TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

ANTTI JÄRVI

DESIGN AND IMPLEMENTATION OF AN NFC-BASED MOBILE INTERACTION CONCEPT FOR A SMART BULLETIN BOARD

Master of Science thesis

Examiner: Professor Kaisa Väänänen.
Examiner and topic approved in the council meeting of Faculty of Computing and Electrical Engineering on 7 October 2015

ABSTRACT

TAMPERE UNIVERSITY OF TECHNOLOGY
Master's Degree Programme in Pervasive Computing
Antti Järvi: Design and Implementation of an NFC-Based Mobile Interaction Concept for a Smart Bulletin Board
Master of Science Thesis 44 pages, 5 appendix pages
October 2015
Major Pervasive Computing
Examiner: Professor Kaisa Väänänen

Keywords: User experience, public display, bulletin board, NFC interaction, gesture-based interaction, user evaluation

Tampere railway station area is going through a renovation in following decades and thus it is a relevant time to research possibilities to improve the area with smart city technologies. KÄPÄLÄ project which is a collaboration of Tampere University and Tampere University of Technology focusing on smart city technologies initiated a research towards innovative service concepts on railway station area. This thesis describes planning, deployment and evaluation of prototype system titled Smart Bulletin Board which is an electronic Bulletin board with motion detection and NFC interaction which was concluded to be suitable topic of research.

The aim for this thesis was to test the SBB concept's user experience and appeal, map possibilities and problems encountered in the deployment of public display system utilizing motion detection and NFC interaction. The goal is also to explore if the NFC technology is suitable and novel technology to act as a data transfer bridge between public display and personal smartphone. This thesis consists of literary review, description of design and implementation phases and two user evaluation studies.

The results of the research suggest that there is promise for the SBB concept as user experience for the system was prominently positive. The user evaluations uncovered multiple interesting usability problems related to combination of public display system, NFC and motion detection interaction which could be researched further.

The results of this thesis could be used by parties planning to implement a public display system or parties involved with NFC or motion detection controls to gain insight on issues related to their usage on public setting.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO
Tietotekniikan koulutusohjelma
JÄRVI, ANTTI: NFC-Teknologiaan Pohjautuvan Älyilmoitustaulun Konseptin Suunnittelu ja Toteutus
Diplomityö, 44 sivua, 5 liitesivua
Lokakuu 2015
Pääaine: Pervasive computing
Tarkastaja: Professori Kaisa Väänänen

Avainsanat: Käyttäjäkokemus, julkinen näyttö, ilmoitustaulu, NFC-vuorovaikutus, eleohjaus, käyttäjätesti,

Tampereen Rautatieasemanseutu käy tulevina vuosikymmeninä läpi huomattavia muutostöitä ja siksi aika on kypsä tutkia miten asemanseudun uuteen infrastruktuuriin voisi soveltaa älykaupunkiteknologioita. Tampereen yliopiston ja Tampereen teknillisen yliopiston älykaupunkia tutkiva yhteistyöprojekti KÄPÄLÄ suorittaa tutkimusta kehittääkseen asemanseudulle uusia innovatiivisia palvelukonsepteja. Tässä Diplomityössä kuvataan Älyilmoitustaulu nimisen järjestelmän suunnittelu, toteutus ja käyttäjätestaus. Älyilmoitustaulu on eleohjausta ja NFC-pohjaista vuorovaikutusta hyödyntävä elektroninen ilmoitustaulu, joka valittiin KÄPÄLÄ-projektin yhdeksi tutkimuskohteeksi.

Tämän diplomityön tavoite oli testata älyilmoitustaulun käyttäjäkokemusta sekä vetovoimaa, tutkia mahdollisuuksia sekä ongelmia mitä kyseisen kaltaisen eleohjausta sekä NFC-vuorovaikutusta sisältävän järjestelmän käyttöönottoon sisältyy. Tavoitteena oli myös tutkia onko NFC-vuorovaikutus sopiva ja uutuusarvoa tuova teknologia puhelimen ja julkisen näytön välillä. Diplomityö sisältää kirjallisuuskatsauksen, kuvauksen järjestelmän suunnittelu- ja toteutusvaiheista sekä kaksi käyttäjätestiä.

Diplomityön tulokset ovat kannustavia tulevaisuuden kannalta sillä järjestelmän käyttäjäkokemusta koskevat testien tulokset olivat suurelta osalta positiivisia. Tutkimuksessa selvisi useita kiinnostavia käytettävyysaspekteja, jotka liittyvät diplomityössä tutkittavan julkisia näyttöjä, NFC-teknologiaa ja eleohjausta yhdistävään järjestelmään.

Tämän tutkimuksen tuloksia voidaan käyttää apuna julkisia näyttöjä sisältävän, NFC-vuorovaikutusta tai eleohjausta sisältävän järjestelmän suunnittelussa ja toteutuksessa.

CONTENTS

1. INTRODUCTION

Tampere railway station area is going through major reconstruction in the following decades. Since the construction has not started yet it is an optimal time period to research how to improve the railway station experience and implement smart city services to the area. Tampere railway station area has many challenges regarding the experiences provided by the area (Väänänen-Vainio-Mattila, et al., 2014). These include improving knowledge of surrounding events and services and improving the overall entertainment value of the railway station area. The system chosen to be implemented and researched in hopes of improving the experiences of the railway station area was Smart Bulletin Board (SBB). An interactive public display system with motion detection controls and NFC-Interaction. NFC-interaction was chosen to be a part of the system because of the rising popularity of the technology (IHS press, 2014), the novelty value and the suitability to the bulletin board concept.

ISO standard defines smart city as system of systems where the "smartness" means an ability to bring together all its resources, to effectively and seamlessly achieve the goals and fulfil the purposes it has set itself. Or in other words how the city's systems work individually and synergize with each other. (JTC, 2014) SBB system is a prime example of smart city service information distribution, and ubiquitous data transfer in public place so exploring similar *Smart city services* is relevant in this work.

Public displays are by definition displays located in public places displaying information. However they are still mostly used for commercial purposes and noninteractive information broadcasting (Boring & Baur, 2013) (Ojala, et al., 2010). Commercial content tends to cause display blindness meaning that people don't focus their attention towards a public display because the users expect the content of the display to be uninteresting (Müller, et al., 2009). We aim to overcome this effect by providing the users a way to publish their own content, search for content that interests them and keep commercial material to minimum.

Near Field Communication technology (NFC) is a short range wireless data transmission technology. It was chosen to be used in this project for its rising popularity in smartphones (IHS press, 2014). In traditional interactive public display systems the NFC-technology has been mainly used for user identification or pairing the mobile device with the public display (Ojala, et al., 2010). In this project we hope to achieve novelty value and

experiment with new ways of utilizing NFC-technology by using it as a data transfer technology between the user's phone and the SBB system.

This thesis is based around Käpälä project which was a project conducted by Tampere University of Technology and University of Tampere. One of the projects objectives was to perform research about smart city services. This thesis is a part of Käpälä project and its goal is to implement a prototype based on the Käpälä project findings and conduct user evaluation on the said prototype. The decided topic for prototype was Smart Bulletin board. The board in question is an interactive public display which implements traditional notification board functionality electronically with motion detection controls and NFC technology based interaction. NFC is used for uploading and downloading information elements from the board and motion detection controls for actual manipulation of the display data. This topic was chosen because it fits several themes discovered in Käpälä projects smart city research. These themes include: Crowdsourcing, visibility of events, discovery of services and locations and interactive waiting hall for Tampere railway station. The SBB also tackles many of the challenges found in Käpälä project related paper (Väänänen-Vainio-Mattila, et al., 2014) such as improving knowledge of surrounding events and services and improving the overall entertainment value of the railway station area.

The goal for this thesis is to test the SBB concept's user experience and appeal, map possibilities and problems encountered in the deployment of public display system utilizing motion detection and NFC interaction and explore if the NFC technology is suitable and novel technology to act as a data transfer bridge between public display and personal smartphone.

The research provided a working prototype of the SBB system and the results showed great potential in the SBB concept and we found multiple points of improvement and problems related to the concept. Due to bureaucratic problems, The Prototype of the system could not be deployed to actual long term testing to public place. To get more comprehensive results on long term behavior of the system and user interaction a continuation is necessary.

The structure of this thesis is as follows. In chapter 2 the related earlier studies are addressed. Chapter 3 describes the motivation, requirements, users, context and the design decisions of the SBB in depth. In chapter 4 the software architecture of the system as well as technologies used, external software modules, the hardware required for the system and challenges faced during implementation. Chapter 5 describes the user evaluation methods, goals for the evaluation, description of participants of evaluation and description of the two distinct studies conducted during research. Chapter 6 contains

Results from the user evaluation divided into subsections: quantative results, Qualitative results, Attrakdiff and summary. Chapter 7 contains success of the project, discussion and summary of the results and future work.

2. RELATED WORK

There exists large amount of research about smart city services, public display systems and NFC-interaction. In this chapter most relevant studies are discussed in detail since these themes are the main research topics in this thesis. Studies included are divided into three subcategories: Smart city services for travelers, Public display systems and NFC-based interaction with mobile devices.

2.1 Smart city services for travelers

Since the SBB system described in this paper is a public display based system aimed to be located in a public transport hub in the related works we are going to focus on public information services, smart tourism and other smart city applications suitable to travelers or other public transport hub users.

Borrego-Jaraba et al. propose a NFC-based solution for helping tourists to find points of interest within the city and navigate through them. To achieve NFC based smart posters are scattered along the city and they can be accessed through user's personal smartphones. These tags contained information about the tourist attraction of the user's locations, general location information and information about nearby attractions. The aim is for tourists to be able to design their own route. User evaluation on the system yielded positive interest towards the concept. (Borrego-Jaraba, et al., 2011)

Mighali et al. introduce an Internet of Things concept with researching a system which enhances museum experience with smart technology. The key concept is providing users with additional information and experiences through their smart devices and the museum acquiring data from user's smart devices. The System aims to provide additional information about museum items automatically based on users location and trigger multimedia events around the museum such as animations. The system is still under development. (Vincenzo, et al., 2015)

Müller et al. have researched the conditions that cause users to engage in mobile device public display interaction. The research was carried out through two user studies investigating on a system providing support on pedestrian navigation. The research revealed multiple interesting metrics involved with public display navigation systems: The importance of situating the display in a way that it doesn't bother other people, Users don't observe the displays throughout the navigation, but instead at certain distinct route sections, displays should be located at direct line of sight and in the natural field of vision

of the user to increase its chances to be registered, to guide users attention between public display and a mobile phone is important to get most out of the system. (Müller, et al., 2008)

Kogan's thesis investigates success factors and challenges of smart city projects through comprehensive research of several case studies. The results suggest that the amount of ICT development is not as important in smart city project as citizen engagement. Other important factors are governance, ICT and Infra. However these factors are relevant only after the citizen engagement has been addressed. ICT and infra meaning the technological dimensions of a smart city including wireless Wi-Fi connectivity, sensor network, fast broadband etc. The technological dimension are however, only an enabling factor for success of smart city project. (Kogan, 2015)

2.2 Public display systems

Public display systems have been researched in abundance and here are presented the most relevant ones to this research which could be found.

Ojala et al. have conducted a large scale long time period research on the usage and user acceptance of multi service public display system called UBI-hotspot. UBI-hotspot system includes multitude of application ranging from City of Oulu information services to games like hangman. System also has applications requiring identification through RDIF distributed among volunteers. This research did not try to solve any particular problem but instead the focus was to gather data about user’s behavior and interaction with public displays in urban setting and recognize reoccurring patterns both in the display usage both indoors and outdoors. Research suggests that the popularity of the public display relays largely on the location. Most active use of the system occurred in locations where people were in a relaxed state of mind and spending time in general. Public transfer hubs had significantly less activity. Most popular services provided by UBI-hotspot were dynamic bus schedule, UbiPostCard: an application for sharing pictures taken by camera integrated to the public display and fun and games applications in general. (Ojala, et al., 2010).

Wouters et al., have conducted a research of deploying interactive public displays in three different communities around the city of Antwerp in Belgium inspecting how the display system will affect said communities by providing new public forum for the people. However the content of the board was published by the owners of the establishments the displays resided in. Focus of the research was to examine the effect of community created content to the community and the participants. The test was conducted by installing public displays in urban area apartment windows for a total of 21 days. The research suggests

this way of social interaction is quite similar to social media services like Facebook the difference being that the social network around public display is determined by its location and because of that the content management should be distributed among community members to sustain interest towards the public displays. (Wouters, et al., 2013).

