Lynggaard (2012c)

Component	Description
Activity	UI component typically corresponding to one screen
Service	Background process without UI
Broadcast Receiver	Component that responds to broadcast Intents
Content Provider	Component that enables applications to share data

Figure 4.22: The four basic Android components: Activity, Service, Broadcast Receiver and Content Provider. In: Lynggaard (2012a)

In the 'eCOpenhagen' application developed for this project, eight different classes that all inherit from the *Activity* class are defined, with each class representing one of the UI screens (compare to Figure 4.19). More specifically, the home screen class 'Menu.java' inherits directly from *Activity* while all the seven other classes inherit from the 'Menu.java' class.
In order to open a new screen, both if the user selected it via one of the application menus or via an NFC tag, one only needs to call the following function using a so-called *Intent* (the example code would open the 'green credit'-screen from the 'home' screen):

```
startActivity(new Intent(Menu.this, Credits.class));
```

As it is common practice in Android, application code and layout are handled separately throughout the whole application. The actual source code is stored in the *src* folder of the Android project, while all the layout-files and other resources, e.g. images and strings, are found in the *res* folder. For each *Activity* class at least one XML-layout file is defined. It contains all the visual elements called *Views* and determines where on the screen they are to be placed. Text is for example defined with a *TextView*, an image with an *ImageView* etc. One can define many different parameters that specify e.g. font size, position or paths that reference to other resources. The defined layout with the various *Views* is then "inflated" at runtime.

The listing below shows a short XML-layout example consisting only of a *TextView* element. A vertical linear layout orientation means that the views it contains are placed vertically underneath each other in the same order as in the XML file. The values used for the font size and color as well as the String that is loaded into the *TextView* are stored in separate XML files and referred to by their unique identifiers. The font color ID for example is 'color/title_color'.

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
   android:layout_width="fill_parent"
   android:layout_height="fill_parent"
   android:orientation="vertical" >

   <TextView
         android:id="@+id/TitleInfo"
         android:layout_height="wrap_content"
         android:layout_width="wrap_content"
         android:text="@string/title"
         android:textSize="@dimen/screen_title_size"
         android:textColor="@color/title_color">
   </TextView>

</LinearLayout>
```

The 'home' menu, the 'point of interest' menu that lets the user choose between sights and green activities, as well as the two menus listing the total of green activities and the total of sights are all realized using an Android *ListView* object, which is a *ViewGroup* that creates a list of scrollable items (Android Developers 2012).

Furthermore it should be added that the display of the actual information about each sight and green activity is handled dynamically. There is only one defined content class and layout XML-file for the green activity detail page and one for the sights. The text files both for the titles and descriptions are stored in separate String arrays, as well as the source-paths for the corresponding images. Images and descriptive texts were taken from (Wonderful Copenhagen 2012b).

A second exercise showing how to write an NFC tag reader application was used to learn about how to establish the communication with the NFC tags that will be placed on the phys-

ical map UI (Lynggaard 2012b). Since the application will require permission to access incoming NFC messages, which must be specifically stated in the application manifest file (*AndroidManifest.xml*), this is the one of the first things one needs to do when working with NFC:

```
<uses-permission android:name="android.permission.NFC" />
```

The application manifest file "presents essential information about the application to the Android system, information the system must have before it can run any of the application's code" (Android Developers 2012). In order to let the Android OS know that the application should be opened when a certain NFC tag is detected, an intent-filter also needs to be included in the manifest. In this case the application will be triggered every time an NDEF-formatted[3] NFC tag that contains plain text is discovered.

```
<intent-filter>
      <action android:name="android.nfc.action.NDEF_DISCOVERED"/>
      <category android:name="android.intent.category.DEFAULT"/>
      <data android:mimeType="text/plain" />
</intent-filter>
```

The rest that is needed for the application to read NFC tag is handled in the 'Menu.java' class. There, an incoming NFC message is resolved in the *resolveIntent(Intent intent)* function:

```
 Boolean resolveIntent(Intent intent){ //returns true if NDEF formatted
    NFC message was discovered
     // Parse the intent
     String action = intent.getAction(); //any incoming action
     if (NfcAdapter.ACTION_NDEF_DISCOVERED.equals(action)){ //NDEF
         formatted NFC action was discovered

           //stores the action message in an array:
        Parcelable[] rawMsgs =
            intent.getParcelableArrayExtra(NfcAdapter.EXTRA_NDEF_MESSAGES);
        if (rawMsgs != null){
           //stores the NDEF message in the 'msgs' array
           msgs = new NdefMessage[rawMsgs.length];
           for (int i = 0; i < rawMsgs.length; i++){
              msgs[i] = (NdefMessage) rawMsgs[i];
           }
        }
        else{
           // Unknown tag type
           ...
        }
        processTag(intent);
        return true;
     }
     return false;
  }
```

[3] common Data Exchange Format defined by NFC Forum, see Section 2.5 for details

The *processTag(Intent intent)* function evaluates the received message based on the String the tag contains and starts the corresponding activity (a code snippet is included in Figure 4.23 which illustrates both encoding and decoding). For this prototype, the encoding is kept very simple. The tags contain a short String consisting of a single letter ('g' for green activity, 's' for sight, 'c' for credit score and 'i' for information) and a number.

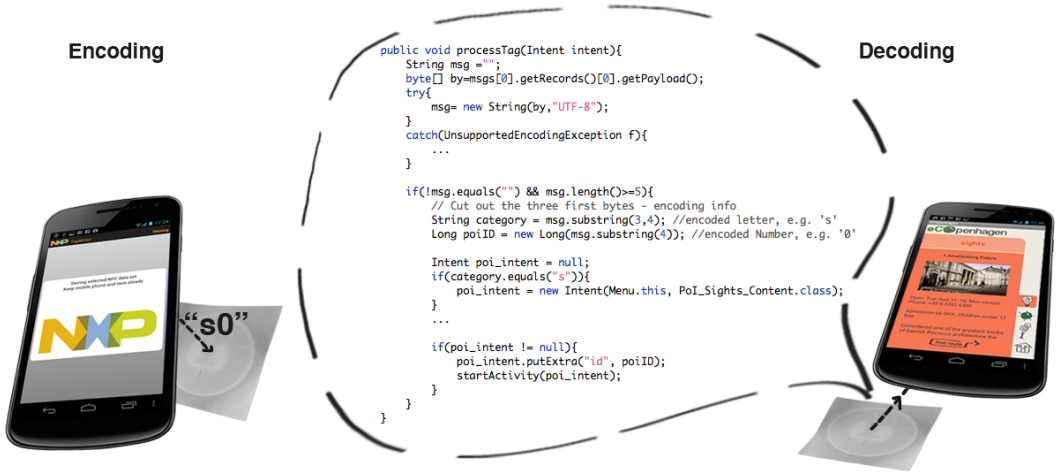


Figure 4.23: Illustration of both the encoding and decoding process of the NFC tags.

For the green activities, the numbers indicate the index of the activity in the arrays that store the corresponding photo, title and description. The same holds for the sights. 'Amalienborg Castle' for example has the index '0', so the corresponding tag would be encoded 's0'. For the credit tag, the number indicates the amounts of collected credits and for the information tag, the number is always '0'. Tags were encoded using the existing, free Android application 'TagWriter' (NXP Semiconductors 2012). The process of storing the text on the tag is depicted in Figure 4.24.

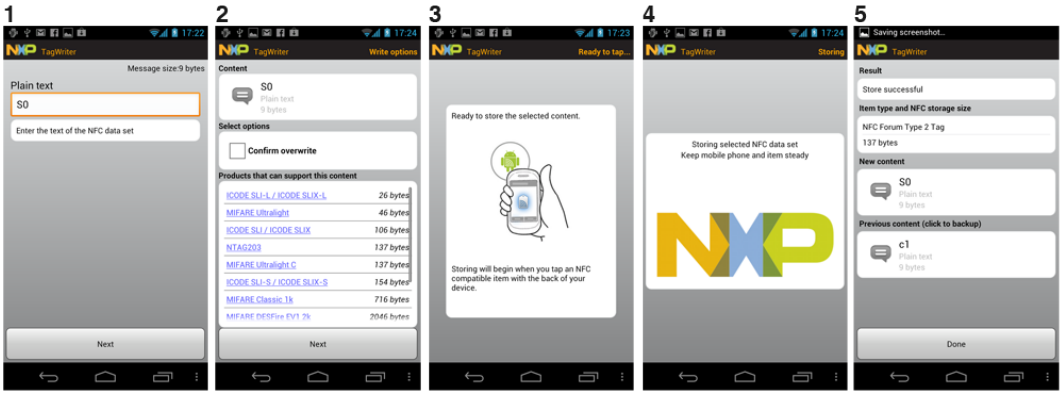


Figure 4.24: Process of storing the String 's0' on the tag that should link to the sight 'Amalieborg Castle' using the application TagWriter for Android (NXP Semiconductors 2012).

However, more secure and complex ways of coding tags exist that could be used if the map were to be made into an actual product. For example, keys can be used to authenticate devices that are permitted full read/write capabilities, while the average user device could only read the tags but not rewrite them. This is especially important if the green credit system was to be installed. For further reading on key management and NFC, refer to Cheng et al. (2011).

As an additional feature, a link to the application Google Maps was established via the 'find route' button. For each sight and green activity, the latitude and longitude coordinate values can be retrieved and, using the current location which would be detected through GPS, the route is automatically calculated and displayed in the Google Maps application. With the current version of the prototype, the GPS locating function is not implemented yet. Instead, the user's position is simulated with pre-set geo coordinates. Figure 4.25 displays the example route from the pre-set user location (A) to Amalienborg Palace (B).

Figure 4.25: Example of the route finder function via Google Maps using pre-set geo-coordinates to simulate the user's current location (A) and the route to Amalienborg Palace (B)

The next part describes shortly how the physical UI was assembled.

