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UNIVERSITY of OULU

PERSONALISED DISPLAYS

Stage 1: Design

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Purpose of the project

Public displays are starting to become more popular every day, but they still have a low interaction rate with the potential users. Most of its use is based on advertisement, which, although it's a revenue for the owner of the display, doesn't provide all that it could to its potential consumers. This types of public spaces are very powerful since they give interactivity and dynamic functionalities to people around it, but the downside is either that the information shown is very generic so that it's useful for everyone that approaches, or it displays too much data so that anyone can find the information they want. This situation limits the richness of the interaction as well as the possible uses of a public display.

Our purpose with this project is to provide more relevant information in public displays through automatic personalization of the content is shows by leveraging the fact that most users carry a smartphone with internet connectivity at all times. This will be achieved by mimicking a bulletin board and transforming it into its digital version which is not only smart but interactive and dynamic. By being digital, more organized layouts could exist compared to the current ones seen on Figure 1 and 2 and much more data could be displayed at the appropriate time while consuming less physical space. The organization is key, since bulletin boards have a big flaw which is that finding content on them is hard. Updates are not as frequent and certainly less visible when they happen, since changing one of the posters doesn't immediately trigger a response from the user.

Figure 1. Bulletin board on the Infinite Corridor at MIT (2004) [35].

Figure 2. A bulletin board from a Starbucks [36].

With this, we would like to find if users are more likely to interact in public spaces if the content is tailored for them when they approach as well as the pros or cons the digital counterpart of a bulletin has versus it. This also gives us the opportunity to explore personalization for groups instead of individuals, as well as study how much information are consumers willing to give in exchange of more tailored information.

Glossary

This section provides a brief explanation of the terms relating to the system design document and the project in general. The terms are alphabetically ordered.

User-Centered Design (UCD)

Is the process of designing a system, from the perspective of how it will be understood and used by a human user. Rather than requiring users to adapt their attitudes and behaviors in order to learn and use a system, a system can be designed to support its intended users' existing beliefs, attitudes, and behaviors as they relate to the tasks that the system is being designed to support [1].

Hypertext Markup Language (HTML)

Is the set of markup symbols or codes inserted in a file intended for display on a World Wide Web browser page [2].

Cascading Style Sheets (CSS)

Is a style sheets that describe how HTML elements are to be displayed on screen, paper, or in other media [3].

JavaScript

Is a programming language commonly used in web development [4].

Nginx

Is an open source HTTP server and reverse proxy, as well as an IMAP/POP3 proxy server that is one of a handful of servers written to address the C10K problems. Unlike traditional servers, NGINX doesn't rely on threads to handle requests. Instead it uses a much more scalable event-driven (asynchronous) architecture [5].

Apache web server

Is a freely available Web server that is distributed under an "open source" license [6].

Go Programming Language (golang)

Is an open source programming language that developed with the purpose of easy, reliable, and simple software building [7].

Application Program Interface (API)

Is a set of routines, protocols, and tools for building software applications [8].

Bluetooth

Is a wireless technology enables communication between Bluetooth compatible devices. It is used for short range connections between desktop and laptop computers, PDAs, digital cameras, scanners, cellular phones, and printers [9].

Wi-Fi

Is a wireless networking technology that allows computers and other devices to communicate over a wireless signal [10].

Airmong-ng

Is a script that can be used to enable monitor mode on wireless interfaces [11].

Generic Attribute Profile (GATT)

It defines the way that two Bluetooth Low Energy devices transfer data back and forth using concepts called Services and Characteristics. It makes use of a generic data protocol called the Attribute Protocol (ATT), which is used to store Services, Characteristics and related data in a simple lookup table using 16-bit IDs for each entry in the table [12].

PayPal

Is a Web-based application for the secure transfer of funds between member accounts. It doesn't cost the user anything to join PayPal or to send money through the service, but there is a fee structure in place for those members who wish to receive money. PayPal relies on the existing infrastructure used by financial institutions and credit card companies and uses advanced fraud prevention technologies to enhance the security of transactions [13].

Redis

Is an open source key-value database sponsored by Pivotal. Is written in ANSI C and runs on POSIX systems such as Linux, Mac OS X and Solaris. It can be accessed by applications through its client API library [14].

Go-socket.io

Is an implementation of socket.io in golang, which is a realtime application framework.

It is compatible with latest implementation of socket.io in node.js, and supports room and namespace [15].

HTTP request multiplexer (Mux library)

It implements a request router and dispatcher. It matches incoming requests against a list of registered routes and calls a handler for the route that matches the URL or other conditions [16].

PostgreSQL

Is an open source relational database management system (DBMS) developed by a worldwide team of volunteers. PostgreSQL is not controlled by any corporation or other private entity and the source code is available free of charge [17].

Transport Layer Security and Secure Sockets Layer (TLS/SSL)

Both of which are frequently referred to as 'SSL', are cryptographic protocols designed to provide communications security over a computer network [18].

Hypertext Transfer Protocol (HTTP)

Is the protocol used to transfer data over the web. It is part of the Internet protocol suite and defines commands and services used for transmitting webpage data [19].