Another research on public displays effect on the community was performed by Jurmu et al., The focus of the research was investigating how an interactive public display impacts community's activities and how it performs as an extension of existing communication channels. The display was located in student guild's room in the University of Oulu. The research included a pre-study on user group's communication channels and based on that the community members can post pictures and other content to the screen remotely through IRC protocol. The content could be then manipulated through the displays touch screen. Results suggested that there is strong locative factor in image uploading with public displays meaning that even though there is a remote interaction possibility on the system users tend to forfeit it and only interact with the display while on the physical location of the device. The understanding and participation of community is a key factor in deploying new technology for community members as well as the flexibility in design. (Jurmu, et al., 2014)

Schroeter et al., researched community engagement through a public display system in Melbourne Australia. The aim for the project was to identify characteristics involved in deployment of the system named DIS. The DIS system included a public display in an urban environment and a multitude of digital interaction ways such as Twitter, SMS or mobile web interface. During the research public displays were launched in variety of events and locations such as the research suggest a holistic scale on identifying different design contexts for which a public screen application has to be tailored for. The research concludes that to engage users to commit meaningful and high quality content to public screens the screen has to be tailored according to the context it will be deployed in a variety of ways including content, features, devices, physical location and hardware. (Schroeter, et al., 2012)

Churchill et al., conducted a long term research on interactive public displays effect on organization environment. System which was researched upon was called Plasma Posters and a single Plasma poster was a large touch screen placed in a public setting with the aim to enable multimedia information sharing. The Plasma Posters were deployed to the FXPAL software research company for 20 consecutive months. All of the interaction events were logged and later interviews were conducted on the community members regarding the Plasma Poster experience along with surveys and observations. The displays received constant use during the test period and the research was deemed

success. However the research suggests that this kind of information sharing should not try to replace existing content sharing means. The Research lists several points that led to the success of the Plasma Poster: participatory design, low effort of use, clear visibility of content author. (Churchill, et al., 2004)

Hosio et al., researched enhancing public display usage with social networking services. The research states that since social networking has already taken a huge role in communication between people it's natural to offer additional value to users through customizing public display content to according to their social networking profiles. During the 10 months data collection period when the displays were deployed to downtown Oulu. The display system is the exact same as in Ojala et al.'s research. The social networking services allowed users to publish various activities from the public display to their Facebook feeds and customize the public display content and visual look as they see fit. The research utilized long term quantative data gathering from the public displays and surveys conducted in public events. The results suggest that usage of this kind of display is rarely used alone and the services supporting multiple users at once were most popular. Other key findings were importance of user contributed content and the need to offer instant rewards to the users to make them utilize the displays again. (Hosio, et al., 2010)

Alt et al. conducted a research on shared notice areas with the ultimate goal of identifying factors on deploying a networked public display system. The focus of the research is exploring on how it could be possible to create a network of public displays that would promote user-generated content; Identifying and tackling problems rising from this kind of design from multiple stakeholder's point of view. The research does not focus on technical details but instead on the social and economic factors. During the research multiple public notice areas were analyzed continuously over 4 week period supplemented with interviews performed on the notice area users. The research identified different stakeholders for notice areas as well as many different types of notice areas. The design principles derived from the results suggest that the notice area system should be designed to fit the context and purpose of the arbitrary board, respect the neighborhood where the notice board resides, support disseminating information the notice board owners sympathize with, support multiple types of input and design to allow multiple types of posts and support take away of the information. (Alt, et al., 2011)

Memarovic et al. discuss a concept called interacting places in their research. The interacting places are public spaces that connect communities through a connected network of public displays. The focus of the research is on the feeling of connectivity among the community members in the communities between interacting places. The research tests two distinct approaches to achieving this: environment originating content

and people originating content. The research suggests that environment originating content is due to effect called ‘triangulation’ where a special feature of the environment stimulates content creation and discussion among community members and it can be stimulated by providing engaging features and content. The people originating content stems from the community’s believes and values and it can be stimulated by providing official information from the community authority, information about significant topics for the community, community events and interests or community contributed content. (Memarovic, et al., 2011)

One interesting aspect of public displays was observed and researched by Muller et al., The feature is called display blindness and it means the effect that people tend to ignore public displays based on their expectations on the display content. The research group conducted two user tests focusing on different aspects of display blindness phenomenon. Results suggest that indeed this phenomenon does exists partly stemming from the negative expectations public displays have achieved. The most important factor in avoiding the display blindness is to research the audience’s expectations and provide content accordingly. Other factors are things like colorfulness, animation and general visual appeal. (Müller, et al., 2009)

FCT4U system was another concept based around the interaction between mobile device and a public display. Public displays identify the users of the system through Bluetooth connection after they have created personal account. This identification allows public displays to show personalized information for the user. FCT4U supports multiple user interactions with reactive layout and content. The content itself consist of different widgets including weather, news and lunch menus of the university the system was deployed in. The interaction of the system works two ways: the public display can be controlled via the android application and in the case of touch screen display the touch screen interaction updates the view of the smart phone application vice versa. The results received from user study performed to the system suggest that the preferred type of interaction for the users is a passive type of usage where the system identifies the user and provides the customized content without active interacting with the system. (Santos, et al., 2013)

Alt et al. have conducted research on interactive public display that utilizes a QR-code to transfer data between public display and a mobile phone. The system was called Digifieds and it implements a digital public notice area where the content can be uploaded and downloaded via a smart phone application. The focus of the research was testing a prototype of digital public notice area. Digifieds implemented two different interaction methods for uploading and downloading content: alphanumeric method where the content transaction happens by typing a code generated by the smartphone application or viewed

by the display, and a QR-code interaction for downloading the content. Digifieds system was evaluated with observations, interviews and a field trial. The results from the test revealed that the content preferred by the users was generally locally relevant, privacy concerns with personal information need to be addressed, and multiple types of interaction techniques were seen as a crucial part of success for public notice area system. (Alt, et al., 2011).

Although SBB uses NFC as a data transfer technology between user's phone and the display, the use case and context of another similar research which was performed by Sebastian Boring et al. using smartphones camera in cooperation with smartphone application to transfer files from public display system by taking a picture of the files meant to be transferred. The tests performed on the interaction technique were successful with high technical success rate and user approval. The most significant finding stated by the research was the users' comfortability on using the system to access semi-sensitive data since the content chosen for transfer can't be easily observed by other people (Boring, et al., 2007)

Peltonen et al. researched data from CityWall project, a large public display installed in Helsinki for eight days. CityWall implemented a simple image navigation system with multi-user capabilities and a large projected screen. An interesting result of the research was that most of the interactions with the display were performed by multiple users instead of a single user and because of that it is important to design large public display systems to support small and large group usage. The systems large size also encouraged social learning phenomenon. (Peltonen, et al., 2008)

2.3 NFC-based interaction with mobile devices

Hardy et al. performed a research on a dynamic tourist map utilizing NFC-technology. The Tourist map was a large dynamic screen with NFC-tag grid used as an interaction technique. The research introduces a new kind of interaction technique called "Touch & interact" meaning that the user can control the tourist map with touching the screen with a smartphone. The system was tested in three studies with the focus being on discovering the usability of the interactions and feedback techniques in the tourist guide system. The research found multiple problems in communication between smartphone and a NFC tag such as latency and accuracy problems but also positive results regarding the phone NFC-tag interaction intuitive and fun when transferring data. (Hardy, et al., 2009).

Another similar research was a Whack-a-mole game conducted by Broll et al. Utilizing similar NFC-grid based interaction as Hardy's research meaning a dynamic view is projected on top of a NFC-grid and the interaction happens by touching the NFC-tags.

The focus of the research is testing how well NFC-technology performs on large public display gaming use. The results suggested that for high speed gaming use the recognition rate of the interaction was only 70% which is sufficient for casual gaming but still requires improvement. Other results included the fact that most of these users are not comfortable playing this type of games in a public setting (Broll, et al., 2011)

Other type of research was performed by Burnett et.al and it investigated a jukebox type of music system utilizing NFC as an identification tool. The system was called CheckinDJ and it functions as a crowdsourcing music chooser. NFC technology is used for the identification and through identification and social media the system aims to gameficate the traditional jukebox interaction. The work is still ongoing but the preliminary results show great promise in the concept. (Burnett, et al., 2012)

Alessandra Basili et al. describe an android application in their paper titled Smart Tourist Card later SMC. SMC is a concept of compressing the services provided to the tourists to a single application. These services include: mobile payment, information services, access authorization, network access, loyalty bonuses, membership cards, vouchers, mobile ticketing, identification and location based services. The research introduces multiple benefits for different stakeholders from tourists to companies, firms, telecommunication operators and public administration. The paper merely examines what kind of NFC services are provided for tourist in this day and age and describes design concepts based on good practices. Though the there is a lack of actual research data the benefits from this kind of application are obvious. (Basili, et al., 2014)

Chang et al. researched NFC technology usage for controlling a NFC enabled smart home environment. The research suggest a system where user can predefine preferred commands to their smartphone and control home appliances without additional adjustment. Key idea is the freedom from controlling a single device and instead specifying more general needs in the application like temperature, humidity and light level and the system uses corresponding devices automatically. The research didn't include user evaluation but the system is going to be expanded to hotels, offices and public spaces. (Chang, et al., 2009)

2.4 Summary

Public display systems have been searched in abundance. Out of the found studies three are similar to SBB project: The UBI-hotspot project which contains multiple applications for users to interact with at public displays and more personalized interaction with RFID tag identification. (Ojala, et al., 2010); Notification area network research which studied how to make electronic notice area network appealing for users. (Alt, et al., 2011) And

Digifieds study which researched data transfer from electronic public notice area to user's phone (Alt, et al., 2011).

Other studies explore on different aspects of SBB system and its technologies. Such as display blindness (Müller, et al., 2009), public display systems effect on organization or community (Jurmu, et al., 2014) (Wouters, et al., 2013) (Memarovic, et al., 2011).

The studies found about NFC technology utilize it as a tool to control home environment (Chang, et al., 2009), as a game controlling interface (Broll, et al., 2011), identification tool for multiple services (Basili, et al., 2014) and an interactive tourist map (Hardy, et al., 2009). There were no studies found on utilizing the NFC-technology as a data-transfer technology between public displays and smartphones and that is one key point of interest in this thesis.

Since the SBB system prototype described in this work consists of multiple different technologies an exact research on the said kind of system has not been previously conducted. The point of interest in this project is the new kind of concept which involves public notice areas, NFC interaction, public displays and smartphones.

3. DESIGN OF THE SMART BULLETIN BOARD

Public displays are generally used to pass information about timetables, events or other general information. Another popular use for these kinds of displays is advertising. Although lot of research and implementation has been done for interaction and different intends of use for public displays: Customized content through smartphone authentication (Clinch, 2013), Whack a mole game with NFC based interaction (Broll, et al., 2011), Content sharing and posting among university community members utilizing Bluetooth and smartphones (Jansen, Rossmanith, et al., 2005). The main use case for public displays is still displaying information (Boring & Baur, 2013).

3.1 The need for smart information sharing in the city

Key point of interest for this project is to research public content sharing and new interaction ways for public information display setting. Goal of this thesis is to examine the functionality of NFC technology and gesture-based interaction as a transaction tool for sharing, displaying and acquiring data in public setting as well as to provide a public forum for people to leave and acquire greetings, pictures, poems, personal advertisement or other kind of content through NFC-terminal using a phone that supports NFC technology. Another key point of interest is researching success factors and challenges for Smart Bulletin Board system and how they could be overcome to provide a high quality service.

Smart Bulletin Board is an interactive public display system which implements traditional notice area system electronically. The system provides simple controls for inspecting and selecting notifications from large display, NFC-terminal for acquiring the chosen content to user's smartphone and smartphone application for creating notifications. The notifications can contain simple content such as text, images, dates and contact information.

Later in the project lifecycle it was decided that SBB will be included into already existing project called Info Wall which is made by Ville Mäkelä from University of Tampere. Info wall is a public display system at UTA which provides various kind of information for the people of the campus. The Info wall has a working motion detection system included (Mäkelä, et al., 2014). This way a large amount of man-hours could be saved by outsourcing a part of the final system implementation.

3.2 System requirements

System requirements were derived from two sources: firstly the earlier research done by the Käpälä project group in the railway station area and Based on the results of the early user studies in Käpälä project and the analysis from the exercise assignments of TUT's Introduction to user experience course. The course in question had 80 student group study user needs of Tampere railway station users and create a new service to fulfill said needs. All of the concepts were analyzed and the requirements for the SBB system were partly derived from said analysis. Timetable and resources available were also significant factors on deciding the requirements for the system. The final requirements are: System is going to be an interactive public display where users can post content to the screen and pick content from the screen using NFC technology. User can also view the content of the board with ease. The system wishes to gain novelty value by overcoming the shortcomings of traditional bulletin board: Notes won't get lost under new notes (Figure 1.), the need to memorize interesting information from the display and the difficulty of shuffling through all the notes on a full board. The physical location for the system is going to be Tampere railway station or a similar public setting. The most important qualities for the system were ease of use and easy approachability since the user group includes all persons who come in contact with the Smartboard regardless what is user's motivation in being at the railway station area.