4.4.2 Assembling the physical map UI

A sheet of Tyvek® (described in Section 4.1) was purchased along with 10 NFC tags (Next generation, NXP NTAG203 25mm round white film face stickers[4]) to make an actual physical map UI prototype (see Figure 4.26).

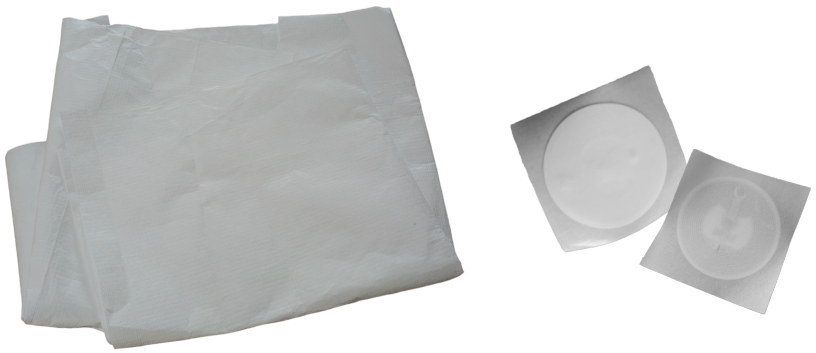


Figure 4.26: Sheet of plain Tyvek® and NFC Tag of type NXP NTAG203 25mm round white film face stickers

One of the tags was used to test whether the sticker would adhere to the Tyvek® , which it did without any problems (see Figure 4.27).

Figure 4.27: Tag used to successfully test the adhesiveness of the tag on a piece of Tyvek®.

The first step towards the actual prototype was to print the map onto the sheet of Tyvek® . This was accomplished with the help of the staff at Vester Kopi (Vester Kopi 2010a) using their industrial plotter. The printing process was documented and is shown in Figure 4.28. Due to some creases in the material, the image was slightly blurred in some areas. But overall the printing went well and as there is already a product out there similar to this (Crumpled City™ , see Section 4.1), a cleaner, blur-free printing result could be achieved under different conditions (no creases in the material) and maybe with a different printing method.

[4] available at RapdNFC.com `http://rapidnfc.com/item/87/white_nfc_tags_ntag203_round_25mm`

It should be pointed out that Vester Kopi is a company offering only environmentally responsible printing services and they were therefore a suitable choice for this project. They are certified with the Nordic Ecolabel 'The Swan'[5], use only CO2-free power and non-hazardeous, eco friendly substances in their production processes, deliver via bicycle when possible and guarantee responsible waste management (Vester Kopi 2010b).

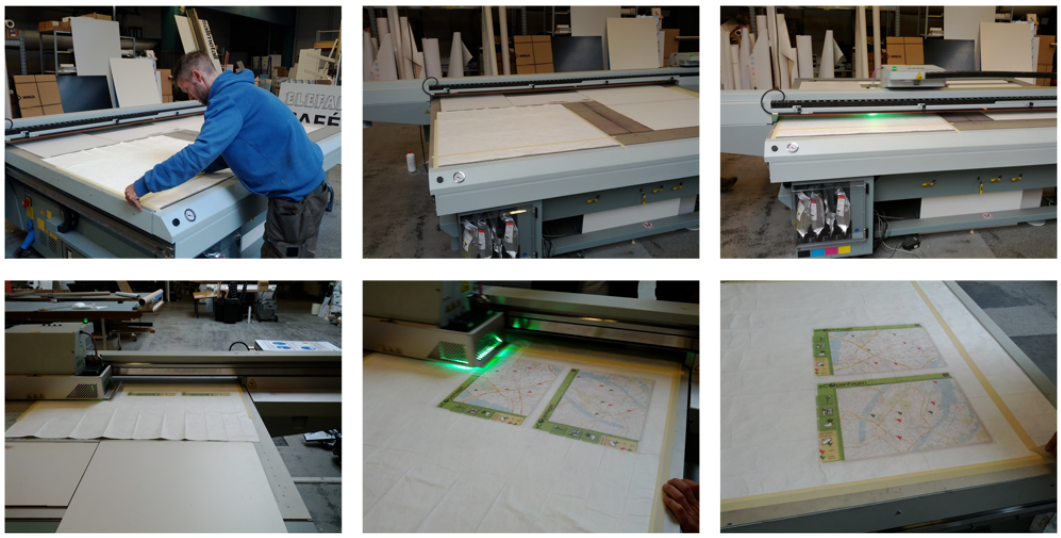


Figure 4.28: Process of printing the map prototype with an industrial plotter at Vester Kopi.

Two different versions of the map were produced (in Din A3 format), one showing the whole inner Copenhagen area and one only depicting an enlarged excerpt (see Appendix B.1 for the final print documents). The latter was decided on following the advice of a fellow student who was asked to give a short first assessment of the cohesiveness of the UI. He noted that, for an unexperienced user testing the prototype, it could be easier to understand a rather complete excerpt including all the icons instead of the whole map showing only very few icons scattered here and there. After the printing, the excerpt version was actually much clearer to read as the street names were completely blurred in the original version. The final result of the printed map is shown in Figure 4.29.

As a final step, the encoded tags were attached to the back of the map (see Figure 4.30).

[5]"The Nordic Ecolabel is the official Ecolabel of the Nordic countries and was established in 1989 by the Nordic Council of Ministers with the purpose of providing an environmental labelling scheme that would contribute to a sustainable consumption. It is a voluntary, positive Ecolabelling of products and services. The Nordic Ecolabel was also initiated as a practical tool for consumers to help them actively choose environmentally-sound products. It is an ISO 14024 type 1 Ecolabelling system and is a third-party control organ." (Nordic Ecolabelling 2012)

Figure 4.29: The printed prototype showing an excerpt of inner Copenhagen.

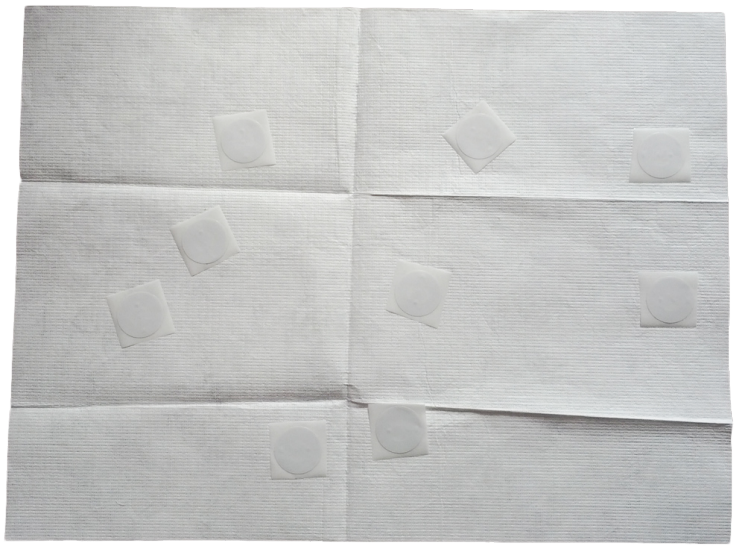


Figure 4.30: The back of the map with the attached NFC tags.

4.5 Summary

The chapter presented the whole process of conceptualizing and designing the prototype of an NFC-enabled, reusable physical city map UI that communicates with a corresponding mobile application as a kind of digital guidebook. The final concept incorporates different sustainable strategies, e.g. the reusability of the map that allows co-ownership in the sense that it could be loaned to tourists e.g. at tourist offices as an alternative to the traditional, disposable paper map. Other aspects relating to sustainability are the dematerialization of the guidebook which was substituted through a digital equivalent, and which provides modularity regarding its content that can easily be updated, expanded or exchanged.

Furthermore, the map contains not only regular city sights, but also various green, eco-friendly touristic activities of different sorts as advertised by Wonderful Copenhagen (2012b). They are meant to help promote the different climate initiatives the Copenhagen Municipal is committed to, and generally raise tourists' awareness regarding the importance of living and sight-seeing in a more sustainable way. With the option to collect green credits, tourists should be encouraged in an even more playful way to explore the green activities that are offered.

Possible future features could include a social component that allows the sharing of experiences, e.g. through platforms like Facebook, or a personal carbon footprint calculator to really distinguish it as climate persuasive service.

A lot of considerations went into the UI design, aiming for a cohesive, clear and playful appearance and navigation of the map UI and the application GUI. The implementation process was also documented, providing an overview of how some of the core functionalities were realized using the java-based Android SDK. The final step towards the functional prototype was assembling the physical map using NFC tag stickers and a sheet of Tyvek® imprinted with the UI graphics.

The next chapter will describe how this prototype and concept was evaluated in a user study.

CHAPTER 5

Evaluation

This chapter describes the evaluation of the prototype. The aim of the evaluation was to assess qualitatively the three different dimensions the system tries to address: usability, the interaction between the tangible and the digital, as well as the marketability of sustainable strategies.

The first section presents the methodology that was applied for the evaluation, followed by a description of an initial pilot study that lead to a refinement of the methodology, and finally the main user study.

5.1 Methodology

As Nielsen (1997) states, "many aspects of usability can be studied by simply asking the users". This can certainly be extended to aspects beyond the usability of a system. Therefore, a user study was conducted in order to evaluate this project.

For the assessment it is important to determine how users interact with the prototype and what they like and dislike about it. Nielsen (1997) suggests that both questionnaires and interviews are suitable methods as they are means to study users' opinions about a system. Preece et al. (2011) identify three main techniques for gathering data, i.e. interviews, questionnaires, and observation, and advise interaction designers not only to focus on one technique as an evaluation tool but rather combine two or more to avoid bias. Observation as the third method "provides context for tasks, and contextualizing the users and the interactive product provides important information about why activities happen the way they do" (Preece et al. 2011).