Design process

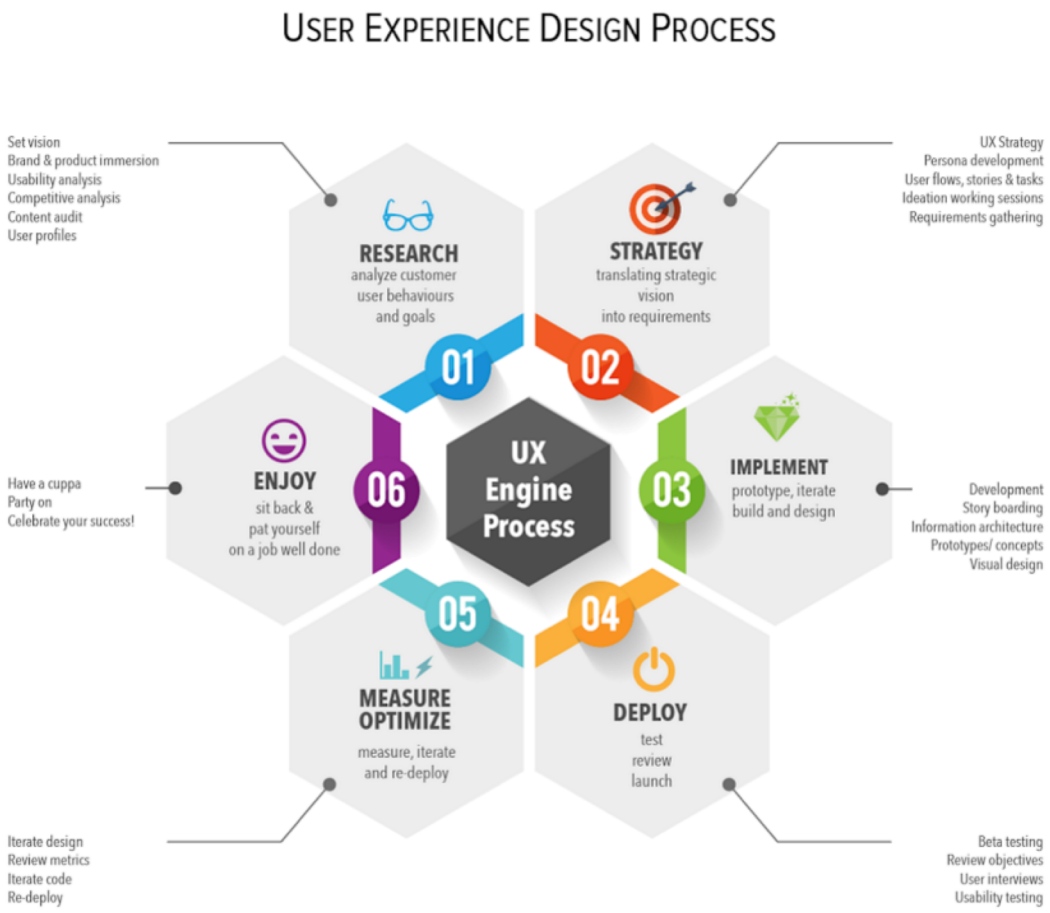

Figure 3. User Centered Design Process [38]. We will iterate phases 3, 4 and 5 until a desired design is achieved

Research

The research phase was dedicated towards a breadth wise investigation of the problem domain and the literature.

1. Brainstorm ideas
    a. Identify capacities of provided devices
2. Assess usability of the suggested system
    a. Identify stakeholders
    b. Identify issues
    c. Why is needed?

3. Literature review
    a. Is there a similar system already?
    b. Discover variety aspects of reported problems
4. Specify goals and features
    a. Observe and list core features of existing service that is similar to ours
    b. What are the requirements?
    c. Feasibility of suggested features?

Each of the above were considered as a within-team deliverables for discussions during team meetings. All team members contributed equally to this phase and also took advices from teaching assistance. During meetings individual ideas were scrutinized, filtered, refined, and finally summarized to generate a cohesive result.

Strategy

The next phase was to ideate and brainstorm. The previous phase had generated information which may not be clarified enough to take further steps, therefore we brainstormed to identify apparent requirements and discuss about arising issues accordingly, then tried to deliver appropriate solutions for that. We spent a considerable amount of time in this phase. There was a various issues with respect to UI design and privacy that were followed by technical difficulties. The workload was equally distributed among the team members and within-team deliverable deadlines were assigned to each as well as weekly meetings.

Implement

The implement phase was dedicated for prototyping and system architecture design. Initially hand-drawn wireframes were prepared followed by a quick and dirty expert evaluation using Nielsen's heuristics [20] and Think-aloud protocol [21].

Web user interface

We have drawn very initial hand-drawn wireframes for each one of the members and narrowed it down into two design options, both wireframes were evaluated by asking simple opinions from our colleagues with a small list of questions, based on that data we selected a design for the hand-drawn wireframe for further design evaluation and later transferred the design to create graphical prototype for iteration.

Mobile user interface

We have drawn initial hand-drawn wireframes for the iterative evaluation. A number of modifications were applied after performing each evaluation. The design was transferred to the graphical prototype for further iteration.

In retrospect, by adhering to our UCD process from Figure 1, we have completed the first and the second phase. The third phase is half-way, the second half will include the programming implementation. Our next deliverable shall explain the latter part of this phase.

State of the art

Now a days, public displays are more and more prevalent in public spaces [3], but a lack of useful ways of interaction exists. Most of the content found in public displays is "almost entirely of non-interactive vertical displays consisting of announcements for services, events, resources, "fun facts," or products, as well as more abstract artistic content" [4]. Not only this, but people have gotten accustomed to them and hence, this displays have become invisible [5]. Several attempts have been made to improve the user experience on them, like studies of the whole interaction between the potential users and the display, like stated by [6], where they studied the interaction phase of user from passing by to a subtle interaction, classified as attention and direct interaction and multiple interaction classified as motivation, and how each of this phases should be tackled differently to enhance the user experience. Furthermore, they, [6], argue that public displays need a balance between capturing attention from people interested, and not annoying people who aren't, as well as enable people to maintain a coherent role in the public.

With this in mind, many studies towards improving the user experience as well as the benefits of this type of interaction have been done. For example, an application to increase civic engagement on young population was done, where public displays were used as a channel of communication with the local government as well as an entertaining activity [7]. Other type of approaches have dealt with crowdsourcing problems for situated public displays, like queue estimations of restaurants by users that can then be used by others in different locations to display useful information about the queue on a potential destination restaurant [8]. This system also merged the use of mobile phones as potential windows to the information gathered by others. With it, they, [8], managed to reduce unoccupied time and create a better waiting experience for their users.