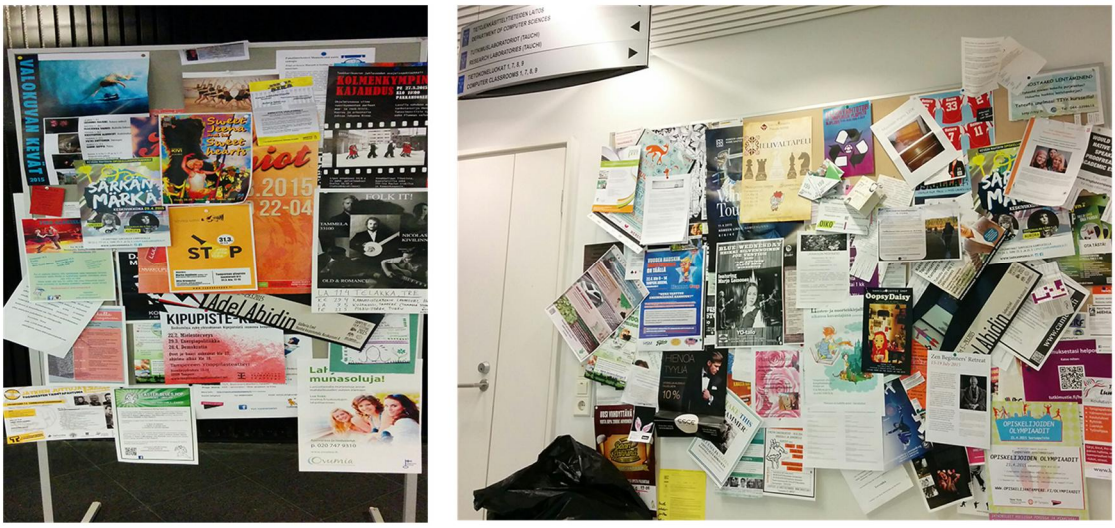

Figure 1. *Shortcomings of classic bulletin boards: notification clutter*

One requirement was that content posting should be only possible at the physical location of the Smartboard. The reason for this was that it would resemble classic bulletin boards even more and it would also reduce the amount of anonymity when posting content so that the amount of messages meant disturb would be reduced. The users can make the

content beforehand but for the actual posting they need to touch the NFC terminal with their smartphone. For the actual posting and advanced interaction with the Smartboard an android phone application was deemed suitable. Android OS was decided upon because it has a well-documented API and provides comprehensive support for NFC interaction. Android OS is also the current most dominant NFC phone provider on the market with whopping 93% of all the smartphones shipped to market at 2013. (IHS press, 2014) For the purposes of testing the Smartboard it would not be necessary to implement other than one working application on a single platform. However acquiring the items from the Smartboard should be possible without the application and on other smartphone operating systems.

3.3 Users

The users for the final system are going to be people using the Tampere Railway station area. The different user groups identified from the Tampere University of Technology user experience course findings were pensioners, students and young people, businessmen, tourists, tourists with family, people working in railway station area, people living near the railway station area and regular visitors and Tampere residents who don't belong to previously mentioned groups. Information about user group attributes can be found from Appendix 4. The goal is to make SBB in a way that it contains information that is appealing to all user groups. All the user groups listed use the board for displaying, acquiring and publishing content. Other stakeholders for the system are the owners of the establishment where the Smartboard is located, possible advertisers and technical maintenance. However these stakeholders will not be addressed in detail in this paper other than in future work section since the goal is to research the basic interaction of main user group towards the Smartboard.

3.4 Context of use

Physical context of the system is going to be a large open space indoors or outdoors. For outdoor usage a special weather resistant hardware is required and the placement of the system has to take sunlight into account so that bright weather does not make the systems content impossible to view. Whether indoors or outdoors the system hardware needs to be either located inside a safe compartment or inside some nearby commercial or public space to avoid vandalism. The motion detection controller used in the system requires minimum of 1.5 meters of distance from the user to the controller but depending on the size of the screen the optimal distance is 1.5 to 2.5 meters. The NFC-terminal controller needs to be located at the at the optimal control zone so that it can be used immediately after an item has been selected.

Social Context of the system is a public setting with constant presence of other people. The location designed for the system is a public transport hub so the user of the system is constantly passed by people moving through the railway station area. This means that the system can't be placed in a way that it blocks path of people as no one would be willing to use it in that case. Since the current system only allows a single user at a time it is important that the interaction is quick and smooth so that a single person does not reserve the system to himself for lengthy periods of time because lacking controls make the interaction slow and cumbersome. Although the system currently only supports one user controlling it at the time using the system with a friend or group of friends with one people responsible for controlling and this aspect makes it important that the usage of the board does not block any path and has a comfortable amount of space for multi-user interaction. One important aspect to note is that since the motion detection is still quite novel interaction style it is important that the motions used for controlling the system must be minimalistic so that the user doesn't draw unnecessary attention when using the system.

Task Context of the system somewhat varies depending on the task user is performing. The user might be walking past the SBB and glance at the display while passing by and after that either stop to look more closely or continue on his or her way. The other type viewing situation would be one where the user is viewing SBBs content in order to spend time while waiting for example a train to depart. In both of these cases the user might be doing some low focus tasks while viewing the system, for example using eating or listening to music. The content publishing and acquiring is so focus consuming task that aside from viewing the SBB screen to see if the transaction was successful it's unlikely that user can focus on other tasks at the same time.

Technical Context of the system contains multitude of technical hardware. The physical viewable system itself requires a computer running windows OS to run the software of the display system as well as Video projector and surface area to project the image and a Microsoft Kinect controller for the motion detection controls. Electricity is naturally required as well as internet connection. For content publishing the user needs to have android smartphone with the SBB application installed. For acquiring content from the board a smartphone with NFC-interface is sufficient.

Picture below (Figure 2) demonstrates a possible context of use. Picture is from the preliminary study premises at Tampere University. More context pictures from the actual railway station area can be found from Appendix 3.

Figure 2. *Example of a possible usage context for the smart bulletin board*

3.5 User tasks

The tasks which can be performed with the SBB are described below. As can be seen from the graph 3.5.1 the main tasks are viewing and shuffling the notifications, opening a single notification for closer inspection, acquiring said notification to phone or creating a new notification to be published to SBB system. This paper focuses solely on the primary stakeholder which is the normal user of the board. Other stakeholders such as Technical support or advertisers are not addressed since this papers focus is on researching the interaction and user experience of the board.

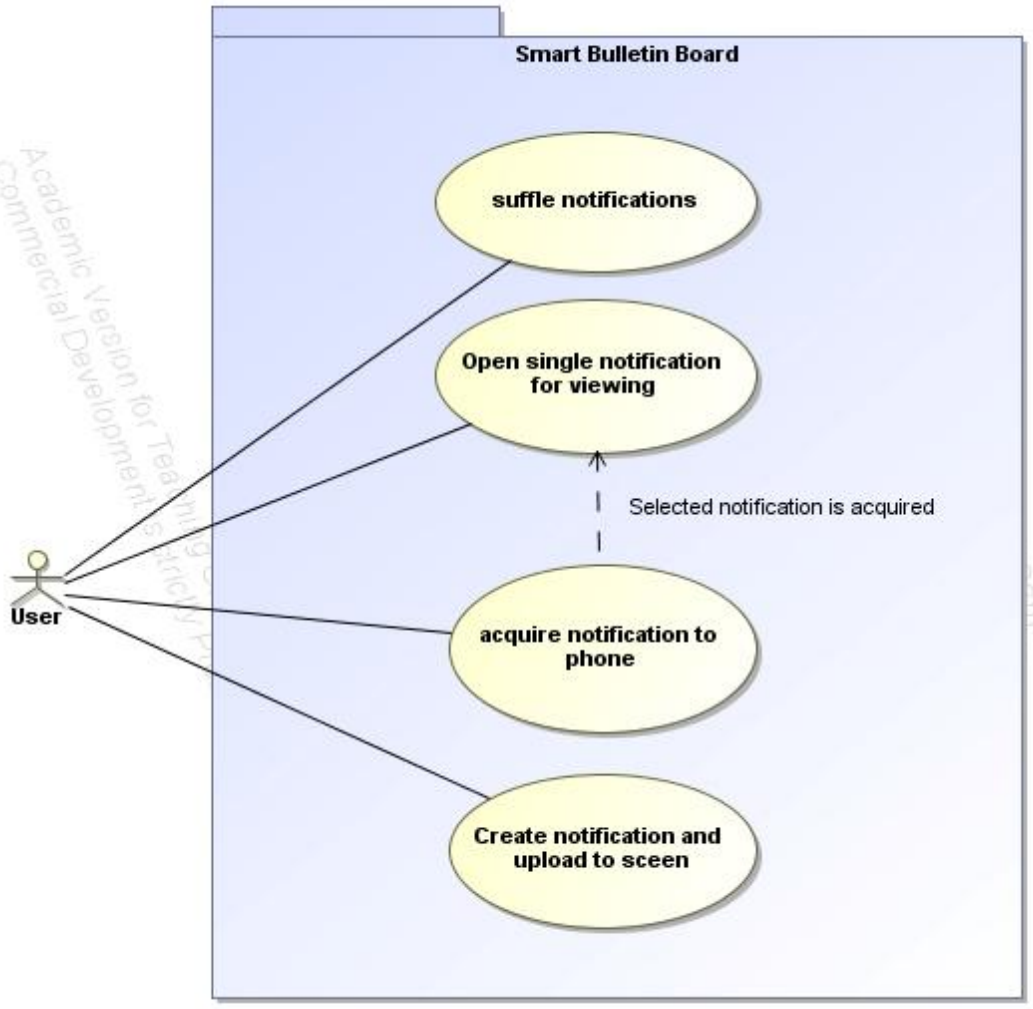

Figure 3. *SBB Use case diagram*

As seen from Figure 3. SBB has 4 distinct User Tasks. Firstly *shuffling the board contents*. User views the thumbnails of content on the board in search of something that interests him. User can change the page that SBB is showing to see more thumbnails. Second task is *Opening a single notification for viewing*. When the user sees a thumbnail of content that interests him he can choose said thumbnail for closer inspection. Choosing a thumbnail expands the notification revealing all information contained in the notification. Third Task is *acquiring notification to phone*. In this task User wishes to grab an interesting notification to his phone for further inspecting later. Interesting content could be appealing content such as poems or pictures. Information content such as contact information, dates for events or maps and directions. Commercial content such as advertisement or discount coupons. When user opens a single notification thumbnail the notification data is automatically transferred to NFC card terminal. So after choosing

a single notification for inspection the user can acquire it by touching the NFC-terminal with his phone. The user can now depart from the SBB with the notification with him or find more interesting notifications. Fourth Task is *Creating notifications and uploading them to the screen*. In this task user creates a notification with the SBB smartphone application. After he has created the notification it can be published to the board by physically touching the NFC-terminal with the phone.

3.6 User task sequences

Here are sequence diagrams visualizing user's interaction with the SBB system. Figure 4 illustrates the task of uploading content to the board.

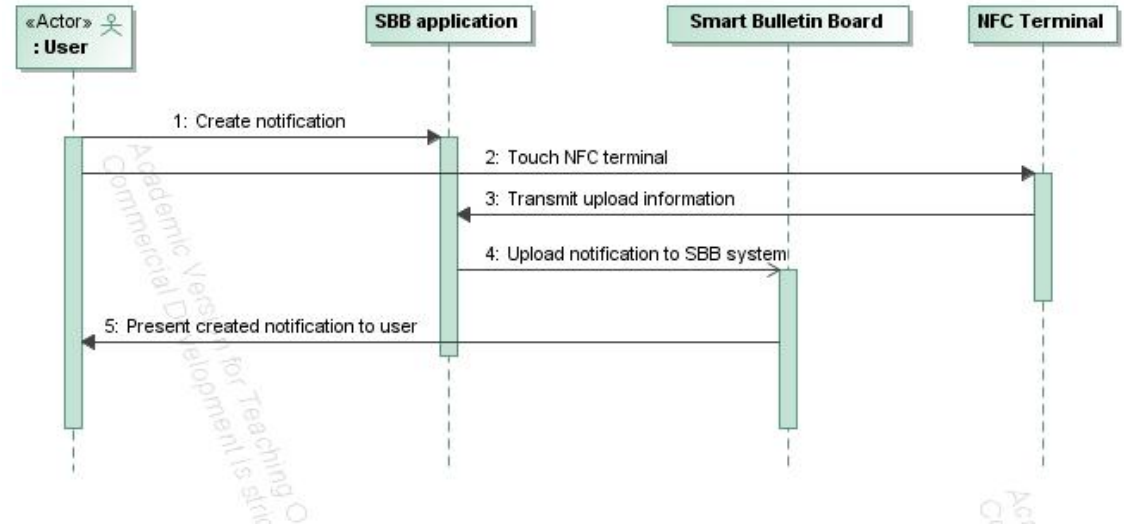

Figure 4. *Sequence diagram of the creation of notification user task*

Figure 5 illustrates the user tasks 1, 2 and 3 described in subchapter 3.5. These tasks are shuffling the notifications, Opening a notification thumbnail for closer inspection and acquiring the notification to phone. As can be seen from 3.6.2 the board always sends data of the notification user is inspecting to NFC-terminal to remove unnecessary step of interaction if the user wishes to acquire the inspected item to his phone.