Employing different methods is referred to as 'Methodological triangulation' and according to Preece et al. (2011), it is one of five key issues that need to be considered when gathering data. the others are goal setting, identifying participants, the relationship between the data collector and the data provider, and pilot studies.

When setting the goals, it is especially important to define the profile of the people the study aims at, i.e. to identify the population. Informed Consent forms that are signed by the participants can furthermore help achieve a clear and professional relationship between them and the data collector to clarify the nature of the study (Preece et al. 2011). With such a statement of consent, participants are asked to "confirm that the purpose of the data gathering and how the data will be used has been explained to them and that they are happy to continue. It also often includes a statement that participants may withdraw at any time, and that in this case none of their data will be used in the study" (Preece et al. 2011).

With a pilot study, i.e. "a small trial run of the main study", the data collector can identify possible shortcomings in the design of the study and correct them accordingly before the actual test (Preece et al. 2011). Aspects that can be considered in such a pilot run are e.g. the checking of equipment, the clarity of instructions and questions or the viability of the procedure as a whole.

For the evaluation of this project, the **DECIDE** framework presented by Preece et al. (2011) was used as a guiding structure:

D etermine the goals.
E xplore the questions.
C hoose the evaluation methods.
I dentify the practical issues.
D ecide how to deal with the ethical issues.
E valuate, analyze, interpret, and present the data.

The goals of the evaluation were determined as part of the problem statement, i.e. the evaluation sets out to find answers to the following questions:

1. How well do users cope with the system in terms of its general usability?
2. Do users embrace the concept of having a tangible interface augmented with additional, dynamic digital content?
3. How big is the success potential of novel and more playful marketing strategies towards a 'greener' urban tourism?

Each of these questions can be explored further, e.g. by asking users more specifically about their likes and dislikes regarding the interface, the interaction between the map and the application or their opinion towards the green aspects of the concept.

For the evaluation methods, it was decided to combine all three data gathering methods suggested by Preece et al. (2011). In addition to be given the opportunity to observe users exploring the system, Root and Draper (1983), as cited in Nielsen (1997), found in their study on 'questionnaires as a software evaluation tool' that "users gave more useful answers if they actually used the system shortly before answering the questionnaire". So after a short

introduction to the system including instructions and the overall idea behind the concept, participants get the chance to explore the prototype on their own with the data collector present as an observer. Sketches and notes are used as the means for the observation. The duration of the exploration phase depends on the participants who are not given any specific time limit.

Immediately after the exploration phase, participants are asked to fill out a short questionnaire. The first version of the questionnaire, which can be found in Appendix C.1, contains 6 questions assessing mainly the usability (Q1 on visual appeal and Q2 on ease of use), the marketability of sustainable tourism (Q3-Q5) as well as the overall concept (Q6). Users are asked to rate each question using a 5-point likert scale as recommended by Nielsen (1997).

As the final evaluation phase, a short interview is conducted. While the interview is based on the answers participants provide through the questionnaire, its overall nature was meant to be more exploratory using non-pre-defined, open questions that would invite the participants to elaborate freely on each questionnaire answer. The interview is recorded using a common dictation device (see Figure 5.1) and should last around 5 minutes.

Figure 5.1: The Olympus WS-311M digital voice recorder used to record the conducted interview. In: Amazon (2012)

Regarding practicalities, the context and target group, or population, are critical for the evaluation to be as authentic as possible. Therefore, the study was designed as a mostly qualitative evaluation with few, but actual tourists testing the prototype in the field, i.e. the city center of Copenhagen. The Copenhagen Visitor Centre was considered a convenient location to spot tourists and thus a possible starting point for the search for participants. Since the study involves a fairly novel, mobile technology, younger tourists are expected to be more easily convinced to participate. Each individual evaluation session should take no longer than 10–15 minutes to steal as little time from tourists as possible.

To ensure that participants feel protected e.g. in terms of their right to privacy, they are asked to sign an Informed Consent Statement, which can be found in Appendix C.2, after the short oral introduction to the system.

Following the advice given by Nielsen (1997) and Preece et al. (2011) that user evaluation studies should always be subject to pilot testing and iterative design before the actual testing, a pilot study was conducted which is described in the following section.

5.2 Pilot Study

Two female German tourists (ages 23 and 24) participated in the pilot study. Both interviews were conducted in the city center of Copenhagen and structured as follows:

1. Introduction to the system.
2. Exploring the system.
3. Short questionnaire.
4. Follow-up interview of 3-5 minutes.

The introduction included a short explanation of the concept and some instructions on how to operate the system. The participants were told that before them they had a prototype of an interactive city map designed as a durable, eco-friendly paper map alternative that could be rented at tourist offices. It was further pointed out that the map displayed two types of points of interest, i.e. sights and green activities. Finally. they were instructed that they could use the phone to get more information about each point of interest and menu icon by touching or hovering over them.

Afterwards they each took their time to explore the map and application (see Figure 5.2). This gave the interviewer a chance to observe how they interacted with the map and phone at the same time and already identify some of the difficulties the participants experienced.

Figure 5.2: The two users exploring the prototype in the pilot study conducted in the city center of Copenhagen.

Subsequently to the exploration phase, the participants were asked to fill out the questionnaire containing 6 questions mainly assessing usability, visual appeal and sustainable aspects using a 5-point rating scale (1 = negative, 5 = positive; see Appendix C.1 for the questionnaire). The answers given are listed in Table 5.1.

	Participant 1	Participant 2	Mean
Q1	5	5	5
Q2	3	3	3
Q3	4	3	3.5
Q4	4	5	4.5
Q5	3	5	4
Q6	4	5	4.5

Table 5.1: Questionnaire results of the pilot study.

The answers were used as a starting point for a follow-up interview with some additional in-depth questions about each answer in the questionnaire. The interview was conducted in German and recorded using a common dictaphone. Transcript and translation of the interviews is attached in Appendix C.3. Unfortunately, the second recording was lost due to some technical issues, but the interview was reconstructed out of memory as accurately as possible.

In addition to the answers provided directly by the participants in the interview, several observations were made during the actual testing phase. Both tourists had some difficulties figuring out how to hold both the map in one hand and the mobile phone in the other and still be able to properly read the tags. They both decided to prop up their knee in order to have an almost table-top-like surface to place the map on (as illustrated in Figure 5.3).

Figure 5.3: Participant propping up one knee as a way of coping with some difficulties regarding the simultaneous use of map and phone.

Another issue that occurred in the first interview was that the participant tried to use the map while it was not completely unfolded. This resulted in some of the tags interfering with each other. The wind, even though there was only little, furthermore caused some problems as it made the map to flap a bit too much, resulting in some unwanted creases and overlays in the material that made it more difficult for the participants to reach some of the tags.

Both participants had some issues in selecting tags in the beginning as they were not holding it in place long enough and couldn't quite locate the NFC reader. They thus needed some further assistance showing them exactly were the reader was located (sensor location is depicted in Figure 4.20 in Section 4.4).
The observations were confirmed by the answers given by the participants in the actual interview. They both identified the previously mentioned difficulties as the biggest challenges the system yet needs to overcome.

Besides from the usability issues mentioned above, Participant 1 pointed out the convenience of having access to a lot of additional information through the mobile application without having to go through an actual guidebook, thus saving a lot of time.

Regarding the sustainable aspects, both claimed they would be willing to loan the map, while also stating that they usually collected multiple paper maps during one stay. The latter could be an indicator that the tangible map would not only replace one paper map per tourist but several which would slightly add to its sustainable value. They were also rather interested in the green activities, as well as the green credit system.

Some conclusions that could be drawn from the pilot study were that the textile-like, light weight material, which on the one hand allows for the map to be folded easily, on the other hand caused some stability problems. It could be an indicator that possibly a different, yet still eco-friendly and long-lasting material might be the better choice. However, this issue cannot be fixed for the following final user study of this project.
The observations also showed that a few more instructions need to be given prior to the explore phase, especially regarding the sensor location and how tags are read. This kind of information cannot be included as detailed in the actual map or application as it could differ from device to device. However, looking into the future under the assumption that NFC will soon be playing a central role e.g. with mobile payment, users are more likely to have gotten used to NFC technology by then, thus knowing the location of the sensors in their phones and how tags can be read.

To give the questionnaire and interview a bit more structure, in order to get more comparable results, they were revised after the pilot study. The changes that were made are described in the next section.

5.3 Revised Methodology

Some methodology refinement was needed after the pilot study. It became e.g apparent that not enough focus was laid on assessing the users' opinion on the both tangible and digital nature of the prototype. To evaluate all three dimensions listed in the problem statement and the goals set in Section 5.1, it was therefore necessary to first of all make some changes to the questionnaire.

The revised questionnaire that was used for the actual user study contains seven instead of 6 questions and can be found in Appendix D.1. Questions 1 and 2 aim at assessing the prototype's general usability, questions 3 and 4 at users' opinion towards the tangible and digital nature of the prototype and Question 5 is concerning the marketability of strategies aimed at promoting more sustainable urban tourism. Question 6 tries to assess current tourist behavior regarding paper maps and was included to see if paper maps were even popular among tourists and whether tourists possibly used multiple paper maps during their stay which would mean that one reusable map would replace more than one paper map per tourist (the latter was only asked in the follow-up interview). The last question investigates the users' overall willingness to adapt the idea.

Other minor changes to the questionnaire include the improvement of the rating options, e.g. the replacement of "rather appealing" with "appealing" or "less appealing" with "little appealing" (compare Appendix D.1, Question 1). Also, instead of saying that maps could be "rented", this term in question five was replaced by the verb "loaned" as the latter implies a slightly different and more suitable connotation: rent = "a sum paid for the hire of equipment", loan = "a thing that is borrowed"[1]. The notion of "borrowing" is much more appropriate since the service is more attractive if tourists don't have to pay for it but rather leave e.g. a deposit or ID for the map that they can collect again when the map is returned. This is especially important to consider since tourists will compare the textile map to the paper map that is already distributed free of charge.