Other types of applications have emerged from the idea of personalising displays, this time not using the smartphones just as a viewing window into the collected data, but as a real interaction with the displays. Personalisation of content has been done leveraging the use of Bluetooth from users' smartphones. In [9], they used the device's Bluetooth name to personalise content in public displays. With it they showed information like maps, pictures, YouTube videos, Google search results, generic web addresses and music. Other systems like Tacita [10], focus on the architecture by tackle many problems of personalising displays, specially privacy and security. They are built to avoid open communication from the phone towards the public displays, and instead the phone recognizes a display in the vicinity and then starts personalising, in this way avoiding just broadcasting the content.

Digging deeper on personalising public displays, different levels of personalisation have been recognized as [11] shows. First, personalised information that must not be shown in the public. Second personalised information that can be shown in the public, and finally personalised information that can be shown in the public if no direct link exists to the source.

Looking closer to the topic at hand, bulletin boards have been studied and tried to be replaced by public displays. This has been passively happening as advertisements fill this public spaces, which before were in posters, but closer approaches exist. Context aware public displays were created as an addition to the paper based notice boards in [12]. They analysed the use of the paper based equivalent and classified posters in actionable and non-actionable ones. The actionable posters had deadlines, like exams, while

the non-actionable didn't, like snippets of news. With this in mind they created two systems, a news display for actionable information, which is not context aware and is just shown as they are created, and a reminder display that show actionable posters at opportune moments depending on the location and the time the display was situated. With this study, they found out that the update rate of information is extremely important, as well as the balance of how much actionable posters versus non-actionable posters were shown. And finally they found out that the displays should be placed in entrances so that users at least have to see them twice, and in waiting areas to maximize viewing time.

Our system takes both worlds, both context aware public displays, which display content appropriate to the time and place where they are, but shows personalised content that is of interest of the passer-by's, and in this way it can provide useful information for everyone.

Scenarios

We created four personas. One is Olli who is a first year student of the University of Oulu. The second one is Risto is another student of the University of Oulu who is more into everything new in the University. The next one is Charlie, a student of master in education that lives in another city than his parents, so he has to pay for rent and everything his parents paid back home. He has an income from the government, but he is used to having certain luxuries that his current income can't support. Lastly there is Esa, who is 30 years old and studies information engineering in the University of Oulu. He uses computer on a daily basis and has years of working experience in developing android and web applications. He is an expert in computer systems although he has only experience on IOS platform. He is currently looking for a job as a mobile or web developer as he is about to graduate, and interested in job conferences or such events that take place in the Oulu area. Based on this personas we created four scenarios.

Scenario 1

First year student in University of Oulu named Olli is walking from guild room to the class but his not quite sure where the class is held. As it happens the third year student Risto is heading to Aula kahvila and walking just in front of Olli. Olli is starting to feel desperate because as a typical introvert finish man he's not in fond of conversation with another human being. Luckily Risto has installed awesome personalized public display application in his phone and connected it to his WebOodi account. When Risto and Olli approaching little hall nearby their guild room the public display in the hall switches its content. Risto and Olli both notice this sudden change on displays content. When Risto sees the new content which says that UBI lecture is about to start in TS102 he remembers that he has enrolled to that course but had totally forgot it's starting today. Same time Olli looks at the changed content on screen and familiar course name and arrow pointing the direction where the class will be held. Because of this subtle change of content in public display Risto might pass this course this year and Olli was able to find the classroom.

Scenario 2

Charlie was going to the University for the first class of Finnish for foreigners. He is parking his bike and takes his phone out to check where his class is. He reads IT-113 and he knows that classroom is on the other side of the Uni, but isn't quite sure where. He starts walking on that direction and sees on the distance a display with some arrows pointing forward and right. He tries to get closer to see what the arrows point at and when he can read what it says he sees the arrow pointing forward with a text next to it saying "Finnish for foreigners" and "IT-113". So, he feels reassured that he is walking in the right direction. Farther on the path he sees another display and now gets closer expecting to see an arrow to his class, but he sees another two classrooms but not his. Then he sees a message next to the display saying scan to personalize. He still has some time, so he scans the code and downloads the app. He meets a friend who knows where the class is, so he walks with him. After class he follows the instructions on the app and finds out the displays he had seen before personalize the content for the people around them who have the app.

Scenario 3

Charlie finally managed to set up the app and continued his normal life, actually forgetting the app completely, like most of the apps he downloads. He is in real need of a job since his parents told him they can't send him more money. He starts going to the bulletin boards in the Uni to try and find a job, and finds it really difficult. It's a wall, full of advertisement, and nothing is organized, so he has to go one by one to find what he needs, a job offer. He starts finding job offers but for something he is not qualified for. He knows there is another bulletin board in a different part of the University, but decides to go home for that day since he is tired. On his way home a display he is passing by moves and shows there is a party the next day which he is attending. He thinks to himself it's good this was there since he had forgotten completely. Then he starts seeing the rest of the content of the display, and sees an offer of a job by the Red Cross. He taps on the screen and his phone vibrates. He looks and sees detailed information for the job offer he is interested in. He decides to check it later when he gets home, happy because he finally found something useful in a place he actually didn't expect, but that will remember from now on.