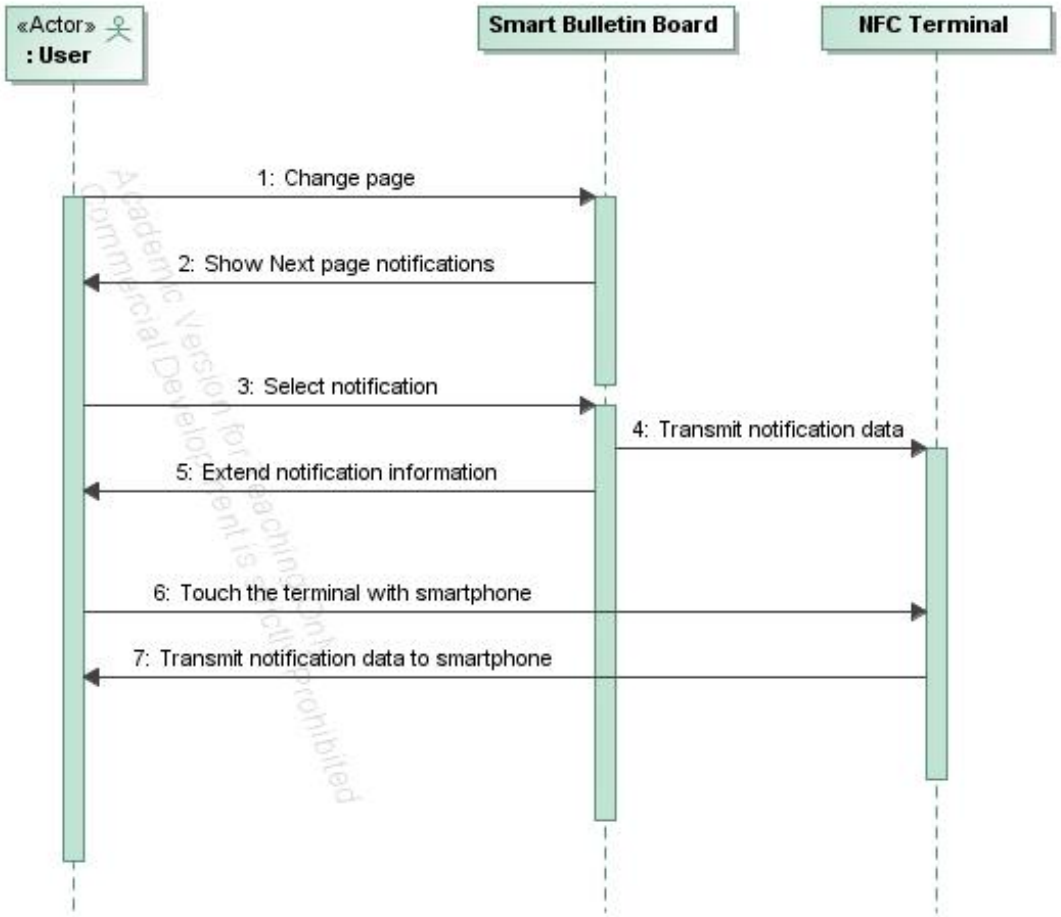

Figure 5*. User task 4 for creating and posting a notification.*

3.7 Main features

Main features of the SBB system are the large public display with motion detection interaction, NFC interaction used for the data transfer from the display to the smartphone, smartphone application for creating notifications to the display and the web server which can be connected to multiple displays at once. Figure 6. Illustrates the system in use. In the picture user is selecting notification from the board using gesture controls. The NFC terminal used for acquiring the notification is located on the table in front of the display.

Figure 6. *Researcher using the SBB system.*

3.8 NFC interaction

NFC is a wireless short range communication technology described more precisely in section 4.2. NFC data-transfer is possible when two NFC capable devices come in close contact with each other. The motivation into choosing NFC interaction as a research topic and as an integral part of the SBB system is twofold: firstly the NFC's touch type interaction resembles the note removal with traditional noticeboards, secondly NFC technology is becoming a defacto standard in modern smartphones. In this thesis it is utilized as a data transaction technique between user's phone and the bulletin board. Figure 7 illustrates the NFC interaction as it is used in SBB system.

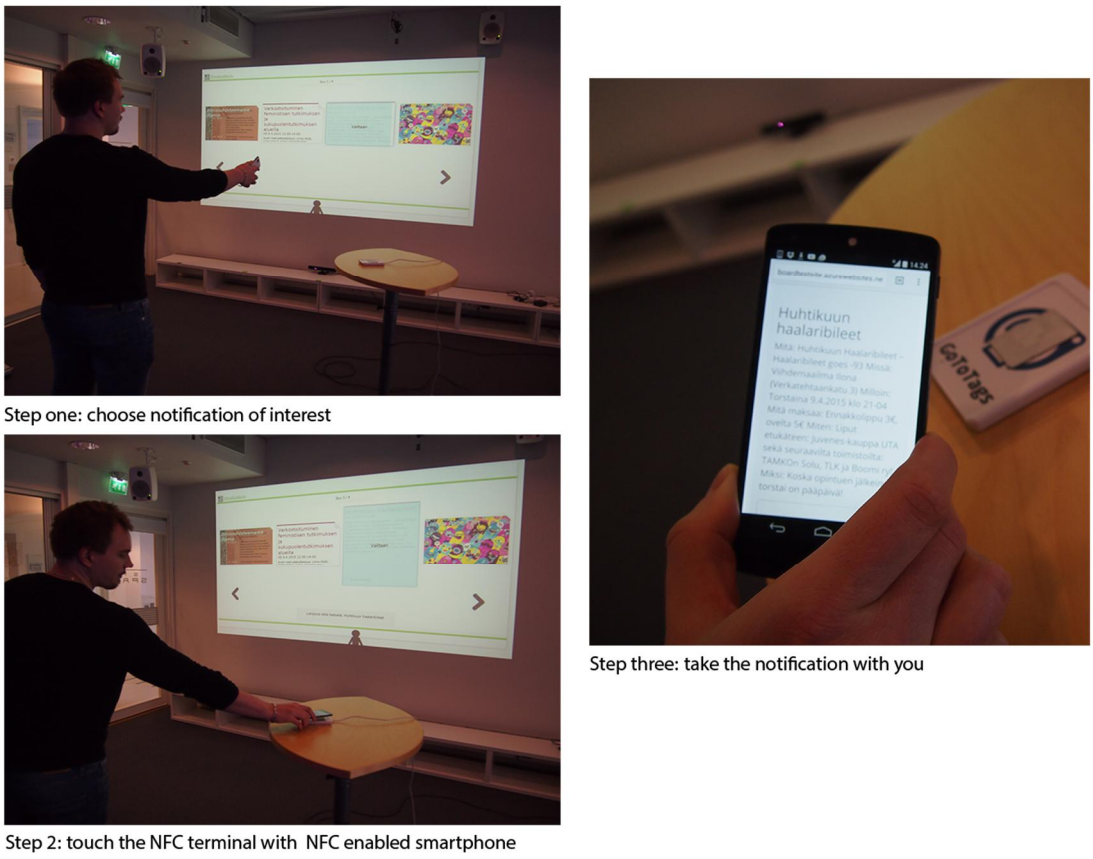

Figure 7. *Gesture and NFC interaction in action*

3.9 Visual design

The visual design guidelines for the system were quite simplistic. The public display user interface was made to simulate post-it tags using the existing look and feel of the info screen system which acted as a groundwork for the display software (Mäkelä, Heimonen, Luhtala, & Turunen, 2014). The visual look of the smartphone application was left intentionally minimal and plain to encourage user feedback during the continuation study (Figure 8). The basic layout and usability follows a standard web form type of user interface with fillable information fields, confirmation buttons and information popups.

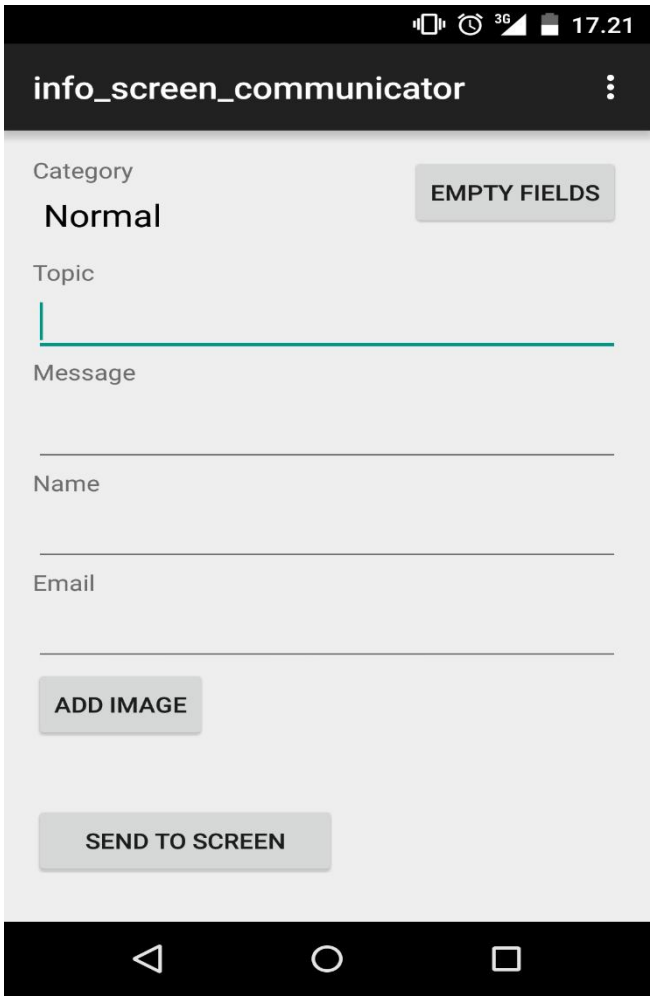

Figure 8. *Smartphone application for uploading notifications to SBB*

4. IMPELEMENTATION OF THE NFC-BASED MOBILE INTERACTION FOR THE SMART BULLETIN BOARD

This Chapter discusses the implementation of the SBB system, chosen architecture solutions, technologies, languages, hardware and issues found during the implementation phase.

4.1 Architecture

We discuss the architecture of the system through module level of abstraction. In this discussion module refers to an independent software component which performs a certain task. Module can consist of multiple software components including databases, other software components and so on (Figure 9).

Smartboard system consists of 5 different modules: **A web server with rest interface**. This is the data storage of the system. The actual board which displays the notifications gets them from this module. Also the android client used for posting information to the board uses the rest interface of this module. Module in itself is a rest web server programmed with asp.net and was run in Azure cloud during the testing phase.

Android client. This was a program made for android OS (API 12.00 and up) and it was used for creating and posting different kind of notifications to the board. Application uses simple HTTP calls to contact the webserver REST interface descripted before to store the data posted by user. For posting pictures to the system the application uses cloud based picture storing service (Cloudinary, ei pvm). Android client implemented a minimalistic user interface which can be seen in picture 4.1.

The Local webserver. This module runs on the computer containing the software which displays the information in the connected viewing device. Its only task is to get input from the gesture controller and pass commands to the component responsible for controlling the NFC-reader/writer. **The NFC card controller software.** This module controls the NFC card terminal used for passing information to the phone of the user. It receives the data from the user interface controller and writes it to the tag residing on top of the card reader.

The user interface and motion detection implementation. The implementation of the actual user interface and the motion detection was made by another project worker and as so we will only discuss it as a single module even though in reality it consists of several different components. The user interface communicates with the rest webserver to acquire the notifications to be viewed. The other task of the user interface is to send REST calls for the local webserver middleware. These calls contain the information about a notification the user has chosen and the address for the selected notification is transmitted to the NFC card controller software and transmitted to user's phone.