Regarding the interview, more structure was needed to improve the comparability of the answers. Instead of taking a more unstructured, explorative approach as done in the pilot study, it was therefore decided to conduct a so-called semi-structured interview:

> *"Semi-structured interviews combine features of structured and unstructured interviews and use both closed and open questions. The interviewer has a basic script for guidance, so that the same topics are covered with each interviewee. The interviewer starts with preplanned questions and then probes the interviewee to say more until no new relevant information is forthcoming."* (Preece et al. 2011)

For each question in the questionnaire, a set of follow-up questions was defined prior to the study, in order to sufficiently assess the three evaluation objectives. The additional questions are listed in Appendix D.3.

The following section presents the final user study.

[1] definitions taken from the pre-installed Mac OS application 'Dictionary' Version 2.1.3

5.4 Main User Study

The main study was conducted over the course of two days at different locations in the city centre of Copenhagen, whereas Rådhuspladsen turned out to be a particularly well-suited spot to engage tourists in a short test as it is used by many as a resting place (Figure 5.4 shows Rådhuspladsen with tourists resting on the stairs and benches).

Figure 5.4: Rådhuspladsen in the city centre of Copenhagen was chosen as a good testing location as many tourists come there to rest.

A total of 10 tourists from 7 different countries ages 22 to 34 (average age: 25,9 years, gender ratio 1:1) took part in the study. Five of them agreed to participate in the full study, i.e. trying out the prototype, filling out the questionnaire and elaborating on the answers in a 5 minute follow-up interview. The other half only had the time and patience to fill out the questionnaire after having explored the prototype.

The introduction included a brief explanation of the nature and purpose of the study, i.e. that a prototype of a new kind of city map was developed as part of the author's Master's Thesis. The green tourism aspects were pointed out, i.e. the reusability of the map, the option to loan it at e.g. tourist offices, the green activities and the green credit system. A short demonstration of how to read the tags with the mobile phone was given as well since the pilot study showed that it was necessary due to the novelty of the technology to point out the exact location of the sensor on the phone as well as how close to hold the phone to the tag in order to read it properly.

5.4.1 Results

The quantitative results of the questionnaire are listed in a table that can be found in Appendix D.2, and the transcript of the five conducted interviews is included in the CD. Due to the small number of participants, no definite behavior patterns or general opinions can

be extracted from the collected data, but the goal is to identify certain trends that could be subjected to further, more representative studies.

In order to single out possible indicative patterns, means were calculated for the quantitative questionnaire answers, and the qualitative interview data was categorized. The latter will thereby be analyzed on a rather high level of detail (as compared to fine level analysis considering each word, phrase, utterance, or gesture) (Preece et al. 2011).

Observations during the exploration phase in which the participants tested the prototype found similar difficulties regarding the usability as in the pilot study, i.e. it appeared to be a challenge for the majority of participants to hold the map at the same time as using the phone to read the tags, as the wind often made the map flap uncontrollably. Whenever possible, participants tried to find a solution to overcome this issue, e.g. by placing it on a flat surface nearby, sitting down and placing the map on their lap or holding it against a wall (see observation sketches in Figure 5.5).

Figure 5.5: Observation sketches of participants holding the map against the wall or placing it on a flat surface to keep the wind from interfering too much.

The questionnaire results also indicate some shortcomings in the interaction between the physical map and mobile phone application (mean Q3 = 3,6 making it the lowest of all the answer means), which could be accounted for by the light-weight, rather "floppy" nature of the material that made it tricky to properly use the map.

To evaluate the interview data, a kind of qualitative content analysis was performed on the transcribed answers the interviewees had provided (Krippendorff 2004; Preece et al. 2011). This means that the answers were categorized and their frequency compared across all participants. Regarding the granularity level, it was decided that an element that is to be categorized can mean anything from a single word to a whole paragraph, as long as it is on the same issue and sentences are adjacent. For example, the following sentence would be one element expressing the participant's appreciation of the button size:

"it's really nice that the information buttons are a little bigger than the rest and that they are of the size so that you can see them better."

Sometimes participants used only one word to express their opinion:

"Easy."

or even a whole paragraph:

"Handling was difficult, using both parts together. Because you need some kind of surface to place the map on. That is the most difficult thing I would say."

A total of 9 categories was used, and within each category elements were either rated as positive, neutral or negative. The whole categorization table can be found in Appendix D.4 and an excerpt is depicted in Figure 5.6. The 9 categories were chosen with the three objectives of this evaluation in mind (usability, interplay of tangible and digital dimensions, marketability of sustainable strategies):

- Usability: Visual Design
- Usability: Ease of Use
- Content
- Usability: Problems with Material
- Tangible Map
- Combination Tangible & Digital
- Sustainable Urban Tourism
- Concept as Marketing Tool for Green Tourism
- Willingness to Adapt

The categorized phrases were also searched for reoccurring patterns and themes as suggested by Preece et al. (2011). Patterns are indicated with different colors in the categorization table. However it should be pointed out that not all identified patterns are equally strong.

One of the most obvious patterns is the one that also supports the assumptions on the usability issues with the map material. The material was described by participants as too "floppy", which caused problems especially if there was some wind. The visual design was described by the majority as "clear", meaning it wasn't overloaded with too much information. The system was further described by most as "easy to use" and it was pointed out by two participants that they were very content with how well the technology worked. The questionnaire results reflect the overall contentment with the usability of the prototype (mean of 4,2 regarding the visual design and 4,8 on the functionality).

More importantly, all five interviewees liked the concept of having a physical map and additional, digital information available in the application. Three participants further believed it to

Category/User	+	Neutral	–
Usability: Visual Design U1	it's really nice that the information buttons are a little bigger than the rest and that they are of the size so that you can see them better. Design of map and app was fine		The font is not very readable
U2	visual design the color and font size and so on was ok		button layout was kind of kind of strange [in app] There was huge space above the buttons which was not used. There was a lot of empty space on the right corner. Somehow use the whole screen
U3	I found it very **clear**.		
U4	It's **clear**, it's easy to understand the design is **good**, wouldn't change anything		
U5	It's easy to understand and it's **nicely made up**. So it's friendly to the eye. **Not too overwhelming** with the information It was really **cool**.		
Usability: Ease of Use U1	It was **clear how to use the map**, nice navigation It was **pretty nice and you could just hold it on the place where you want to go and then it pops up on the phone**		

Figure 5.6: Excerpt of the Content Analysis Table showing the positive, neutral or negative categorization columns.

be more fun than the all digital or all physical alternatives. There was some reluctance towards choosing this version over the traditional map. This could maybe be accounted for by the novelty of the technology, but the skeptics all stated that they saw potential and would be willing to try this version for a longer period of time assuming it was in a more sophisticated stage and their phones were equipped with the right technology:

"If I had the phone I would try this combination" ... "I think I have to use it for a little while but at the moment I would think [I prefer] the mixture. Of both. [over digital and all physical]" ... "It would probably be nice to try this one out and see how it goes."

One of the participants directly compared the mobile application to the traditional guidebook she would normally use, pointing out the core advantage of having a digital guidebook application instead that was also considered by the author and backed up by findings in the literature (see Section 2.6):

> *"Because otherwise if you didn't have the information at the current location one would after all also have to take out the guidebook and the mobile phone is more practical."*

One participant pointed out a rather convincing argument in favor of the tangible map:

> *"I like having a physical map because there is it's usually a bigger... you usually see the bigger picture. And on a mobile phone application you just see a little part of where you want to go."*

In this regard it can be added that the questionnaire results indicate that tourists are likely to collect a paper map (mean = 4,1), which could also be interpreted as there being a general need for a physical map artifact and that tourists haven't generally adapted to using all digital maps yet.

Regarding the green tourism strategies, most of the interviewees felt there was a need for the promotion of such, including offering green activities, and three participants stated that they considered this particular strategy as motivating.

Overall, the interviewees displayed a high willingness to adapt this new kind of map, given they were to have the technology available in their phone. Two specifically named the green activities as the main factor for their own motivation to adapt, and one the feature of having all the additional information available. The questionnaire results back up this notion, as they show a mean rating of 4,1 for Question 7 which assesses the willingness to adapt.

5.5 Summary

The concept was evaluated based on the three goals that were set in the problem statement, following the DECIDE framework (Preece et al. 2011) as a guiding scheme. Three evaluation methods were combined, i.e. observation and a quantitative questionnaire followed by a qualitative interview.In the observation phase, users were encouraged to explore the prototype on their own and as long as they felt was needed.

Both the questionnaire and interview were revised after a small pilot study with two users, whereas the latter was planned more carefully as a semi-structured interview as compared to its initial, more unstructured character. This enabled a better comparison across all interviewees. The pilot study also revealed that a more elaborate introduction to the technology was needed, including instructions on how to read the NFC tags and that the map should be completely unfolded to guarantee a more reliable performance.

While the results indicate certain usability problems resulting from the "floppy" material of the map, the overall usability was rated rather positively. Users were also generally fond of having both a tangible map and additional, digital content on the mobile application and most also saw the map as a potentially effective and fun marketing tool to promote more sustainable tourism. Overall, they were open to the thought of using it in the future if it was to be available and if by then their phones were equipped with the necessary technology.

However, it needs to be kept in mind that this study was very small and to draw any final conclusions rather than indications on users' opinion, it would be necessary to conduct a larger, more representative study.

CHAPTER 6

Discussion

The overall motivation behind this project was to investigate whether novel technology could provide persuasive incentives to promote and implement strategies towards a more sustainable urban tourism. This general problem statement was furthermore broken down into three more specific evaluation criteria, i.e. the concept should be evaluated based on the prototype's general usability, the users' appreciation of having both a tangible artifact and a digital application as well as the marketability of a more sustainable kind of urban tourism.