Scenario 4

Esa is a 30 year old student in the department of Information engineering in the University of Oulu and has been developing computer systems for over 7 years, this consists 5 years of working experience in a IT company located in Oulu region. This has been taking already 10 years to graduate for him as he had to work and study at the same time. He is specialized in developing computer system in general, more specifically in the domain of mobile and web application. However he had only worked on IOS platform thus not as familiar with android interface as IOS interface. For his last project at the university, he is taking Mobile and Social computing course and there he is obligated to conduct android application development. Currently he is not working for any companies but is hoping to find one as soon as possible. When he was walking through the main lobby of the university, he found a display unusually activated that looks bit like a bulletin board at the university. This attracted him to invest more about the system by approaching closer to the display. Since he is relatively well known of such computer system architecture and design, he first try to tap on the title in which he found under the category of

JOB. As a response, he triggers a small pop up window at the location he just interact that it says “open here” or “send to mobile”. He immediately notices that this system could cooperate with a mobile application. Then he installed the application on a testing mobile that he is provided for the course work. Although he is not the best one with android mobile interface, he was able to add tags of his interest in settings as the UI design was coherent and consistent as if that is been used in many other computer system interfaces. A moment passed, he realized the contents switch to another and there he finds job offers for IT companies as well. He then taps on again without hesitation. He selects “send to mobile” as the same pop up window appeared on the display. He gets a notification of something on the mobile and was able to read details of the offer by opening the notification tap. Overall he was happy to figure out such useful system in the university and surprised the simplicity and intuition of the system design interface.

Use-Case

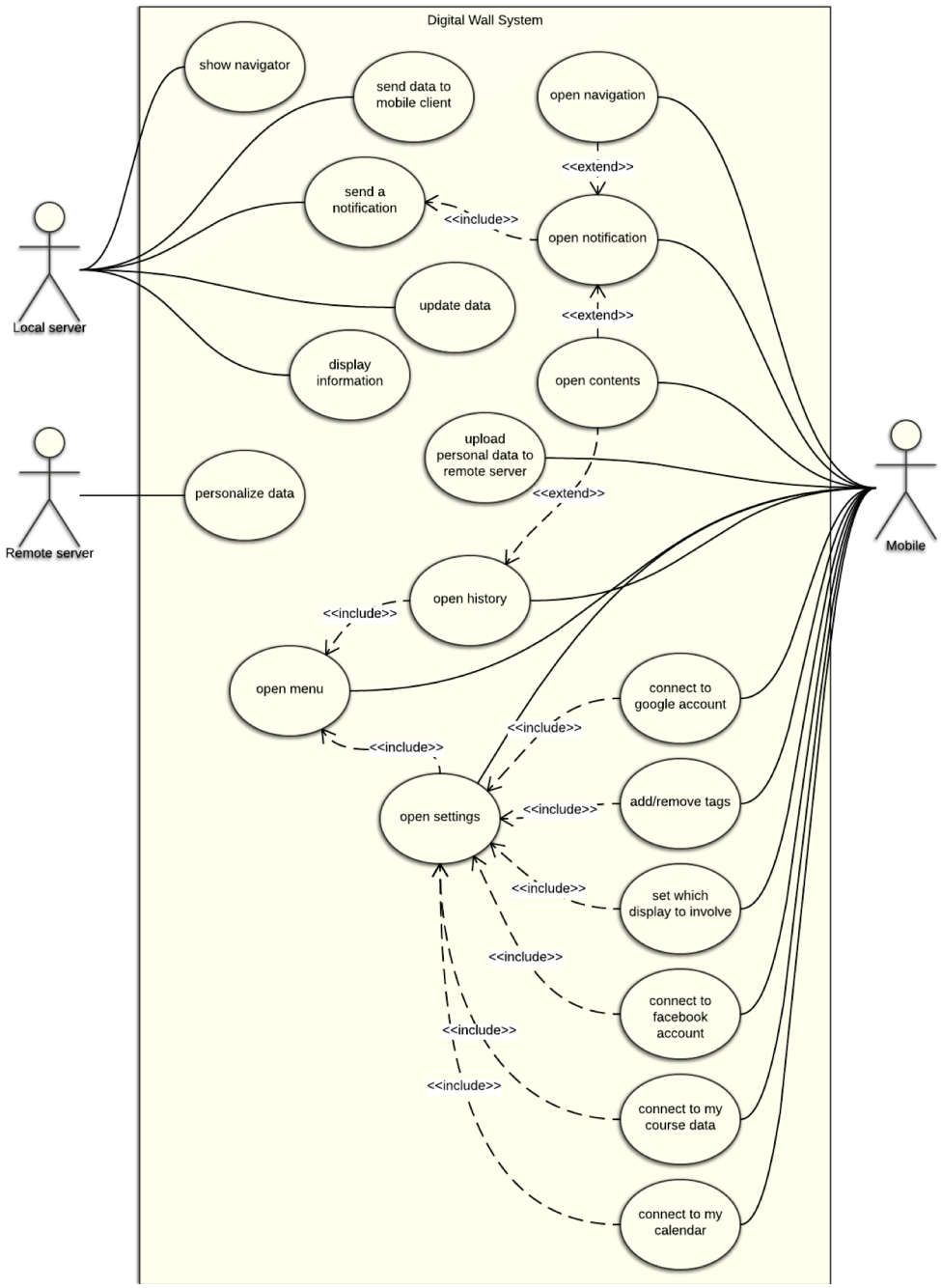

Figure 3. Use-Case Diagram

Requirements

Here the term ‘navigator’ refers to the left top section of the display, here the term ‘bubble’ refers to the right top corner section of the display, here the term ‘body’ refers to the section in which fosters, categories and other personalized data are displayed on the display, here the term ‘navigation’ refers to the google map feature with indoor map on the mobile, here the term ‘system’ while it represents the entire system, each device that we utilize is also called system with an addition descriptive word that specifies which system it is (i.e mobile system, display system).

Original requirement

As quoted in the requirements document from the Applied Computing Project coursework, the original requirements were started as follows:

“This project explores personalising public displays using data from users’ smartphones (mobile sensing)”

The original requirement is well started. To clarify it, we have arranged a number of brainstorming sessions within team members and a few times with the teaching assistance to confirm the idea, then we were able to come up with decent ideas that theme of the project, which data to personalize and how to arrange them intuitively on the public display as described below.