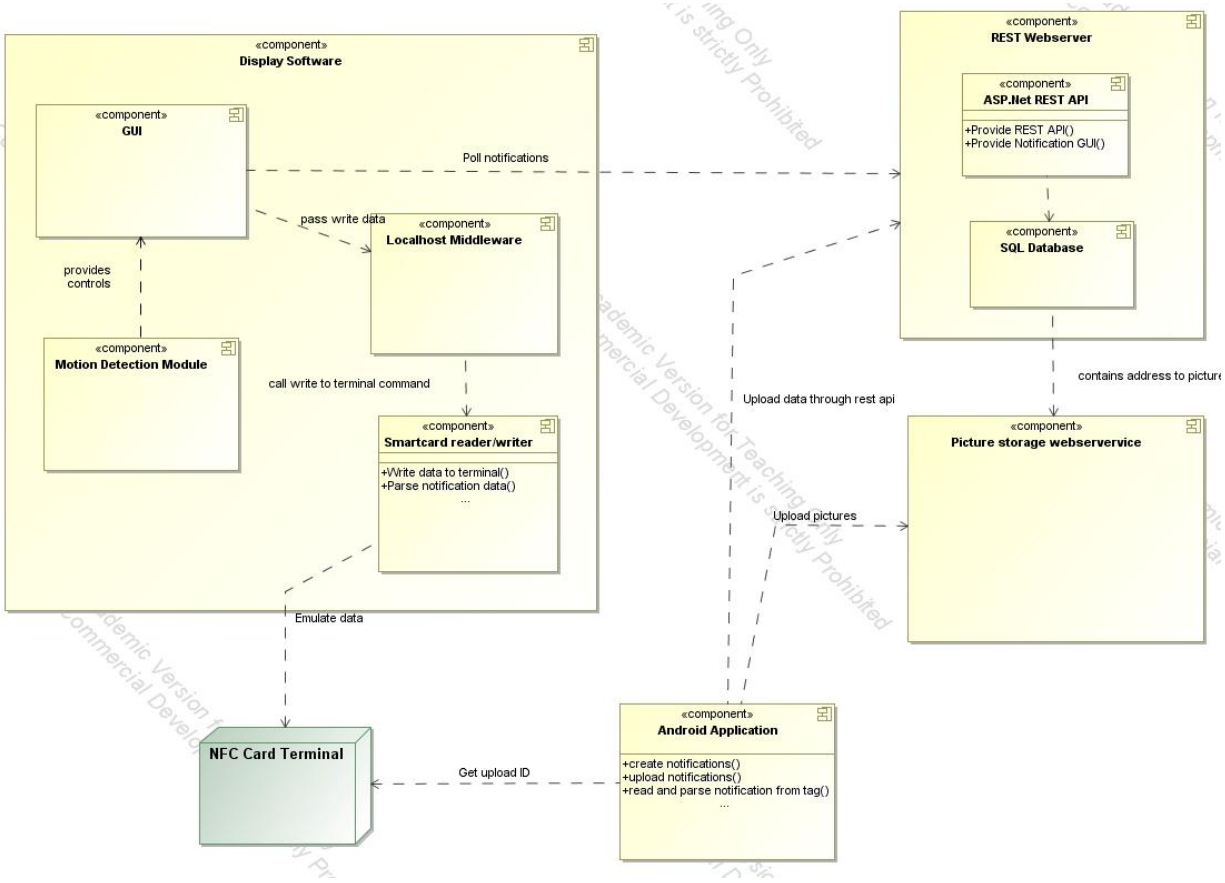

Figure 9. *High level architecture*

4.2 NFC and NDEF

NFC stands for Near Field communication technology. NFC is short range wireless data transmission technology between two devices. This means that you can exchange digital content, do transactions and connect with electronic devices with a single touch. NFC is an ISO standardized technology (Curran, et al., 2012)

Since NFC technology range is 10 cm at maximum it is suitable for the requirement of the physical interaction described in the requirements section. Another reason for selecting NFC as an interaction technology is the popularity of the technology. According to IHS Technology the amount of NFC enabled smartphones has increased 128% from 120 million units of the 2012 to 275 million units of 2013. They estimate that the amount of NFC enabled phones will rise 325% from 2013 through 2018 and the percentage of all smartphones supporting NFC will increase from 18.2% of all shipped phones of 2013 to covering 64% of all shipped smartphones by 2018. (IHS press, 2014)

NDEF stands for NFC Data Exchange Format and it's simply a standardized form of saving data to NFC tags. NDEF is a NFC forum specification for NFC data transfer and by using it in SBB system we can ensure that almost every standard NFC device including smartphones should be able to interact with the system.

4.3 Programming languages

C#. According to Microsoft documentation "C# is a programming language that is designed for building a variety of applications that run on the .NET Framework. C# is simple, powerful, type-safe, and object-oriented. The many innovations in C# enable rapid application development while retaining the expressiveness and elegance of C-style languages." (Microsoft, 2015). For this project C# was chosen to be used since the Thesis worker had prior experience in the language. In addition the Information wall user interface and motion detection control used in the Smartboard system were partly implemented with C# so for compatibility purposes it was natural to pick C# as an implementation language.

ASP.NET. "ASP.NET is a unified web development model that includes the services necessary for you to build enterprise-class web applications" (Microsoft, 2015). It was used in the project for implementing the web-server. The reason it was chosen for the project was that it's practically a C# extension for web developing so most of the development could be with only one language. Another motivation for choosing ASP.NET was for learning technologies Thesis worker had no prior experience from.

JavaScript is described by MDN as follows: a lightweight, interpreted, object-oriented language with first-class functions, most known as the scripting language for Web pages, but used in many non-browser environments as well such as node.js or Apache CouchDB. It is a prototype-based, multi-paradigm scripting language that is dynamic, and supports object-oriented, imperative, and functional programming styles. Read more about JavaScript. (MDN, 2015)

4.4 External Software

During the Käpälä project it was decided that Smartboard will be implemented with motion detection controls and the implementation of the system will be made in co-operation with Ville Mäkelä from University of Tampere. Ville Mäkelä has worked in a project implemented a motion detection system to a public display in previous project and conducted research on that topic. The visual style of the Smartboard was made to resemble that of Info screen because it might be later included in the Info screen system. Also the libraries used for motion detection and parsing the motion detection data were provided by Mäkelä's previous project (Mäkelä, Heimonen, Luhtala, & Turunen, 2014). Other external software included NDEF library which was used to parse NFC communication messages to and from NDEF format and a NFC library which provided a higher level interface for working with the NFC terminal.

4.5 Hardware used

The physical hardware for the prototype included the following (Figure 10.): **Microsoft kinetic controller** was used for motion detection and manipulating the view on the SBB display. **NFC-terminal** which was located on a podium in front of the display and was used for the data transfer between user's phone and the system. **Video projector** which projected the user interface to wall surface. All of the above components were connected to the **local server machine** which was located in a locked cupboard during each of the evaluation sessions.

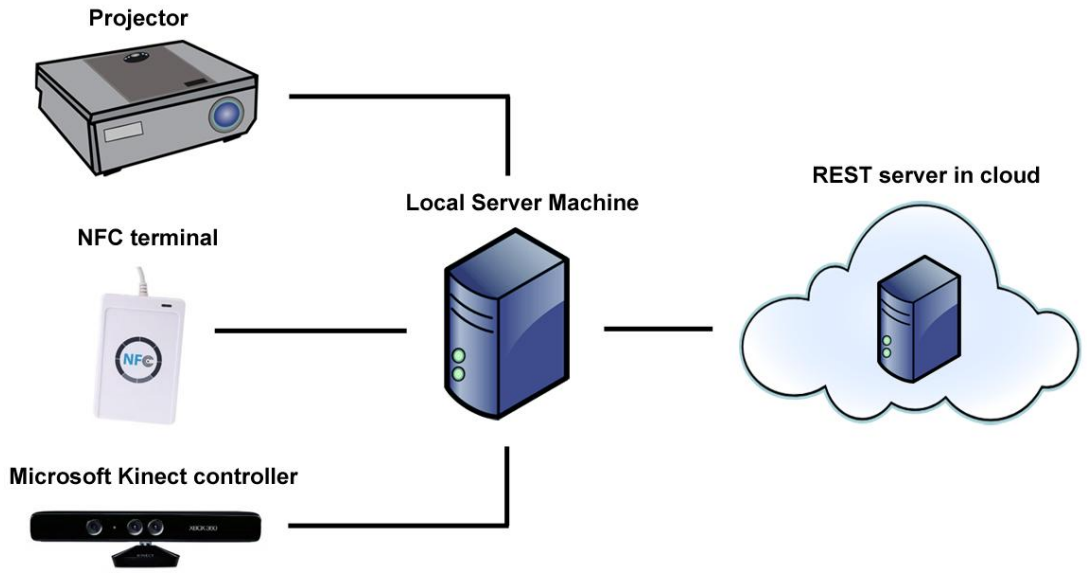

Figure 10. SBB system hardware

4.6 Challenges faced during implementation

The implementation of the prototype went rather smoothly except the problems caused by the NFC interface. The original idea was to implement a NFC P2P communication between the smartphone and the NFC terminal connected to the system. This would have meant that the phone and the terminal would enact in a communication where the devices communicate between each other by acting as a sender and as a receiver in turns. This communication type between devices would have been natural data transfer type between the devices. However this part proved to be much harder than anticipated since the NFC-terminal did not respond to the commands sent to it in expected way. The documentation found for implementing the P2P interaction between the NFC-terminal and the phone was also quite lacking. Another way was to set the terminal to act in a passive mode and only serve information to the smartphone but this implementation faced same problems as the P2P approach. With more time it might have been possible to research the said interactions further and implement them properly but due to schedule other ways of implementation had to be examined. So instead of P2P interaction or passive mode, another approach was chosen for making the communication between smartphone and terminal possible: An NFC tag was pasted on top of the terminal and it acted as a medium of communication. So the terminal merely writes the data selected to the tag and powers off to not cause interference when the smartphone reads the tag. This approach has some benefits compared to the others. Firstly by writing the data in NDEF format to the tag means that every smartphone with NFC capabilities is able to read the data supplied to

since the smartphone does not require any external applications for using the board. It can also be assumed that future NFC devices can also understand the format since it’s an industry standard (GoToTags, 2015). Another more minor benefit is the power savings provided since the card terminal is powered on only when a new write event on the tag is required. All in all this approach worked really well in the user tests, however for actual use of this interaction in the public some re-engineering needs to be used since currently it has some security flaws that need to be addressed.

5. USER EVALUATION

After the system was completed and technical testing carried out two user evaluation sessions were conducted. The testing was divided to two phases named Preliminary study and Continuation study respectively. Preliminary study was conducted prior to Continuation study because recruiting Continuation study participants took place in Preliminary study. The reason for this division is that from Preliminary study we hoped to acquire quantative data on the first impressions, experiences and feedback in realistic context of use whereas the Continuation study focused on acquiring in depth qualitative data with more comprehensive session including multiple tasks for the users, lengthy interview and an AttrakDiff (GmbH, 2013) questionnaire.

5.1 Methods used

User Tasks. Users were given tasks to be performed with the SBB system. This was done both to observe the interaction and identify possible patterns or occurring problems with the usage of the system. The users are given minimal instructions on how to use the system to observe the usability factors. **Semi Structured interview** is used to acquire two way communication with the test user and to acquire more in depth information about the user experience. **AttrakDiff** is a survey for determining products perceived pragmatic quality, hedonic quality and attractiveness (GmbH, 2013). Standard surveys with Likert scale (McLeaod, 2008) were used to gather quantative data.

5.2 Goals of the evaluation

The Goals of the tests are to determine if the concept of content sharing board is appealing to users, if it is needed, what kind of experiences the users want from it and how it can be improved. Another goal is to observe and identify user experience problems and possibilities involved with interaction of public display system including NFC and gesture interaction. Both phases of the testing also include comprehensive themes from the motion detection controls of the system which is related to Ville Mäkelä's portion of the project.

5.3 Participants

Participants for the Preliminary study interviews consisted of people passing by a café situated in the main building of University of Tampere. For the Preliminary Phase the

number of participants was 31 where 19 participants were male and 12 female. Due to the short duration of the Preliminary phase no additional background information were gathered apart from age and sex. As for Continuation study the number of participants was thirteen test users from which 11 were recruited through Preliminary phase interviews and two from the University of Tampere TAUCHI department. The original planned context was Tampere Railway station and the target group railway station users but since the final user evaluation was carried out at Tampere University and the users were also recruited from the university campus area it can be said that the results of this evaluation are skewed and not fully applicable to the railway station area. All of the test users have academic background with nine being university students and four post doc students and university researchers. Six of the Continuation study participants were female and seven male and the average age of continuation phase participants was 28 with standard deviation of 5,5.