A user study was conducted in order to assess the developed prototype of a tangible, reusable city map as a physical UI for a mobile guidebook application providing the urban tourist with additional information about sights and green activities that can be found throughout the city of Copenhagen. The study identified several indicators that tourists found the prototype easy to use, with the exception of the map material causing problems during the interaction.

More importantly, they were also interested in the hybrid nature of the prototype, meaning the combination of the digital and the physical. The study further showed that almost all polled tourists still used paper maps which could support the theory identified in the problem analysis that paper maps act as an important tangible artifact for tourists. The majority found that green tourism should be promoted and that the type of strategy attempted with the present concept had the potential to contribute to raising awareness among tourists. The overall willingness to adapt this new kind of city map if it was available was also high, whereas both the green activities as well as the additional information were named as motivating factors.

Revisiting the problem statement with these findings in mind, it could be said that certain trends were observed suggesting that novel technology like physical NFC multi-tag interfaces combined with a thorough concept such as incorporating green activities could provide persuasive incentives to promote and implement strategies towards a more sustainable urban tourism.

Yet, To clearly validate the statement, a more elaborate study should be conducted as part of future research, possibly adopting some of the improvement suggestions made by the interviewees and other considerations that arose from the tests, e.g. to rid the prototype of its biggest faults.

One of the main issues regarding the usability which participants observed when interacting with the prototype was the map material. A stiffer, yet still sustainable alternative needs to be found to give the map more stability. Furthermore, the map in its current state cannot be properly used when partially folded because of a high chance of tags overlapping and thusly interfering with each other. This will be fairly unpractical especially if the actual map is supposed to be bigger than the prototype. While it would therefore be good to find a way to have a kind of one-directional tag, it is not certain to what extent this is possible yet. The best solution here is also a stiffer map material that would allowed the map to be used completely unfolded and still be practical. A possible solution could be constructing a similar frame as used for foldable frisbees, which are made of a textile material, can be folded and when expanded still guarantee stability (see Figure 6.1).

Figure 6.1: Foldable Frisbee as a possible inspiration for solving the material issues identified in the study (floppiness of map). Source: `http://dinhinternational.com/products-promotional/foldable-frisbee.html`, viewed 14/05/2012

More thought should also be directed towards the green activity reward system, e.g. what kind of rewards could be obtained with the collected credits and possible motivation alternatives.

Regarding the actual test and methodology, it is probably advisable to review the questionnaire again, take out the question that asks if participants are likely to collect a paper map as it is not that relevant in relation to the overall goals, and maybe make some additional changes so the questions reflect the goals even more. It could be nice to expand the field study a little more, and e.g. let participants try out the prototype while walking through the city to see how they cope with various situations that require the map or guidebook app.

Overall, the results of the study reflect a positive response of participants towards the concept, which is encouraging and calls for more projects of the like, i.e. investigating the advantages of physical objects and UIs combined or augmented with digital content, as well as ways for ICT to help promote and achieve various sustainable goals across all kinds of different application sectors. The present study only reflects one of the many opportunities that ICT provides regarding the latter, but as section 2.3 shows, there are many more ways to raise awareness, change behavior or improve current products or services.

6.1 Future Vision

The author believes that great opportunities lie in the combination of tangible objects and digital content, especially in the sector of urban tourism where the physical map is likely to remain a collaborative artifact of importance and simple yet effective orientation device for many. Exploring this concept as a playful mean to promote more sustainable strategies for urban tourism was just one example of many possible scenarios. The playfulness and novelty of the technology are generally strong assets that could prove useful in other areas as well, for example to promote the 'family-friendly' way of visiting a city, the most active way of visiting a city and so on.

The digital component in addition to the tangible map leaves room for many different ideas, such as incorporating actual mobile games for each activity or additional socializing components that enable the sharing of experiences, e.g. in the form of photos, videos or more simple reviews, with other tourists, family and friends at home etc. The digital dimension also carries great potential for customization features that can add value to the tourists: they could create and dynamically update their own itineraries without losing either the tangible component of the map nor the possibility to make their own marks and notes on a paper map, whereas the latter also has the disadvantage of being mostly permanent, possibly resulting in a chaotic, barely readable collection of pen-marks all over the map.

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List of Figures

APPENDIX A

Concept

A.1 List of Copenhagen's goals as part of their 'Eco-Metropolis' vision stated in 2007. Adapted from: City of Copenhagen (2007)

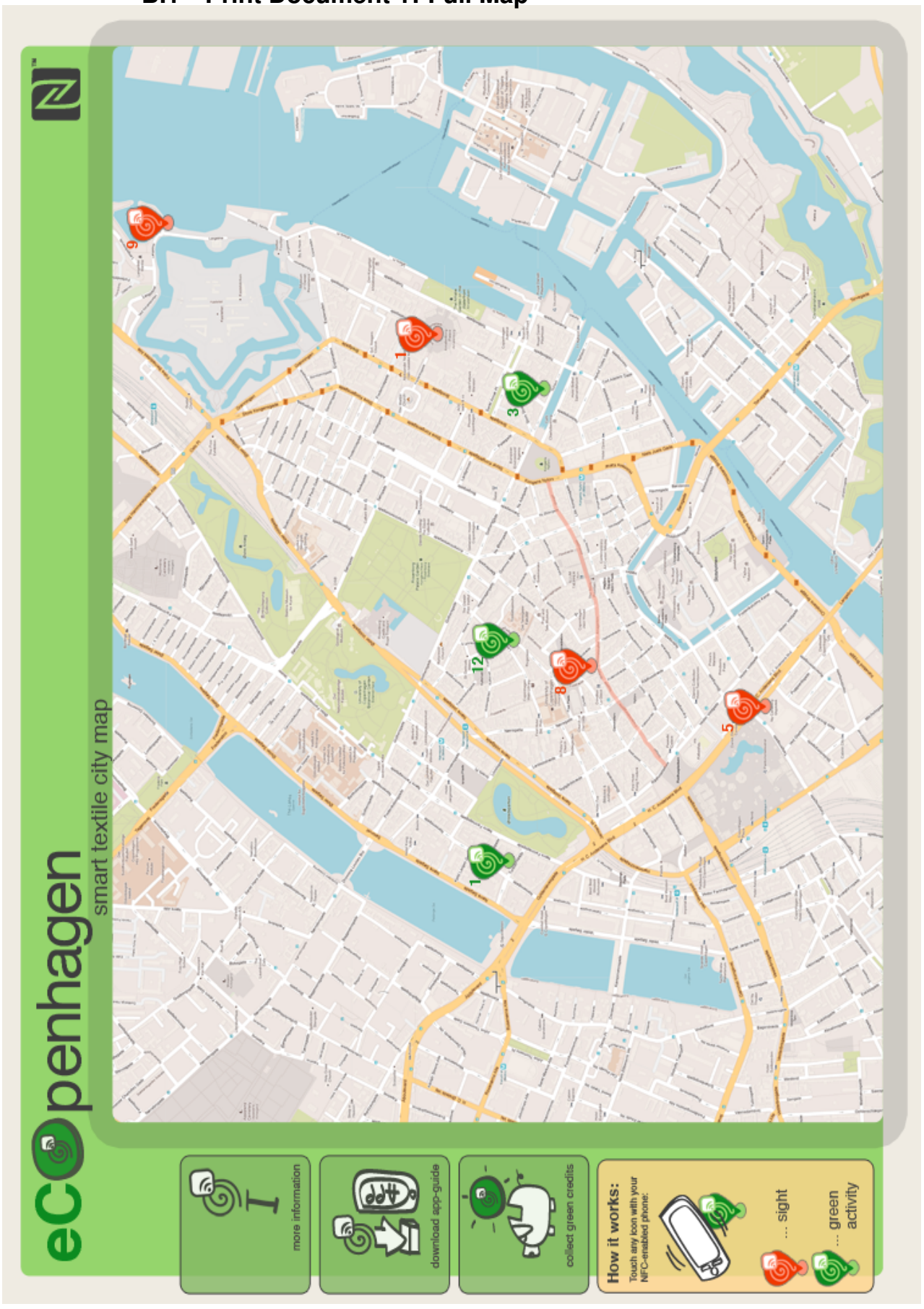
ECO-METROPOLIS OUR VISION CPH 2015

IN 2015	WHERE ARE WE TODAY?
AT LEAST 50 % OF PEOPLE WILL GO TO THEIR WORK PLACE OR EDUCATIONAL INSTITUTION IN COPENHAGEN BY BIKE.	36 %
THE NUMBER OF SERIOUSLY INJURED CYCLISTS IN COPENHAGEN TO BE HALVED COMPARED TO TODAY.	118 CYCLISTS A YEAR
AT LEAST 80 % OF CYCLISTS IN COPENHAGEN TO FEEL SAFE AND SECURE IN TRAFFIC.	58 %
A REDUCTION OF COPENHAGEN'S CO_2 EMISSIONS OF AT LEAST 20 % COMPARED TO TODAY.	COPENHAGEN EMITS A COMBINED TOTAL OF 2.4M TONNES (2005 FIGURES) = 4.9 TONNES PER INHABITANT
90 % OF COPENHAGENERS SHOULD BE ABLE TO WALK TO A PARK, A BEACH, A NATURAL AREA OR SEA SWIMMING-POOL IN LESS THAN 15 MINUTES.	ABOUT 60 %
COPENHAGENERS WILL BE VISITING THE CITY'S PARKS, NATURAL AREAS, SEA SWIMMING-POOLS AND BEACHES TWICE AS OFTEN AS TODAY.	TODAY, COPENHAGENERS VISIT THE CITY'S PARKS, NATURAL AREAS, SEA SWIMMING-POOLS AND BEACHES EVERY OTHER DAY, AND STAY THERE ONE HOUR ON AVERAGE.