Statement of Need (SON)

Using the scenarios from the previous section (Personas, Scenarios, & Use cases), brainstorming and UI usability evaluation we have selected a list of requirements specified as below.

1. Student who’s looking for a lecture room for his/her course shall be able to utilize navigation that comes with an indoor map of the university and with a marker at the location of the room, also navigator directs him/her to the rough direction of the lecture room in the earlier stage.
2. Students who are looking for information
    a. Student who’s passing by the display will be able to find general personalized information in a form of bulletin boards in the university campus.
    b. Student who’s sharing additional personal data such as calendar, social media with the system will be able to find recommendations for public events, schedule, and other useful information as well that are underlying his/her interest.

Functional / Non-functional requirements

The above SONs are generic and hence we decided to boilerplate them. This will make our task easier to identify functional and non-functional requirements. The boilerplate used is - <stakeholder> shall be able to <capabilities><performance or constraints>. <capabilities> are the functional requirement of the

system, while <performance or constraints> are the non-functional or performance requirements of the system. The boiler-plated SONs depicting the functional and non-functional requirements are:

1. The <**user**> shall be able to <**capability**> on/from/by display <**performance or constrains**>
    a. The <user> shall be able to <be identified> <if he/she is close to the display system>
        i. The <user> shall be able to <be notified about the system> <if he/she is close to the display system>
        ii. The <user> shall be able to <connect calendar data> <if he/she wishes to>
    b. The <user> shall be able to <remove/hide contents being shown> <if he/she interacts with the display system>
    c. The <user> shall be able to <find direction of the lecture room in the navigator> <if he/she is close to the display system>
        i. The <user> shall be able to <find posters in the body in accordance with his/her interest> <if he/she is close to the display system>
        ii. The <user> shall be able to <find categories of contents in the body in accordance with his/her interest> <if he/she is close to the display system>
        iii. The <user> shall be able to <find personalized data in the bubble> <if he/she is close to the display system>
        iv. The <user> shall be able to <find course names in the body in accordance with his/her course registration> <if he/she is close to the display system and the course registration data is configured to share>
    d. The <user> shall be able to <send information in the navigator onto the mobile system> <if he/she interacts with the display system>
        i. The <user> shall be able to <send details of selected contents in the body onto the mobile system> <if he/she interacts with the display system>

2. The <**user**> shall be able to <**capability**> onto/on mobile <**performance or constrains**>
    a. The <user> shall be able to <connect facebook data> <if he/she wishes to>
        i. The <user> shall be able to <connect google data> <if he/she wishes to>
    b. The <user> shall be able to <configure which display to engage the data to personalize> <if he/she wishes to>
        i. The <user> shall be able to <configure category tags for showing on the display> <if he/she wishes to>
    c. The <user> shall be able to <find history of contents that he/she has read before> <if he/she has obtained the information in advance from the display system>
        i. The <user> shall be able to <find navigation to navigate to the lecture room> <if he/she has obtained the information in advance from the display system>
        ii. The <user> shall be able to <find details of the content selected on the display system> <if he/she has obtained the information in advance from the display system>

Privacy requirements

As our system is designed to be used in a public space we have severe concerns regarding privacy. According to the result from the UI design / usability evaluation, users in general don't like to share or expose their personal data but controlled in certain level of revelation i.e anonymous data exposure etc, thus we have added some of additional feature requirements that are also categorized as functional/non-functional requirements.

1. Users should be able to decide which data not to share
    a. configure feature to connect/disconnect personal data from the social media
    b. configure feature to connect/disconnect course data from the course registration information
    c. configure feature to connect/disconnect calendar data
    d. configure feature to choose which category tags of personalized data to display
2. Display system should not display personalized data when the user is not around
    a. fade away personalized information from the display system as the user leaves
    b. configure feature to choose which display to engage the data personalization

Additionally the focus for this requirement also lies on letting users understood that it is them to decide which data to personalize in terms of privacy concerns.

User interface requirements

We have two different user interfaces, (i) mobile users (ii) web users. As a system is designed to be used in a busy area, we have our concerns on creating best intuitive UI design that ensures users to recognize the contents of the system while walking by such as font size, colour selection and simplicity.

We have developed our both systems' UI design based on the UI design /usability evaluation.

Mobile user interface

The objective for the mobile UI design is to ensure easy to read contents within the relatively small screen. We have referred Google material design library to achieve design consistency.

Web user interface

The objective for the web UI design consists two parts; (i) to allow users understood that the display system cooperates with the mobile system, in other words the display system is interactive (ii) to have users realized that the information on the display system is personalized to them. Also one minor requirement for the navigator design is found during evaluation that the navigator should not mislead users onto wrong direction by such ambiguous design.

Service requirements

As our system is designed to utilize personalized data, selection in stakeholders who provide the data to personalize is critical, thus in this project we delimited the range of stakeholders to the students in university, means that the provided information likely focus on students' interest.

Usability requirements

While respective systems work together within the system, we intend to make users understood the usage of respective systems before having them all in their hands at a time, by achieving that we expect to remove some of the usage barriers that users may encounter when first time use the system, in exemplified cases where an user fails to realize that the display system can extend its capacity to the mobile system for a different usability experience, and thus we provide a screen with tutorial text that guide how to manipulate the system on the mobile system, this would ensure users realizing the mobile system can support the display system, which also indicates to the users by allowing personal data to share through the mobile system they could benefit useful information provided on the display system which are fundamentally underlying their interest.

Performance requirements

For the best user experience, the mobile system should keep the server up to date with the agreed-to-share data within predefined time of interval.