5.4 Preliminary study

Preliminary study consist of extremely short (3-5 min) user tests performed on passersby. The aim for Preliminary study of the research is to introduce the system to the users in normal context of use, gather information about the user's first impressions and experiences of the system and explore how appealing the concept of the SBB system is for the users. Preliminary study is also used to recruit test users who find the concept interesting to the follow up interview in the continuation study. Preliminary study was conducted from 31.3 to 2.4 and it was be conducted at Tampere University at 10.00-14.00. The precise location is next to Alakuppila Coffee shop. There is a picture of preliminary study premises illustrated in Appendix 3. Test consists of a single task and a questionnaire where interested by passers are asked to test the system and answer a survey afterwards. Tester will also collect notes on anything he observes during the test. Template for Phase one can be found in Appendix 4. During the Preliminary study the SBB system was populated with notifications the researchers theorized as a possible content for the test context. The content consisted of different university event notifications, a notification containing a coupon for yoga class, casual messages, couple of casual photographs and a picture promoting work of a graphic artist.

5.5 Continuation study

Continuation study consists of four user tasks (Appendix 2.), interview (Appendix 1.) and AttrakDiff questionnaire (Appendix 3.). Continuation study tests were conducted from 7.4 to 17.4. Location for the tests was SIMSPACE classroom at UTA. Testing methods used were User test, semi-structured interview, background survey and AttrakDiff

questionnaire. The tests duration was approximately 60 minutes à. User test was chosen as a method because we want to get information about possible problems when using the system and observe how the user feels and reacts interacting with the system. Interview was chosen to acquire more detailed information from the users after User test about their opinions of the usability, their general opinions about the system and anything that emerged during the User test session. We also want to scope what kind of experiences the users wish from the intelligent usability board. During the Continuation study the contents of the SBB board remained the same compared to phase one with the exceptions of a specific party event being added to allow for a simple content finding task for the user tests phase of the research.

6. RESULTS OF THE USER EVALUATION

This chapter includes and discusses the results from the user evaluation sessions 1 and 2 respectively including survey questions, interview results and the AttrakDiff results. Chapter 6.1 contains all questions from the survey used in user evaluation session. Chapter 6.2 contains the interview results divided into themes.

6.1 Quantitative results: user experience

These results were collected with a survey form handed out to the users at the preliminary study interview and at the end of continuation study user evaluation session. In the Graph below (Figure 11.) are the results from the Preliminary study user evaluation session survey. Only background information collected from the users at preliminary study was sex. There were no significant differences found in the results between the sexes. The number of participants in the survey was 31.

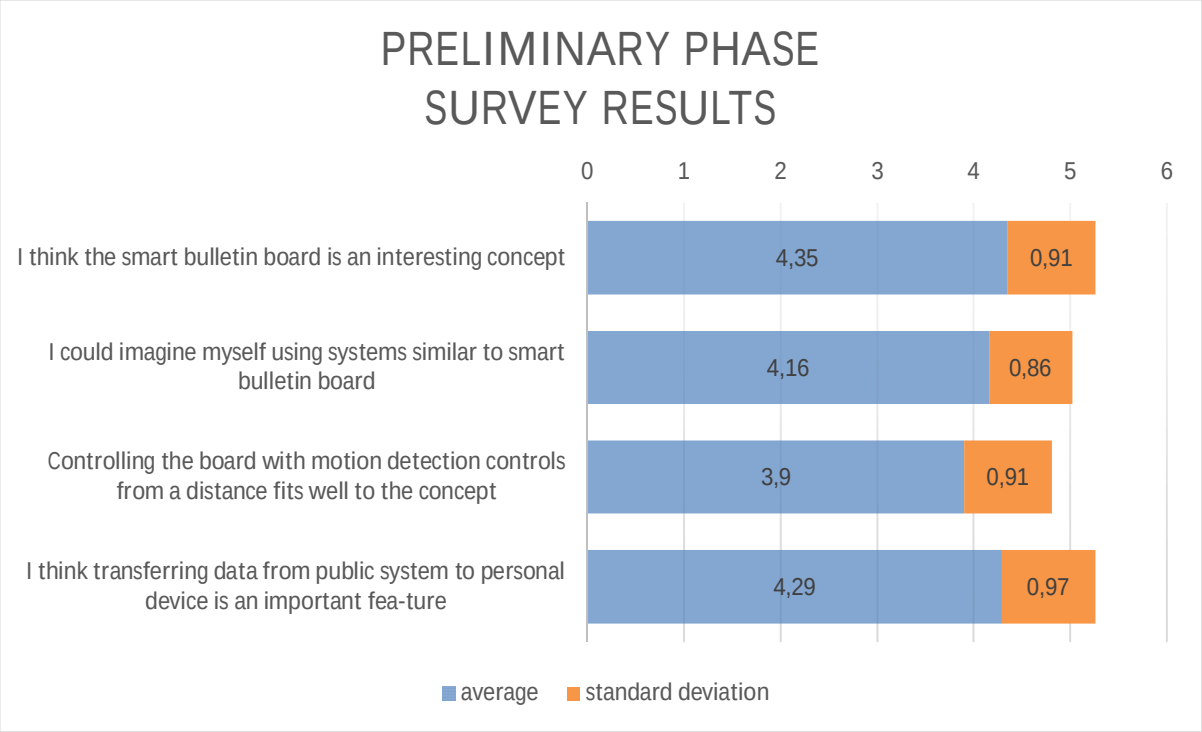

Figure 11. Preliminary study survey results (N = 31)
1 = “Strongly disagree”, 5 = “Completely agree”

Test users found the Smartboard system interesting and could imagine themselves using a similar system in the future. The data transfer feature was also seen as an important feature. The only question averaging below four was about how the motion detection interaction fits with the system while the result is still above average. The conceptual model was not obvious to the users and many needed advice on how to use the system. This effect was highlighted even further in the phase two user evaluation. One thing to note is that out of the preliminary study participants 30% wanted to take part in the continuation study of the evaluation which is really high participation percentage for this kind of recruitment process.

6.1.1 Continuation study survey results

Background information of the users was collected in the continuation study with a survey. As stated before six of the users were female and seven male with the average age of 28 years ranging from 20 to 38. All of the users had academic background being university students (10) or post doc students (3). Every user had prior experience of motion detection technology ranging from few times usage (7), to several times (2) and regular usage (4). Most users were familiarized with motion detection technology through motion detection games (10). The rest through occupation (2) and studies (1). NFC technology was familiar to most users; few users claimed to have never used it (2), majority were regular users (6) and the rest claimed to have used the technology few times (3) or several times (2). All except one users (10) who had used NFC technology before mentioned Tampere public transport card as their primary NFC experience and the remaining user mentioned the near pay technologies as his primary NFC experience. Bulletin boards were also familiar and frequently used by users; most users used theme weekly (8) or monthly (4). One user claimed to use them only couple of times in a year. The context for the usage varied from university (7) to work place (1) and apartment complex (1). The content that interests users in these encounters with bulletin boards ranged from university and studies related content (8), special offers (1), politics (1), events (2), flea market content (1), public transport schedules (1), hobbies (1) and general news (1).

Continuation study survey was filled by the users after they had participated in user tests and the interview. The background factors were not found to correlate with any particular trend in the results except for slight difference between sexes. Females were more positive towards the use of gesture controls ranking lower points in questions: “I would prefer using some other form of interaction than gesturing for similar systems” and “I would not want to use gestures for interaction in a public setting” with over 1.1 points and smaller standard deviation.

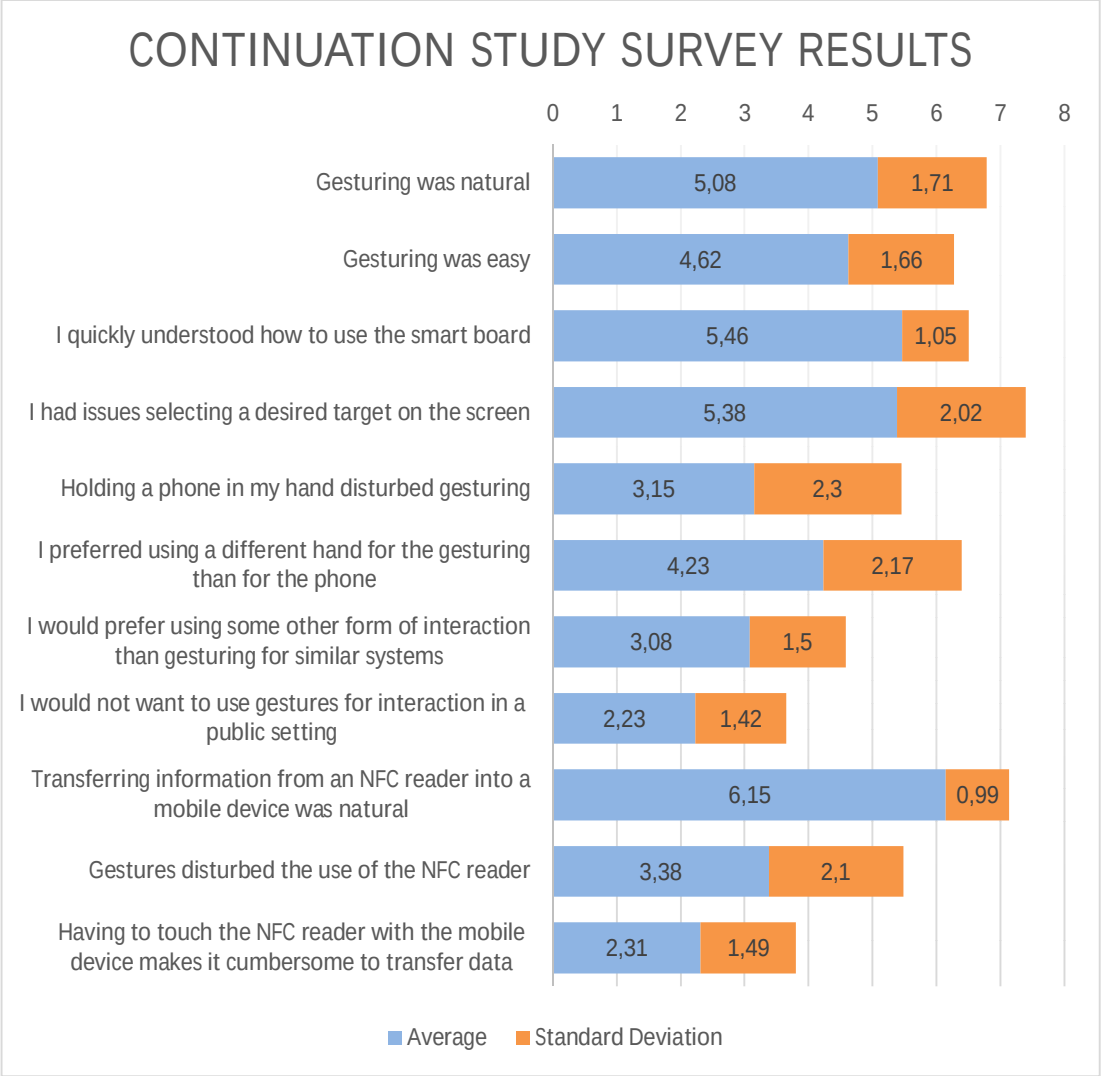

Figure 12. Continuation study survey results (N= XX)

1 = “Strongly disagree”, 7 = “Strongly agree”

The results from the survey are encouraging (Figure 12). Gesturing felt natural and easy to users as well as understanding the idea behind the SBB. It should be noted however that since the participants in the continuation study had already gotten their first touch of the system in the preliminary study it is unlikely that the results would be this positive to a person who is completely new to the system.

Almost all users had trouble in choosing desired elements at some point of the task session and the effect can be seen in the graph. This was due problems related with the gesture controls described in more detail at subchapter 6.2.2.

The question concerning the effect of the phone on the interaction had the most divided opinions among the users. During the observation part of the users were clearly confused about the relationship between the phone and gesture interaction. Some users thought the phone to be some sort of motion detection control for interacting with the screen. The NFC interaction felt natural to the users with a large consensus. However the combination of NFC interaction with the gesture controls divided opinions among the users.

6.2 Qualitative results

This section covers the results from the actual interview section of the user evaluation and data gathered from observing the user tasks.