COPENHAGENERS SHOULD BE ABLE TO SLEEP PEACEFULLY, FREE FROM NOISE HARMFUL TO HEALTH FROM STREET TRAFFIC. ALL SCHOOLS AND INSTITUTIONS SHOULD BE SUBJECT TO ONLY LOW TRAFFIC-NOISE LEVELS.	THERE ARE NO CURRENT MEASUREMENTS TAKEN OF TRAFFIC-NOISE LEVELS AT NIGHT. MEASURED ON A ROUND-THE-CLOCK BASIS, ABOUT 40,000 DWELLINGS ARE SUBJECT TO EXCESSIVE NOISE LEVELS. TODAY, ABOUT 10 SCHOOLS AND 20 INSTITUTIONS ARE SUBJECT TO NOISE FROM STREET TRAFFIC. EVEN MORE, HOWEVER, ARE ESTIMATED TO BE SUBJECT TO MORE THAN A LOW NOISE LEVEL, THAT IS TO SAY MORE THAN 55DB.
THE AIR SHOULD BE SO CLEAN THAT COPENHAGENERS' HEALTH WILL NOT BE DAMAGED.	LIKE THE VAST MAJORITY OF BIG EUROPEAN CITIES, COPENHAGEN ALSO FINDS IT DIFFICULT TO LIVE UP TO THE AIR QUALITY SPECIFICATIONS FOR NITROUS DIOXIDE (NO2) AND LARGE PARTICLES (PM10)
THERE SHOULD BE AT LEAST 20 % ORGANIC FOOD IN THE CITY'S FOOD CONSUMPTION.	ABOUT 7 % NATIONWIDE
THE CITY TO LEAD THE WAY WITH AT LEAST 90 % ORGANIC FOOD IN ITS INSTITUTIONS.	45 %
COPENHAGEN SHOULD BE EUROPE'S CLEANEST CAPITAL AND ONE OF THE CLEANEST CAPITALS IN THE WORLD. RUBBISH SHOULD BE CLEARED FROM PUBLIC STREETS WITHIN EIGHT HOURS.	COPENHAGEN IS RECKONED TO BE AMONGST THE TOP THIRD OF THE CLEANEST CAPITALS IN EUROPE. TODAY, IN THE INNER CITY, 36 HOURS ELAPSE IN SOME PLACES BEFORE THE STREETS ARE CLEANED.

APPENDIX B

Prototype

B.1 Print Document 1: Full Map



B.2 Print Document 2: Excerpt Map

B.3 N-Mark Trademark License Agreement

NFC Forum, Inc. N-Mark Trademark License Agreement

Schedule A
THE LICENSED MARK

Note: a high-resolution file of the Licensed Mark will be provided by the Forum upon execution of the Agreement

Schedule B
Requirements

Tags and Media:

1. Data on the tag must be stored in NDEF format, according to the requirements of the NFC Forum NDEF Specification and NFC Forum Tag Operation Specifications for the relevant NFC Forum tag type.
2. As allowed in the NDEF Specification, the data type of NDEF records included in an NDEF message may be described using Internet content type identifiers, URIs, or NFC Forum RTDs. If an NDEF message contains a record which uses the NFC Forum Well-Known or NFC Forum External type name formats (i.e. has a TNF field value of either 0x01 or 0x04), the type field value must conform to the requirements of the NFC Forum RTD Specification.
3. If a used type field value is a well-known RTD value, the content of the record and record header fields must additionally conform to the requirements of any specifications controlling the use of that well-known RTD value (e.g., NFC Smart Poster, NFC URI, or NFC Text RTD Specifications).

Specifications

1. NFC Data Exchange Format (NDEF) Technical Specification
2. NFC Record Type Definition (RTD) Technical Specification
3. NFC Forum Type 1 Tag Type Operation Specification
4. NFC Forum Type 2 Tag Operation Specification
5. NFC Forum Type 3 Tag Operation Specification
6. NFC Forum Type 4 Tag Operation Specification

Note: The Specifications can be downloaded free of charge from the Forum website at http://www.nfc-forum.org.

Software and Devices:

The NFC Forum enabled device shall fulfill all the functionality listed in Section 4 of “NFC Forum Device Requirements” document, which is available at http://www.nfc-forum.org/certification/certification_documents/.

Schedule C
BRAND GUIDE

Note: The current version of the NFC Forum Brand Guide, as amended from time to time, can be downloaded free of charge from the Forum Website at http://www.nfc-forum.org/resources/N-Mark/brandguide.pdf.

APPENDIX C

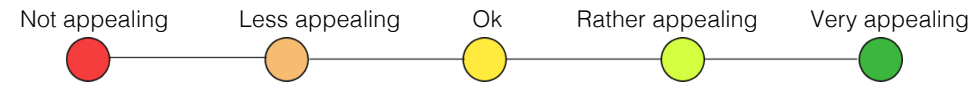
Pilot Study

C.1 Pilot Study Questionnaire

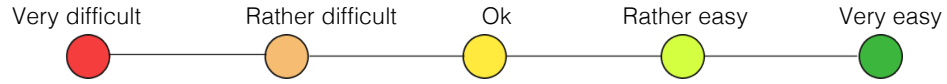
eCopenhagen

Feedback

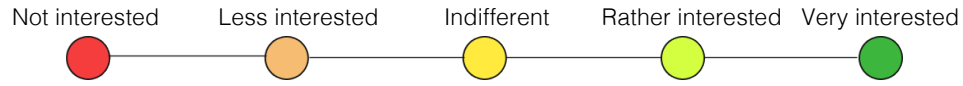
1. How appealing did you find the **design** of the app and mobile application (e.g. color scheme, graphics, text size)?



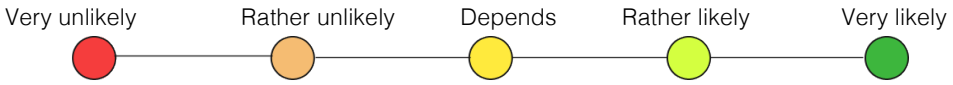
2. How difficult or easy was it to use the map and application?



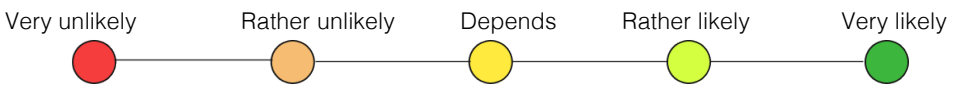
3. How interested are you in green urban tourism and engaging in 'green activities' during your stay in Copenhagen?



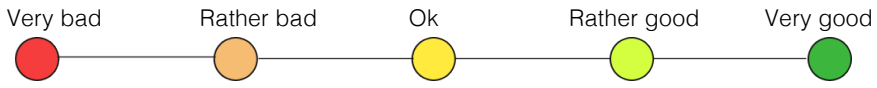
4. When you visit a city, how likely are you to collect a paper map at the local tourist office?



5. If you could rent the textile map at the tourist office (assuming you had this kind of phone), how likely would you be to **rent it instead of taking a paper map**?



6. How do you rate the overall idea?



C.2 Statement of Informed Consent

Statement of consent for participation in Prototype Evaluation

This is an evaluation of a physical mobile interaction prototype consisting of a tangible map and a mobile application. The prototype was created as part of a Master's Thesis (study programme: Medialogy, Aalborg University Copenhagen).

Your participation in this evaluation includes:

– Exploring the prototype in the presence of an observer.

– Answering a questionnaire.

– Interview with audio recording.

The results will be used to analyze the value of the prototype.

The audio recordings ,questionnaire answers and observation notes will be used in the work related to this Master's Thesis and possible future related research. The footage might be referred to in the documentation of the work, **but no names will appear**.

By signing this contract I declare myself in agreement with the above conditions.

_____ _____

Date Signature

Thank you for participating!

C.3 Pilot Study Transcript

Pilot Study Transcript

User 1: female, 24 years, German, M.Sc. student

I = Interviewer, U = User

Remarks during operation:

U: Bisschen umständlich zu halten. It's a bit tricky to hold.

Observations: Had problems to hold the map and the phone at the same time.

Didn't fully unfold the map at first which caused problem because tags interfered with each other. Interviewer intervened and advised to unfold the map.

Phone went into standby which caused confusion.

Interview:

I: Was gefällt dir am visuellen Design am Besten? What do you like best about the visual design?

U: Ich find die Grafiken cool. Ja. Also ich hätte jetzt gesagt auch beim Design find ich das auch gut dass auch so viele Informationen dazu stehen. Find ich auch gut. Aber ist ja jetzt nicht wirklich Design dann. I find the graphics cool. Well and I would say that I find it good that there is so much information available. But that doesn't really regard the design.

I: Nee aber das macht ja nichts. Und die Textgröße ist in Ordnung? No, but that's not a problem. And the font size is ok?

U: Ja. Yes.

U: Man kanns im Homeverzeichnis wiederfinden und des ist halt so ne Übersicht. One can find things again also through the home screen and that provides kind of a nice overview.

I: Und warum jetzt nur ok in Sachen Schwierigkeitsgrad? And why only an „ok" in terms of ease of use?

U: Wenn man halt auf den Sensor mit dem Handy das abtasten möchte ist es halt problematisch weil die map sich bewegt. Wo man manchmal halt nicht direkt so drauf kommt. Würd ich sagen. When you want to touch the sensor with the mobile phone it's problematic because the map is moving. You sometimes can't quite figure out how to select something.

I: Ok das war die größte Schwierigkeit? Ok so that was the biggest challenge?

U: Ja. Und weil die halt dann verweht war und dann man nich richtig hinkam. Yes. And because the wind kind of got in the way and you couldn't really reach the tag anymore.