System design

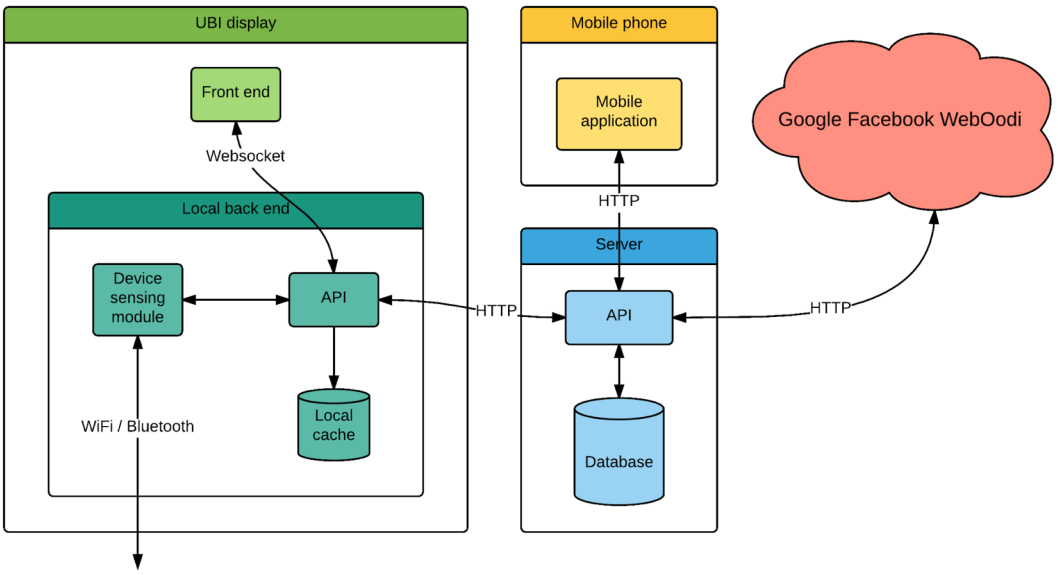

Figure 4. Three tier system design.

At this state design of this system consists of three major components which can be divided into smaller subsystems as displayed in Figure 4. These major parts are UBI display, mobile phone and server.

UBI display

The largest subsystem is the UBI display component which contains front end and local back end. Front end will be build using html, javascript and css and it communicates with local back end through socket.io websocket library. Depending on access level on UBI display the static front end files will be served with Nginx or Apache web server.
Local backend will be built with golang which allows fast and easy deployment with static binary files and offers great variety of libraries for multiple use cases with build in concurrency patterns. Back end will contain three components device sensing module, local cache and API module. Device sensing module will use Bluetooth and Wi-Fi interfaces to detect passing devices. To make this possible we will use airmon-ng which turns Wi-Fi interface in monitor mode and allows us to detect mac addresses of passing devices. For Bluetooth sensing we will use PayPal's gatt library for golang. Local cache will contain data that needs to accessible within milliseconds to personalize data on display for passing users. At first this will be stored as map of structs in application's memory but can be converted to Redis in-memory data storage if needed. API module will serve as connection point for all modules in UBI display and as a gateway to main server. For websocket connection we will use go-socket.io framework and gorilla's mux library for the http connections.

Main server

The main server will contain two main components; database and API module. For the database we will use PostgreSQL and the API will be built with golang. API acts as a connection point for UBI displays, mobile clients and external data sources. Through this API module the data will be synchronized between data sources and PostgreSQL database.

Mobile application

Mobile application will be native Android application build with android-sdk. This mobile client will communicate with API over http and also receive push notifications from cloud. For push notification we will most likely use Google's cloud platform which allows us to send notifications and easily capture those on mobile device.

Security

To make sure connections are secure and data is safe we use TLS/SSL with all HTTP connections. The connections from UBI displays to main server will be authenticated with access tokens which are provided in deployment. The connections from mobile application to API are identified and authenticated with WebOodi credentials. The connections from API to external data sources are authenticated with API keys provided by external data sources such as Facebook and google.

Interface design

We created different designs for the public displays based on the features and ideas we had for the system, thinking of our initial objective which was to make personalised public displays. This are the wireframes of the first ideas:

Wireframes

Idea 1: This was an idea shown in Figures 5 to 8 was based on a graph in which the user's name would be in the centre, and around it would be information of his interest. Then when the user tapped something, the display would split in two parts, one showing information which requires higher privacy and another with less, as shown in Figure 6.

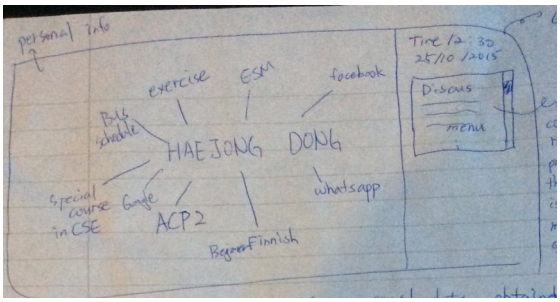

Figure 5. Graph format with user's name in the center.

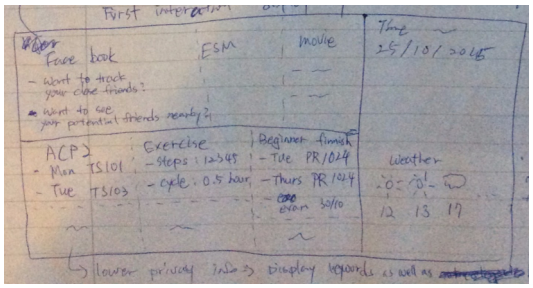

Figure 6. Three containers (top - high privacy info, bottom - low privacy info, right - generic information like weather).