6.2.1 Overall user experience

Using the smart bulletin board divided opinions among the users. For six out of thirteen users the gesture control and the conceptual model of the Smartboard felt really intuitive and natural. However even the most positive users had suggestions for improvement of the system. For five users out of thirteen the system felt displeasing: hectic, clumsy and frustrating. Two users agreed that the usage was pleasing but added that the system had lot to improve. *"It's frustrating when you can't keep your hands down even though you know that's how the smart screen works. Reacts too easily to gestures."* (Female, 26), "Quite fine: Intuitive, fast and effective. No bigger problems. Takes useless input/takes input too easily." (Male, 20)

The users found the mobile application easy to use. Only problems encountered were the obscurity of the android operating system for two users and finding the button to change type of the item to be published for one user. One user (female, 27) mentioned that you don't know whether you should look towards the smart board or the application whilst posting content and indeed the system does not give any indication on this matter. Other user (male, 34) got irritated by the unresponsiveness of the card terminal and suggested that there should be some sort of frame to guide the phone to a correct position on top of the reader to improve the responsiveness. *"Android operating system was not familiar and caused some problems. Item type change was hard to find"* (male, 37), *"Works well. Best part of the interaction. Sending and receiving works well"* (male, 20)

Three out of thirteen users described the overall experience as a negative one. Main reasons for the negative experience were problems regarding the motion detection control. The greatest problem for the displeased users was that there was no obvious way to set the screen into a static mode meaning that the screen interprets the slightest of hand movements as input even though the user just wanted to view the contents on the screen.

Interesting scenario similar of this problem was when user chose the page switching button to move to next page of the system and started to inspect the contents of the new page, many users focused on the content of the board while their hand stayed in the gesturing position. This caused page to change unintentionally which frustrated users. One user pointed out that you can't be doing anything else while using the SBB system for example holding a cup of coffee or use a pen and paper to write down information from the board if your phone is not NFC enabled.

Users also pointed out that the latency for the automatic page change is too short. You don't have enough time to inspect the board properly before the page changes. Suggestions for improvement included some sort of locking mechanism to stop the Smartboard from taking input, improving the input detection, adding more information on a single page, adding categories for notifications and removing unnecessary UI items like the position indicator of the user.

Eight out of thirteen users mentioned that there is some level of learning curve before using the system feels comfortable which is quite significant. This means that in the conceptual model has to be improved for the interaction to be more easily adaptable.

6.2.2 Interaction techniques

The users felt comfortable using the gesture controls for interacting with the board. The consensus among the users was that the gesture control system is ideal for really large screens. Many users commented that the interaction needs to be improved so be more fluent also many users commented that after initial starting shock the usage becomes significantly easier. Indeed it's crucial that the interaction works perfectly and is as intuitive as possible since the social pressure causes quick abandonment for services that require learning.

The greatest problems related to the gesture interaction were understanding the dimensions of the gesture interaction and adjusting hand movements accordingly. User tests revealed the lack of calibration of the dimensions. Many users had problems choosing the notifications at the edges of the screen since you had to actually point slightly over the edge of the screen to sift focus to them. This also relates to the social factor of the interaction since users don't want to appear foolish in a public place large exaggerating gestures should be avoided which was commented upon by some users.

Since the projected screen of the system is quite large and the controlling distance to the screen is somewhat lengthy the screen contents are easily viewable by other people. Some users commented on their discomfort to view personal content in the system. Other social

aspect of the interaction brought up is the case where the content in the board is some sort of information multiple people want to access inside a small time period. For example test results or train schedules.

One particular observation of the interaction was the simultaneous usage of the smartphone and the gesture controls. Users were divided among their preference of how to interact with the display. Some gestured towards the display using the smartphone as a controller tool although it is not required for navigating the contents. This might be due to the testing situation making it easier to hold the phone in their hands the whole time so the testing situation is not completely realistic in this sense.

Most of the users saw a large touch screen as a valid alternative for the projector and gesture control combination as it would offer more privacy and familiar conceptual model as touch screens are much more common than gesture control systems. Surprisingly several users appraised the gesture controls for the hygienic safety it provides which would not be reached with touch screen.

The Android application was seen sufficient for publishing simple content. Some users commented that for more advanced notifications the smartphone content creation is lacking. The users were mainly satisfied with the simple content types the application supported although video content and the possibility to post direct links for advanced information sharing were commented upon.

The NFC interaction had some novelty value. Users thought that the data transfer trough NFC felt natural. However, during the interaction user had to place the smartphone to the right spot on the NFC-terminal so that the data transfer would start since the NFC-reader inside the smartphone needs to be aligned relatively on spot. One user suggested some kind of cage to force the phone to always align properly however since smartphones come in variety of sizes and the NFC chip location is not standardized some other option has to be researched.

6.2.3 Usability findings

One thing that stood out during the user tests was that it was quite cumbersome for the users to choose a notification to be transferred to the card terminal. The problem was that while users chose a notification and started moving the smartphone towards the NFC terminal to collect it, the Smartboard interpreted this as an input and usually started to change the page due to the input usually hitting the page change button near the edge of the screen. This confused most of the users and usually they stopped the interaction and started to look for the notification previously chosen even though changing the page does

not change the content of the NFC terminal. At worst case the unintended input caused another notification to be transferred to the terminal which meant that the user had to start over if he noticed what was happening or receive unwanted notification. One user in particular got so frustrated to this effect that for the rest of the tasks he constantly pointed to the screen with other hand to keep the view locked while reaching to the NFC terminal with the hand holding the smartphone. Quotes: "Terrible usability. Targeting was terrible. The greatest problem is that the screen thinks every gesture user makes is a command for the screen. Learning curve exists. The time for page change is also too short". (Male, 37), "Fun to use but could be easier. Useful in notification in board cases where there is lots of information. Could have categories for different kinds of content. Clear and fun idea". (Female, 22)

6.2.4 User needs for the smartboard

Content users wish to grab with them from the board comes in multitude of types. Most users mentioned events as a thing they would like to grab from the board. This is quite understandable since dates, times and locations are generally hard to remember. Other similar items most of the users mentioned were public transportation schedules. Users also saw potential in tourism applications: grabbing maps and information about local attractions. Couple of users saw possibilities for advanced map interaction with choosing the area from the map and grabbing that particular area from the terminal. News were also a content most of the users were willing to grab from the board but on the same time part of those users stated that only really shocking or personally important news would be meaningful enough to be read on a public setting.

Most of the users mentioned that the content of the board should depend heavily on the location and context. Content could be, for example, cultural event notifications in library, student party events, student welfare news and test results in university. More innovative ideas no how the SBB type system could be used extracted from the interviews were: Using the system as an application on building customized schedules for an event like the Restaurant Day or conference where the schedule would also contain detailed information about the events, a system to support art gallery, an art project collaboration system, a system for delegating work tasks at meetings, a quick health analysis system and different type of gaming purposes.

Although the testing prototype had a coupon type of notification only couple of users mentioned that grabbing coupons or watching personalized adverts was something they would be willing to do. In that sense commercial content does not appear to be too appealing in SBB context. The visual look of the SBB board did not raise great deal of

emotion in the users. Users stated that the color was too neutral and there was too much empty space and that bright colors or interesting design would draw more attention and would be more pleasing. All users stated that they could see themselves using the SBB system in the future although most stated that the interaction problems have to be fixed before they would bother to use it.

6.3 AttrakDiff results

AttrakDiff questionnaire was handed to the users as the final part of the continuation study and the results can be seen below (Figure 13).

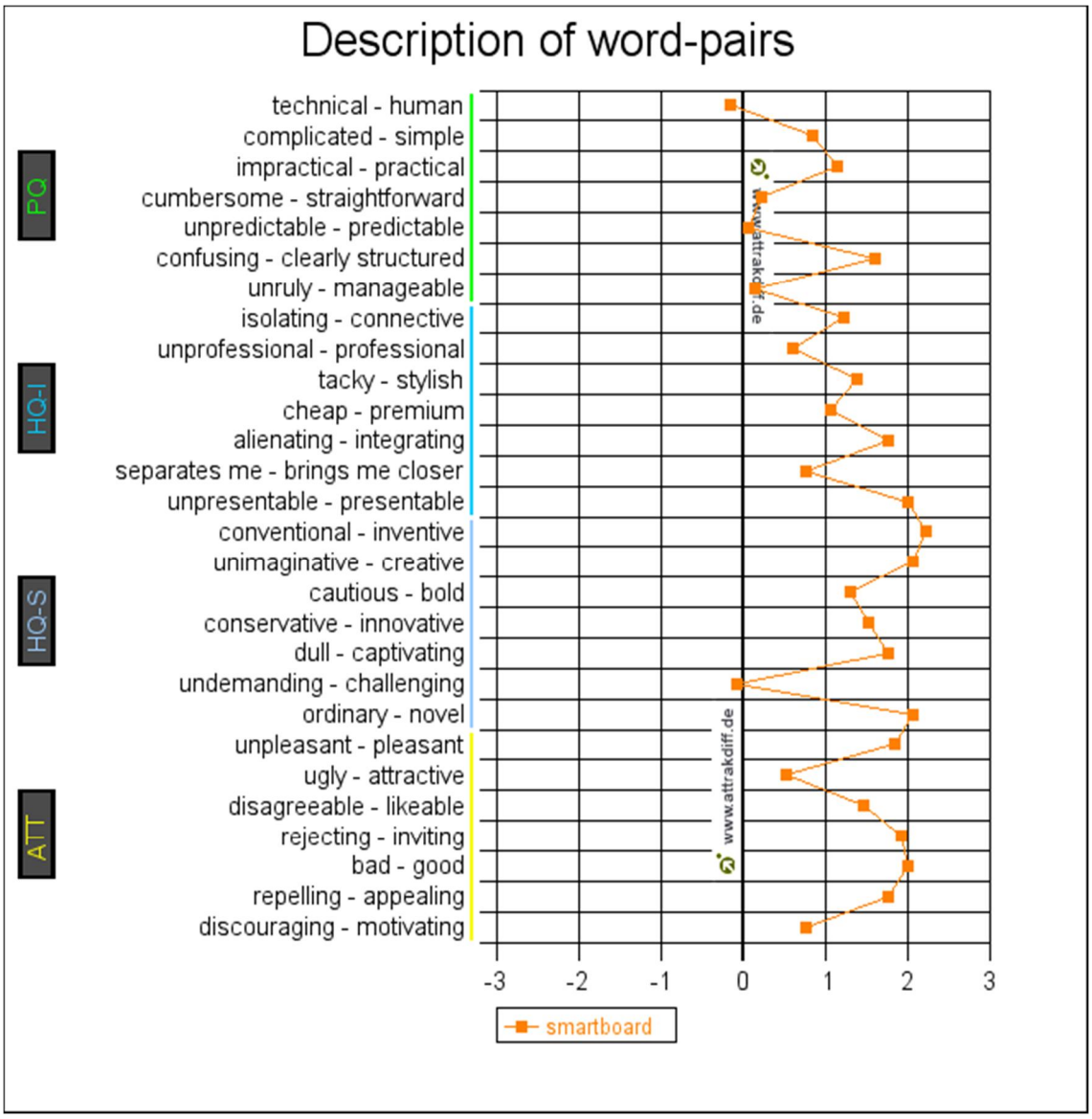

Figure 13. AttrakDiff results

For pragmatic quality the system received slightly above average results as well as for identity, stimulation and attractiveness (Figure 14). Points of interest in the word pairs are the extreme negative side the attributes technical, cumbersome, unpredictable and unruly. On the extreme positive side there are attributes undemanding, presentable, inventive, creativity, good and novel. The results suggest that the largest problems of the experience of usage stem from the pragmatic quality and indeed multiple usability problems were found through observing the user task and interviews.

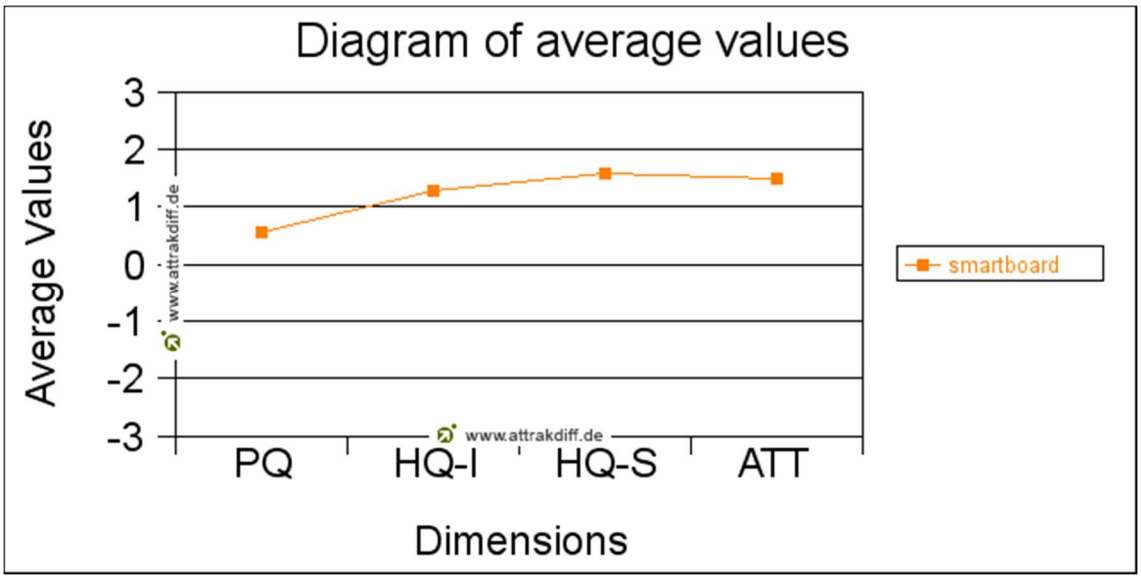

Figure 14. AttrakDiff Averages

6.4 Summary of the results

The results achieved from the tests show promise for the SBB concept. All of the users stated that they would be willing to use similar system in the future as long as the usability problems were fixed and the system overall polished. The gesture interaction and the NFC interaction felt natural for the users individually but using them together caused decrease in user experience. This is one of the key findings of the research: when the user has chosen a notification from the SBB system to be transferred to the NFC terminal the physical act of moving the phone on top of the terminal frequently caused the board to interpret user's movement as an unintended input. At worst this meant that the user had to pick the notification he wanted to grab again and even when that was avoided the effect caused severe confusion and discomfort. Similar problem related to the gesture controls was the fact that while user performs a gesture the system interprets it as a constant input, meaning that user needs to stop the gesture in order to stop the display from receiving input. The importance of proper configuration of the controls sensitivity, latency and

comfortable dimensions emerged as a critical factor in implementing gesture controlled system.