I: Ok, dann, und... was müsste man tun, um dich noch mehr für grünen Tourismus zu begeistern? [Pause] Oder woran liegts? Ok, so, what would have to be done to get you to be even more enthusiastic about green tourism?

U: Lange Pause. Long pause.

I: Wenn du jetzt nichts weißt machts auch nichts. Wir können auch zur nächsten Frage übergehen. If you can't think of an answer that's ok. We can move on to the next questions.

U: Ja, bitte. Yes, please.

I: Ja, du hast jetzt gesagt, du bist, du nimmst dir meistens auch ne Papierkarte mit. Yes, you indicated that you often collect a paper map.

U: (Zustimmendes) Mhm. (Agreeing) Mhm.

I: Ähm, wie lange hält die so in der Regel? How long does it usually last?

U: Einen Tag. Durch den Wind, durch was auch immer, wird die sehr schnell zerstört, ja. One day. With the wind and whatever, it gets destroyed quickly, yes.

I: Und dann würdest du auch noch andere Karten im Laufe des Besuchs...? And do you pick up more maps throughout the rest of your stay?

U: Ja. Yes.

I: Jeden Tag ne neue quasi? A new one each day?

U: Ja. Sozusagen. Aber obwohl die eine hab ich jetzt auch schon etwas länger. Yes. You could say so. On the other hand this one I have now has already lasted a bit longer.

I: Und ähm ja würdest du auch gerne dann so eine Karte ausleihen wenn das Konzept dementsprechend gut ist? And would you rent such a map if the concept was respectively improved?

U: Ja. Müsste man halt nur wissen an welchen Stellen... Am besten in Hostels! Da sollte man das verteilen. Yes. One would have to know where to get them. Hostes would be good. They should distribute them there.

I: Und wie viel würdest du am liebsten maximal dafür ausgeben? And how much would you be willing to spend on it?

U: [denkt nach] [thinking]

I: Oder eher gegen Pfand? Or rather in return for a deposit?

U: Gegen Pfand. For a deposit.

I: Und was gefällt dir am besten an der ganzen Sache? And what do you like best about the whole concept?

U: Ich finde die Informationen über die einzelnen Gebäude und Sehenswürdigkeiten. Das geht schnell, man kann das schnell nachschauen. Die einzelnen Infos. Ohne lange da irgendwie durch einen Reiseführer zu blättern. I think the information you get about the individual builings and sights. It's fast and you can quickly look it up. The individual pieces of information. Without having to skim through the whole guide book each time.

I: Und äh was müsste es noch haben um ne 5 zu kriegen dafür? And what needs to be improved in order for you to give the concept a 5?

U: Ja das bisschen bessere Handling. Würd ich mal sagen. Yes the better handling (of the map) I would say.

I: Ok, alles klar, dankeschön! Ok, thank you!

User 2: female, 23 years, German, M.Sc. student

I = Interviewer, U = User

Recording was lost.

During explanation:

remark on where users could use the credits they can collect. What about sights can you use them there?

During Operation:

Interviewer noticed that she had to set bags down before she started the test. She also angled her knee/ prop on stairs so she could place the map on the knee to use it.

Pilot Study Transcript

Looked through the app first without using the interface.

Irritated by the fact that in the app all the menu items were selected at some point.

Couldn't find the sensor right away. Interviewer showed it after some confusion and failed selection attempts.

Held phone upside-down to select icons.

Remark: I think the "find route" option is really neat.

Interview:

I: Visual Design of Interface, i.e. map and application? (when i first used the word interface, there was confusion about what is meant by that)

U: Like the unique design of icons. Especially in the app. It's different to the standard buttons you usually see.

I: What were the difficulties?

U: You need 2 hands. I had to set down my shopping bags to use it. But in a way you need to hands if you wanted to hold a guidebook and map at the same time, too. Would be nice to be able to hold the map in place better. Fixate it somehow. Maybe on a book-cover, cardboard-like surface.

I: What about the green activities?

U: Didn't know about Copenhagen being a green city before. That they have all these initiatives.

I: Do you think this kind of technology can spread this green spirit among tourists?

U: Yes definitely. It's a new, innovative idea that is interesting just from the technology and interaction point of view. And to use something like this which I feel people would enjoy to use will definitely promote green tourism.

Pilot Study Transcript

I would really like to participate in green activities and I think it's nice to have them on the map so I can know about them. Now I wouldn't know such things existed or how to find them.

I: Would you like to engage in green activities in other cities you visit as well?

U: Yes definitely.

I: How long do paper maps usually last during your stay?

U: paper maps don't last more than a day. I would say I use at least but often no more than 2 maps per city vacation.

I: How much would you be willing to rent it for?

U: I would definitely rent it. For max. 5 Euros. Or in return for a deposit.

I: How did you like the idea overall?

U: Overall, I think it's a very nice idea. I really like the design and the green aspect. It's still hard when you are walking to have both the map and the phone operating without problems. Could be problematic with rain and more wind. Is it waterproof?

I: The textile material is. The tag will be once it can be sewn into textiles.

(*U:* I like how they have these city bikes with the maps in front where the handles are. That would be a nice place for the map. But then I guess it's not good to ride the bike and read the map at the same time)

APPENDIX D

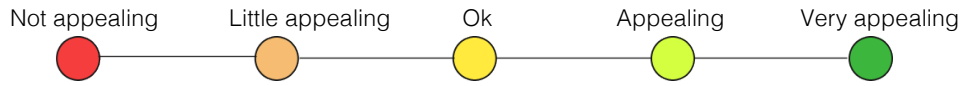
Final User Study

D.1 Final Questionnaire

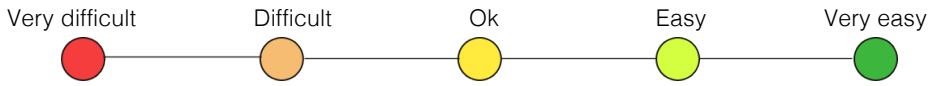
eCopenhagen :: Feedback ::

Age	Gender	Nationality	Occupation

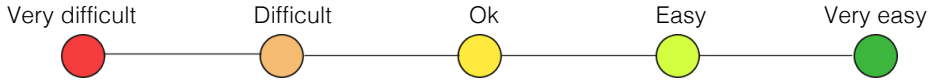
1. How appealing did you find the **visual design** (e.g. colors, layout, text size)?



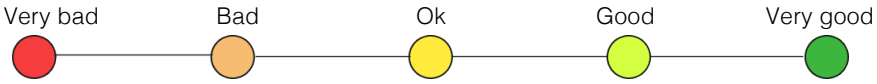
2. How difficult/ easy was it to understand the **functionality of icons and buttons**?



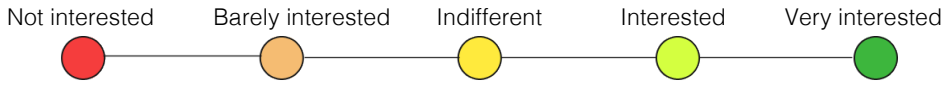
3. How difficult/ easy was it to use the map and application **together**?



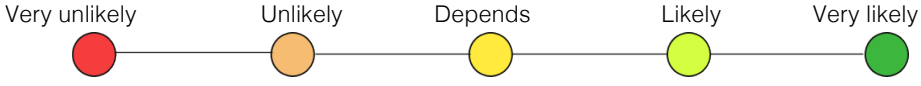
4. How do you rate the overall concept of having **both a physical interface** (map) **and additional digital content** (mobile app)?



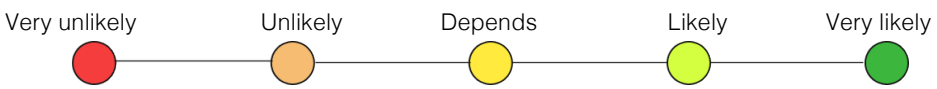
5. How interested are you in **green urban tourism and 'green activities'** when visiting a new city?



6. When you visit a city, how likely are you to **collect a paper map**?



7. If you could loan such a textile map (assuming you had this kind of phone), how likely would you be to **loan it instead of taking a paper map**?



Questionnaire Results Main Study

					Usability		Tangible&Digital		Green Strategies	Paper Map	Adaption
User	**Age**	**Gender**	**Nationality**	**Occupation**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**
U1	24	F	Germany	Student	4	5	3	4	5	5	4
U2	24	M	Germany	Student	4	5	3	3	4	5	5
U3	23	F	Germany	Student	5	5	3	4	4	5	5
U4	27	M	Germany	Student	5	5	3	3	4	5	3
U5	34	F	Albania	Artist	5	5	5	5	5	1	5
U6	26	M	Sweden	Carpenter	3	4	3	3	4	4	5
U7	32	F	China	Project Manager	5	5	5	4	4	4	3
U8	22	M	Australia	Student	4	5	5	5	4	5	4
U9	23	M	USA	Student	4	4	2	4	4	4	3
U10	24	F	Finland	Student	3	5	4	4	2	3	4
Means	27,4	F			4,4	5	4	4,2	4	3,6	4,2
	24,4	M			4	4,6	3,2	3,6	4	4,6	4
	25,9	All			4,2	4,8	3,6	3,9	4	4,1	4,1
					4,5		3,75		4	4,1	4,1
Std. Dev.					0,788811	0,421637	1,074968	0,737865	0,816497	1,286684	0,875595
Percent		50%	40% German	70% students							

D.3 Pre-defined Interview Questions

eCopenhagen :: Interview ::

1. How appealing did you find the visual design (e.g. colors, layout, text size)?

What did/ didn't you like?

If you could change/ add something, what would it be?