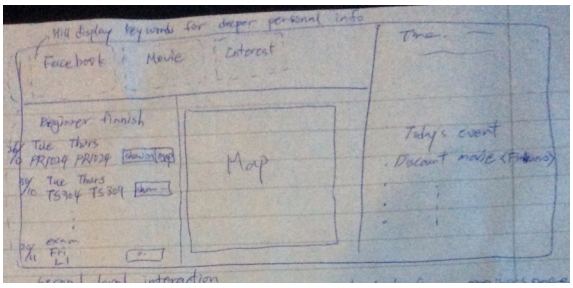

Figure 7. Navigation system on the bottom left, special keywords for deeper interaction top right, general information on the right.

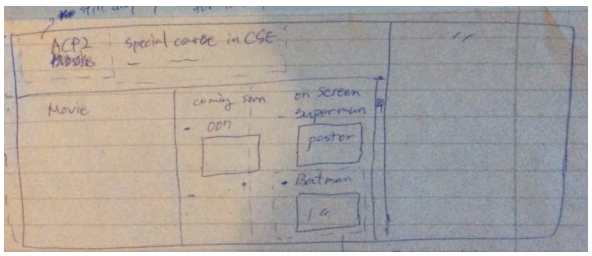

Figure 8. Deeper interaction UI.

Idea 2: This idea was centred around navigation specifically in the university. Some advertisement would be shown on the top and a list of courses on the side.

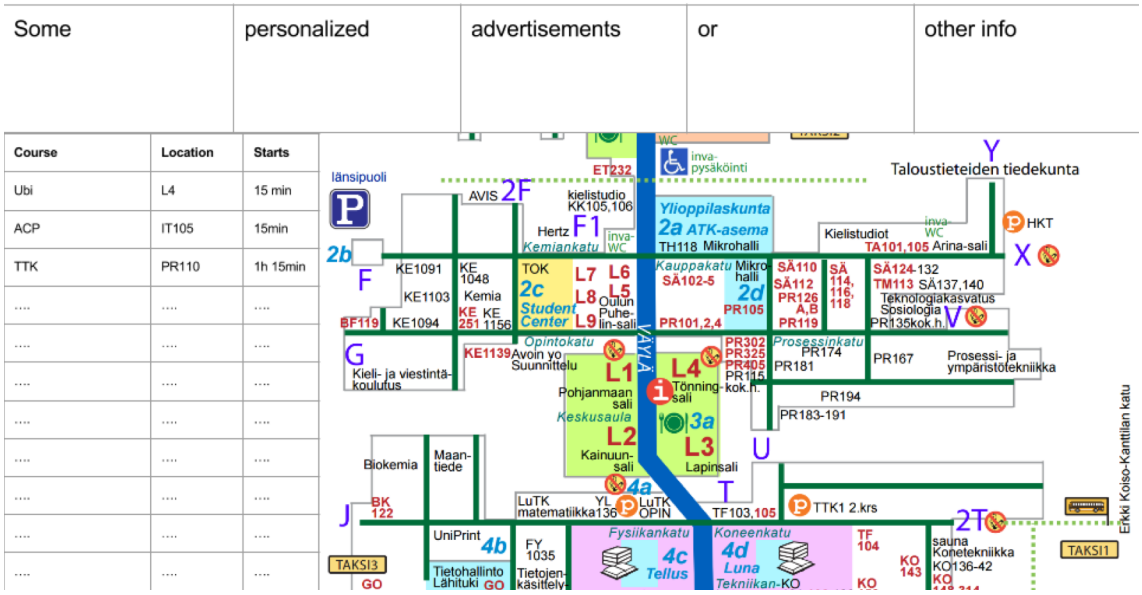

Figure 9. Navigation centred interaction with advertisements or other information on the top. Courses on the left and a map on the right for the courses.

Idea 3: This idea was a mixture of navigation and other personalised content, having some big images for users standing far or just passing by, as well as some content of the day in the top right corner.

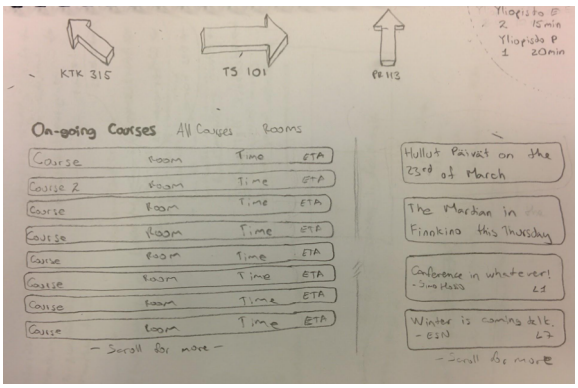

Figure 10. Directional arrows on the top. Semi circle to attract attention on the top right. courses on the bottom left and news and events on the bottom right.

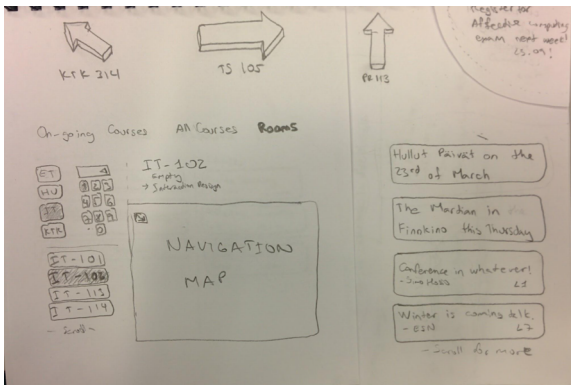

Figure 11. When navigation is required, the courses are replaced with a map to the destination. The top right corner is personalised for a user arriving so he sees something to approach.

Based on this wireframes, we discussed them and asked several people for input, after which we took ideas of each and created the following three sketches. The map was removed from the public display since most of the feedback mentioned it was useless since the users had to memorize it for it to be useful. We also decrease the level of personalisation till the point where people are not identifiable anymore since our participants mentioned concerns in several occasions when the thought of their privacy being displayed.