The NFC interaction got particularly positive reviews from the evaluations. However, there is still room for improvement. One key finding was the alignment of the smartphone over the NFC terminal. It's not obvious to the users how to align the phone properly since the NFC chip on the phone has to be directly aligned with the terminal for the data transfer to succeed. Another interesting point was the requirement of visual message in both the smartphone application and on the display while uploading content to the screen since users generally could look at either one.

NFC and gesture controls in themselves appear to users as novel technologies in public context of use and thus it's important to provide visual ques and instructions on how the system works if it's not possible to make system absolutely intuitive. This is especially important in public setting since users will abandon the system if they feel stupid using it. Another important finding regarding the public context was the fact that the control gestures should be as minimal and simple as possible since the users don't have time or motivation to learn complex gestures and the fact that more complex or big gestures make user draw unwanted attention. The most popular content users would like to grab from the board was events and location related content. Users didn't want to see personal information on the board at public place since the display contents are even more visible than on traditional public display due to huge screen and user being unable to block the visibility to the content due to remote gesture interaction.

The AttrakDiff survey results suggest that the biggest problems of the system were on pragmatic qualities. This finding is supported by the results from other survey and interviews. This means that usability is the most lacking factor of the system.

7. CONCLUSIONS

This chapter sums up the results of the research and compares said results to related research. Based on results and discussion future research is suggested.

7.1 Success of the project

The research was carried out successfully as we managed to construct a working prototype of the SBB system and conduct UX testing on the system. The data received from the research was interesting and gave a good founding for future research and implementation of SBB and similar systems. SBB system shows promise as users generally thought the system had novelty value, was creative and undemanding among other things. The quality of experience on the system was mainly positive with prominent problems being usability-related. Some of the usability problems found would be sufficient for follow up research: The problem of simultaneous interaction of motion detection and NFC terminal, how to solve the problem of system getting unintentional constant input from the user and the alignment problem of NFC enabled device with the NFC terminal.

Greatest drawbacks in the project were the fact that the SBB system was not tested in the railway station area as was originally planned. The testing for both studies was performed at Tampere University which skewed the results since all of the users were linked in some way with University campus area. Because the railway station area was not available as a testing environment the long time period statistical data could not be acquired.

7.2 Discussion

The UBI hotspot research suggest that the location like the railway station area would not be an optimal place for a public display system such as SBB. (Ojala, et al., 2010). The long term study on multiple public displays, named UBI hotspots, scattered around city of Oulu suggests that public transport hubs had the lowest use rate of all the observed displays while the highest rates were at locations where people were not in a hurry. If the SBB system were to be implemented to the railway station area at some point this conclusion should be addressed by placing the SBB system in a location where people wait for public transportation or otherwise spend time casually. However the most popular services of UBI-hotspot included same ones discovered in this research such as public transport schedules.

Research by Wouters et al. on giving control of public displays to local communities created interesting results. Results of the test suggest that sharing the content creation among multiple community members creates sustainable engagement towards the display. (Wouters, et al., 2013) Similar results were discovered by Hosio et al., regarding the most popular content which was content created by the users (Hosio, et al., 2010). In this research the results suggest that users would be more interested towards information content than self-expressive content. This is probably due the fact that a bulletin board is generally seen more as an information sharing and commercial medium than it's a channel for self-expression. What many of the public display researches suggest and what matches the result of this study is that public display content should be tailored to match the context the display is located. (Schroeter, et al., 2012), (Alt, et al., 2011), (Alt, et al., 2011). However since SBB system is in principle a system open for everyone to contribute content to there probably needs to be an authority enforcing the notifications to stay context related. The Context related content is also a rather realistic approach to please the stakeholders who own the physical location where the display is located (Alt, et al., 2011)

In addition to the context related content mentioned in the previous paragraph Alt et al.'s research states that supporting multiple types of input possibilities is an important feature since user needs on the notification areas differ from wanting to post a simple handwritten "on sale" type of notification on the spot to complex and graphically impressive event posters. In our research part of the users mentioned that more complex content creation is cumbersome on small smartphone screen. Our research agrees that this feature is rather important for two reasons. Firstly offering multiple ways of creating content allows people to be more self-expressive adding to the appeal of the board. Secondly the more complex and visually impressive content which is a factor in combating the effect of display blindness described by Müller et al.'s research (Müller, et al., 2009).

However the visual appeal is only one factor in avoiding display blindness. Müller et al.'s research describes Display Blindness as a phenomenon where user's negative expectations towards display contents discourage interaction with the display. (Müller, et al., 2009) According to Müller et al. The most significant step to take to prevent display blindness phenomenon is to research the audience's expectations and provide the content accordingly. This phenomenon was discussed earlier in this chapter and the context and user base relevant content seems to affect display blindness as well. Study that researched the combined use of mobile devices and public displays in navigation purposes suggested that the displays location in relation of the user is a key factor to engage user interaction with the display (Müller, et al., 2008). Since the majority of tests conducted in this study

were laboratory tests no research could be conducted about the optimal location of the system. This is an important question to study in continuation projects.

7.3 Summary and future work

The design, prototyping and evaluation gave a good insight into problems, possibilities and qualities involved with electronic gesture controlled notice board as well as for the gesture control and NFC interaction combination in general. Results of the study suggest that there exists a novelty value for NFC based data transfer in bulletin board data transfer. The experience of the user was prominently positive towards the concept. SBB shows some promise since the feedback was mainly positive and all users were eager to use the system. Although the user experience was positive it's important to fix the problems discovered during the research and develop the system even further based on relative research findings if SBB system is to be deployed to the real world.

The research revealed multiple interesting findings related to the user experience of gesture controlled bulletin board. The core findings were three usability issues discovered during the evaluation: **NFC and Gesture control collision** was an effect that happens when user accidentally triggers motion detection interaction while trying to solely use NFC interaction. This problem is a subset of **Continuous interaction effect** where user gives unintentional input to the system when his focus shifts to the content in the middle of interaction. Another key finding was **NFC device alignment issue** which is a result of the fact that NFC sensors of the two devices in communication have to be aligned spot on to successfully communicate. These results can be used in future projects involving NFC and gesture controls.

In summary the project was a success and it gave good insight to the problems and possibilities revolving around public displays with gesture controls and NFC interaction. In the future research it would be important to address the questions left unaddressed due to lack of possibility to deploy the system into actual location for long term testing: Since the uploading interaction requires the android application what is the proper way to disperse the application to the users. Original idea was to supply the display with a QR code to provide download link for the application. The long term research would also be required to map what kind of content users would be willing to publish. The results acquired from this study don't describe the content users would contribute in depth. Even more so since the results come from laboratory experiments. In addition comprehensive research of the deployment context is relevant to providing successful content and to provide guidelines to the users on the content creation.

For actual use in public places the system needs more comprehensive security features and control over the content. Does the system need an assigned administrator who removes inappropriate notifications or would some sort of community approval system for the messages be adequate? The commercial aspect of the system should also be addressed: Who is going to pay for the upkeep of the system and why? Other critically important factor is to map the community and culture of the designed location of SBB systems as our research and related works deem the context related content as a critical factor in success of this kind of public display system. The multiuser aspect of the system could also be studied upon since many of the related works stated that people tend to use public displays in groups rather than alone (Peltonen, et al., 2008) (Hosio, et al., 2010).

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APPENDIX 1: CONTINUATION SESSION QUESTIONS

Background Information:

1. Occupation?
2. Age?

Questions:

1. (If there was anything that popped out during the user test like user reaction or other points of interest they should be attended here. Adjust depending on circumstances)

2. How did you find using the community board?
3. How did you find using the mobile application?
4. How would you describe the experience?
5. Was anything particularly easy or hard?
6. How did you find using gestures as an interaction technique?
7. Are there any issues related to using gestures in this context?
8. How would you feel about using gestures for interaction in a public setting?
9. Did you feel that the application restricted publishing content in some way?
10. What kind of content would you want to grab from the smart board? (discount tickets, maps… etc)
11. What did you think about the visual look of the content sharing board?
12. Where do you think this kind of interaction system would fit the best? (Why?)
13. Do you see yourself using this kind of service in the future?

APPENDIX 2: CONTINUATION SESSION TASKS

Task	Goal	Approx. time consumption
Task 1: Add a simple text message to the board. It can be anything you like. Don't put date or picture at this point	Test the basic interaction	3 min
Task 2: Search an item left by your friend "Severi" and pick it to the phone. (The message is customized for the interviewee)	Test the motion detection interaction and the visibility of the information. And how the interviewee feels about personal messages	3min
Task 3: Add item with a picture to the board. "You want to show everyone how cool the Simspace area is. Take a picture of it and tell something about it."	Test more advanced functionality of the application. Which is adding a picture to a post.	3 min
Task 4: Pick up a date for a certain event to your phone.	Test Motion detection interaction and finding specific data.	3 min
Task 5: Add an event about a protest against global warming you are organizing with date, email address and time to the information wall. So that people can contact you and let you know they are coming.	Test how adding different kinds of data works. Is adding email, date and time intuitive.	3 min
Task 6: Search for an email address with which you can sign up to a social event. The event in question is Wappu masquerade	Test how intuitive the different data types are.	3 min

APPENDIX 3: ATTRAKDIFF SURVEY

1	Human	☐☐☐☐☐☐☐	Technical
2	Isolating	☐☐☐☐☐☐☐	Connective
3	Pleasant	☐☐☐☐☐☐☐	unpleasant
4	Inventive	☐☐☐☐☐☐☐	Conventional
5	Simple	☐☐☐☐☐☐☐	Complicated
6	Professional	☐☐☐☐☐☐☐	Unprofessional
7	Ugly	☐☐☐☐☐☐☐	Attractive
8	Practical	☐☐☐☐☐☐☐	Impractical
9	Likeable	☐☐☐☐☐☐☐	Disagreeable
10	Cumbersome	☐☐☐☐☐☐☐	Straightforward
11	Stylish	☐☐☐☐☐☐☐	Tacky
12	Predictable	☐☐☐☐☐☐☐	Unpredictable
13	Cheap	☐☐☐☐☐☐☐	Premium
14	Alienating	☐☐☐☐☐☐☐	Integrating
15	Brings me closer to people	☐☐☐☐☐☐☐	Separates me from people
16	Unpresentable	☐☐☐☐☐☐☐	Presentable
17	Rejecting	☐☐☐☐☐☐☐	Inviting
18	Unimaginative	☐☐☐☐☐☐☐	Creative
19	Good	☐☐☐☐☐☐☐	Bad
20	Confusing	☐☐☐☐☐☐☐	Clearly structured
21	Repelling	☐☐☐☐☐☐☐	Appealing
22	Bold	☐☐☐☐☐☐☐	Cautious
23	Innovative	☐☐☐☐☐☐☐	Conservative
24	Dull	☐☐☐☐☐☐☐	Captivating
25	Undemanding	☐☐☐☐☐☐☐	Challenging
26	Motivating	☐☐☐☐☐☐☐	Discouraging
27	Novel	☐☐☐☐☐☐☐	Ordinary
28	Unruly	☐☐☐☐☐☐☐	Manageable

APPENDIX 4. PRELIMINARY PHASE SURVEY

1. I think the smart bulletin board is an interesting concept
2. I could imagine myself using systems similar to smart bulletin board
3. Controlling the board with motion detection controls from a distance fits well to the concept
4. I think transferring data from public system to personal device is an important feature.

APPENDIX 5: IMAGES FROM THE RAILWAY STATION CONTEXT