Did you like/dislike the map and application equally much?

What's your favorite/least favorite element of the design?

2. How difficult/ easy was it to understand the functionality of icons and buttons?

What in particular didn't you understand?

If you could change/ add something, what would it be?

Did you feel the same about the map and the application? Was one of the two (map & application) better/worse to understand?

What's your favorite/least favorite element of the navigation?

3. How difficult/ easy was it to use the map and application together?

What caused the most difficulties?

Which task was the easiest/ hardest to accomplish?

Do you have some ideas on how to improve the system to overcome some of the challenges?

4. How do you rate the overall concept of having both a physical interface (map) and additional digital content (mobile app)?

What do you like/dislike about it?

Do you think this method is more fun than the all digital/ all physical?

Which of the three methods do you find the most practical as a tourist:

- paper map and guidebook
- digital map and guide application
- physical map and digital guide?

Why do you prefer this method?

5. How interested are you in green urban tourism and 'green activities' when visiting a new city?

Do you feel like there is a need for promoting green tourism?

Do you think you would be more motivated to pursue green activities if you can collect credits than if there wasn't such a feature?

6. When you visit a city, how likely are you to collect a paper map?

How long does it last?

Do you usually collect more than one map during a stay?

How do you dispose of the map (recycling Y/N)?

7. If you could loan such a textile map (assuming you had this kind of phone), how likely would you be to loan it instead of taking a paper map?

What would be your personal motivation to loan such a map?

Would you loan it if you didn't have the phone?

Why/ Why not?

D.4 Qualitative Content Analysis of the conducted interviews

Qualitative Content Analysis

Category/User	+	Neutral	–
Usability: Visual Design U1	it's really nice that the information buttons are a little bigger than the rest and that they are of the size so that you can see them better. Design of map and app was fine		The font is not very readable
U2	visual design the color and font size and so on was ok		button layout was kind of kind of strange [in app] There was huge space above the buttons which was not used. There was a lot of empty space on the right corner. Somehow use the whole screen
U3	I found it very **clear**.		
U4	It's **clear**, it's easy to understand the design is **good**, wouldn't change anything		
U5	It's easy to understand and it's **nicely made up**. So it's friendly to the eye. **Not too overwhelming** with the information It was really **cool**.		
Usability: Ease of Use U1	It was **clear how to use the map**, nice navigation It was **pretty nice and you could just hold it on the place where you want to go and then it pops up on the phone**		
U2	**Easy** Likes **easiness of the usage** of the map but also		
U3	It was **understandable**	I just didn't know that I had to press there again but after all that's because I didn't know the phone before. So if I knew the phone, I would know what to do. In terms of that I had to press something on the screen to go back to a new point.	

U4	**idiot-proof**, if you ever got lost in the navigation you simply chose a new icon and you are at the right place amazing **how well it works** everything was fine. Likes navigation on app, so I can find the paths to the thing I want to visit. I found that generally, it **worked very intuitively**. both the interplay of map and app as well as the operation of the app as such. everything **works very very well**		
U5	And then (after she knew how everything worked) it was **pretty easy to use** afterwards. the moment you learn how to do it right then **it's easy**. This was **easy**.	I just needed to know how it worked.	
Content U1			
U2			
U3	I thought the routes, so the localization and displaying where I want to go was rather good. And that opening hours are displayed. Likes to have opening hours		
U4	**Green aspect**		
U5	the **green point** activities. Practically all the information you can get through your phone. That was pretty smart. gives all a map is supposed to give. A map is supposed to give information in an easy way and understandable way so everything was fine.		
Usability: Problems with Material U1		You can't really make this harder because then you can't fold it any more. And that would be annoying.	hard because of the **wind**, the map was flying around because **it's so thin**. (mentioned 2x)
U2		Perhaps **stiffen** the map up a little bit.	Handling was difficult, using both parts together. Because you need some kind of surface to place the map on. That is the most

			difficult thing I would say. Yeah you have to hold the map and simultaneously place the phone over the right area. That was kind of tricky. But it's manageable.
U3		take a **stiffer map**	The only difficulty was, that the map was a bit **floppy.** So maybe something else there, if possible, maybe a **harder** material or so. If there is something like that available. Difficult to hold the map in place against the **wind**.
U4		I don't know if it's possible to make the map out of a different material so that it's **more stable** like it's the case with the average map.	**very floppy** so that with the map in one hand and the phone in the other, I had to coordinate that with both hands and especially with the **wind** that becomes very very problematic.
U5			
U10	I like the material reminds me of FedEx envelops. i used to cover my school books with the material		
Tangible Map **U1**	I like having a physical map because there is it's usually a bigger... you usually see the bigger picture. And on a mobile phone application you just see a little part of where you want to go.		
U2	I'm more the map kind		
U3	I find it great that you simply have it in your hand and that you can change the orientation yourself if you get lost and I think the mobile phone would always turn back/rotate the screen automatically and that would be tiring I think. And here you can determine the orientation/ direction yourself.		
U4			
U5			I mean I cannot read a normal map. Yea I'm too dumb for that.
Combination Tangible & Digital **U1**	it's nice to have this phone, application because then **you can look stuff up and you know about the place where you want to go.** It would probably be **nice to try** this one out and see how it goes.	I just used it [app] in combination with the map. I can't really decide [which version she prefers]	
U2	I like the idea of **getting additional information if you need them** I think the idea is quite good	I would probably use the map alone more often.	

	Likes the **additional infos** if you need them to some certain points. So you keep the map quite clear and just get the information if you need them. **It's more fun to use than** the all digital or all physical version I think I **have to use it for a little while** but at the moment I would think [I prefer] the mixture. Of both. [over digital and all physical] just like the idea of having a physical map and if I need them or f I want to have them to certain points the **additional information.**		
U3	I actually find it rather good. Because otherwise if you didn't have **the information** at the current location one would after all also have to take out the guidebook and the mobile phone is more practical. find this version better [over all digital/all physical] because I like to be able to have/hold it in my hand. **Good that infos are available** even if I didn't have my guidebook		
U4	**Maybe it could be more fun** if I see on the map that there are other green activities so I will look which ones there are If I had the phone **I would try this combination** interplay of the map on the one side and also the app in the background that I **can link to additional things. That I can get additional information beyond the map.**		I'm not sure if there is a need for this combination. Since often when I'm out with my phone I can just look things up on the internet and still gladly have a physical map in my hands. I would choose the physical [regular] map mm because I couldn't use these maps on my phone.
U5	it's a great idea and it's time-saving so that's the most important part I guess for a newcomer in a new city- you want to visit in the easiest way and that makes it possible. Absolutely **more fun** than regular methods	If I had to rank them then it would be first everything on the phone, and then the phone and map combination, and then the last one the map: I guess it's more the practical thing. I mean if you kind of lose the map or if you kind of ruin it somehow or so I guess that would be that.	

More Sustainable Urban Tourism U1	[green tourism] is a great thing because you can just **make people aware** of what's around them and how to be a little greener and save the environment.		
U2			Little to less interest in green tourism Not really a need to promote green tourism
U3	I find it interesting that you're not so fixated on mass tourism… Instead you can do more sustainable things, maybe some small insider Tipps, from small businesses or about smaller events that are happening. **Definitely important** that this kind of initiative is supported		
U4	**There is a need** of course. And green tourism I think will be a big thing in the future in the next five or ten years.		
U5	**There is a need:** Most people don't know, so it's a matter of... yea, the **more people know about it** the more would take advantage of it and use it. And everything so definitely, yea.		
Concept as Marketing Tool for Green Tourism U1	If you are here longer and know how to use those credits then [the credit system] might be nice.		if you were just in a city for a short time [the credit system] probably won't make any difference.
U2	[**motivation** for pursuing green activities with credits over no credits] **Depends** on how you could use the credits I think. If you get a free drink or something then definitely.		
U3	I **can imagine well that one could utilize** that **[to motivate]**. Especially since most people do use such a smart phone or have it and such a map that you don't necessarily throw into the next corner is maybe also a nice thing.	you have to think of a system to motivate people to return the map. Because some people would probably try to keep the map and be too lazy to return them at the information centre. That somehow there is a reward for returning the map. Maybe some kind of discount. Or that one could return it at other places as well. Maybe at those stations that are marked on the map. some people would like to just keep the map at home for themselves that way.	

U4	Thinks people **would be more motivated** in general if there was things, strategies or promotions like this to participate in green tourist activities. **If you see there are other green activities I can do in the city then I will have a further look at them.**		
U5	**More motivating** because it **is just right in front of their eyes, it's tempting you know.** Like you kind of get the information and then you say 'why not, let's try that' so it's definitely, yes.		
Willingness to Adapt U1	I think it **would be nice to see those green locations**. And have a look at what they are offering [without having a phone] you **could see where the green activities are** and just go there so it would be nice to use this map, too.		
U2	If I have the cool (?) device I think I would loan it.	No phone: Then I don't think there I any use. Or probably both maps would **serve the same features** and I don't see the reason not to but I don't also neither see the reason to.	
U3	Would loan it because of additional information, e.g. opening hours and no need for guidebook		No phone: then I probably wouldn't loan it **because I can just as well take one of the others.** And that would almost bet he same then using the other map. Only that I would have to give it away afterwards.
U4	maybe I would try it out **because of the green aspects** behind this.		No phone: wouldn't loan it. after all the **functionality kind of goes away** then.
U5	I think it was a genius idea. It worked fine for me. I would definitely use it getting to see the more of it. I mean use the time wisely and nicely and yea I mean do as much as I can. Within the timeframe available. And that definitely helps. No phone: I absolutely would [use it]. I would buy it if I had to Cause it's easy to use I find, Even if I didn't have the phone to read all the information the map gives I found it easy to use. I mean sometimes it has so many signs in it and symbols in it and I simply get lost. This one was easy.		