Sketches

Based on these ideas and some feedback a new design was created inspired by bulletin boards. Since now our approach removed the map and we didn't want to show content to personal in a public space, the most similar real world example of what we envisioned were the bulletin boards, which show content anyone can read but that as well can be trying to target a very narrow group of people. We created 3 sketches of the public displays with this new concept in mind which Figures 12 to 14 show.

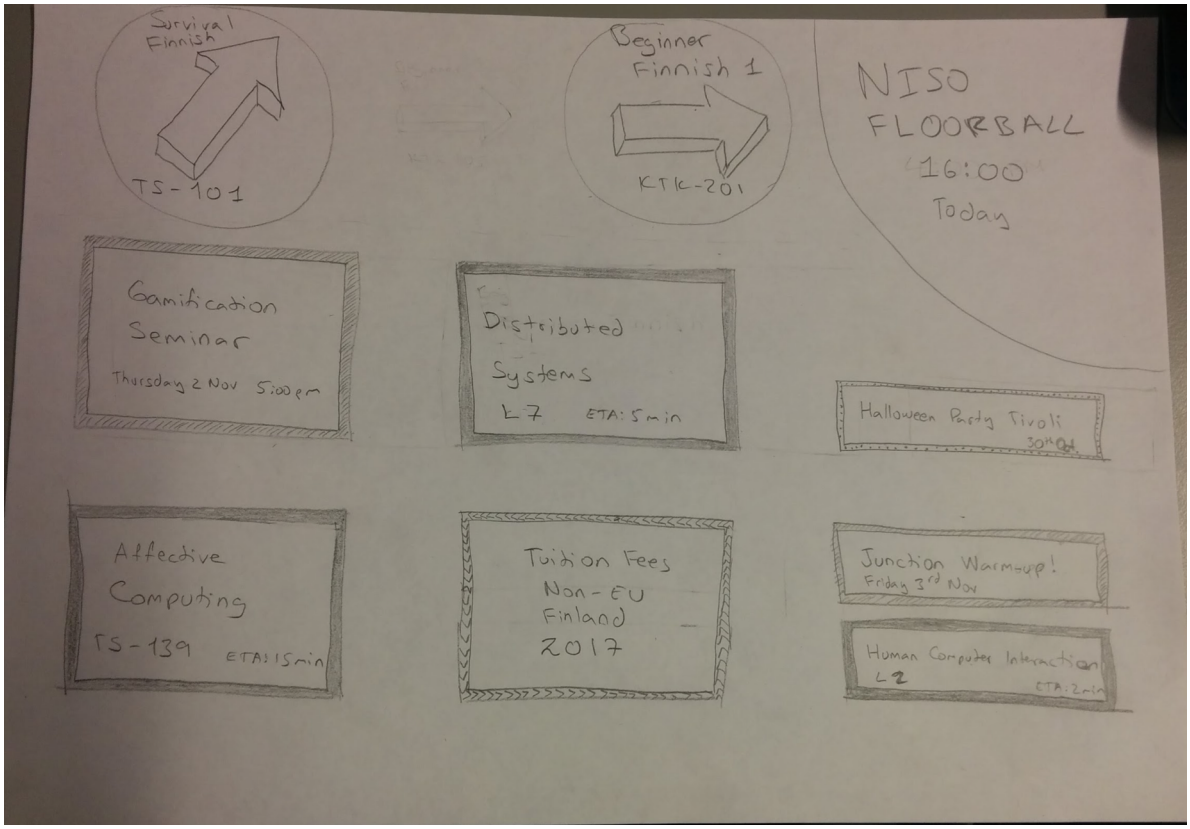

Figure 12. Idea of similar data colour coded with top right bubble and navigation arrows.

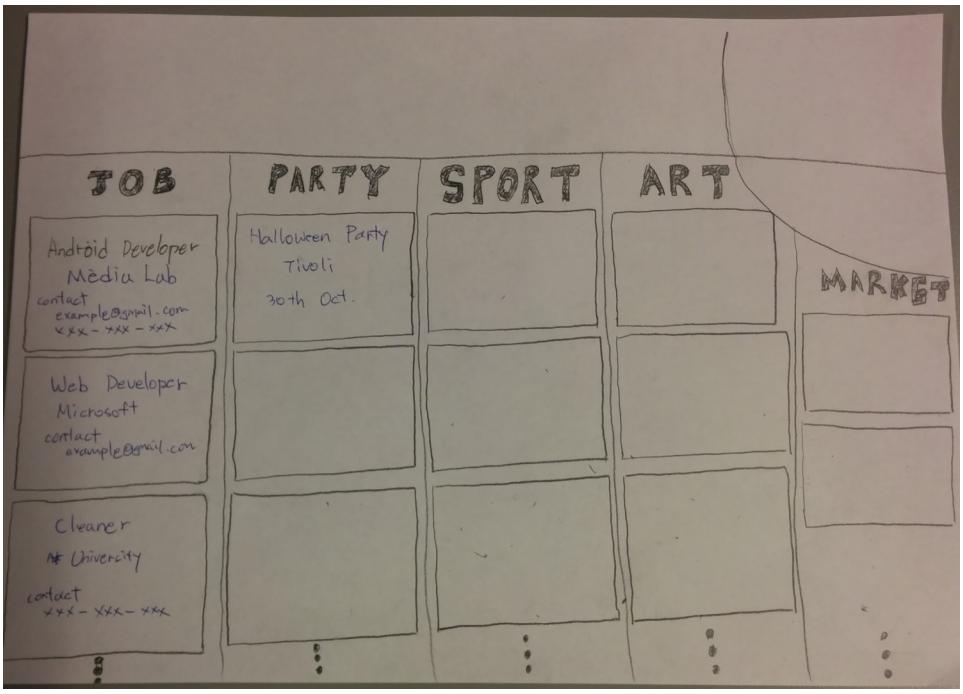

Figure 13. Similar data organized in categories under a title with scrollable columns. Top right bubble and a navigation row.

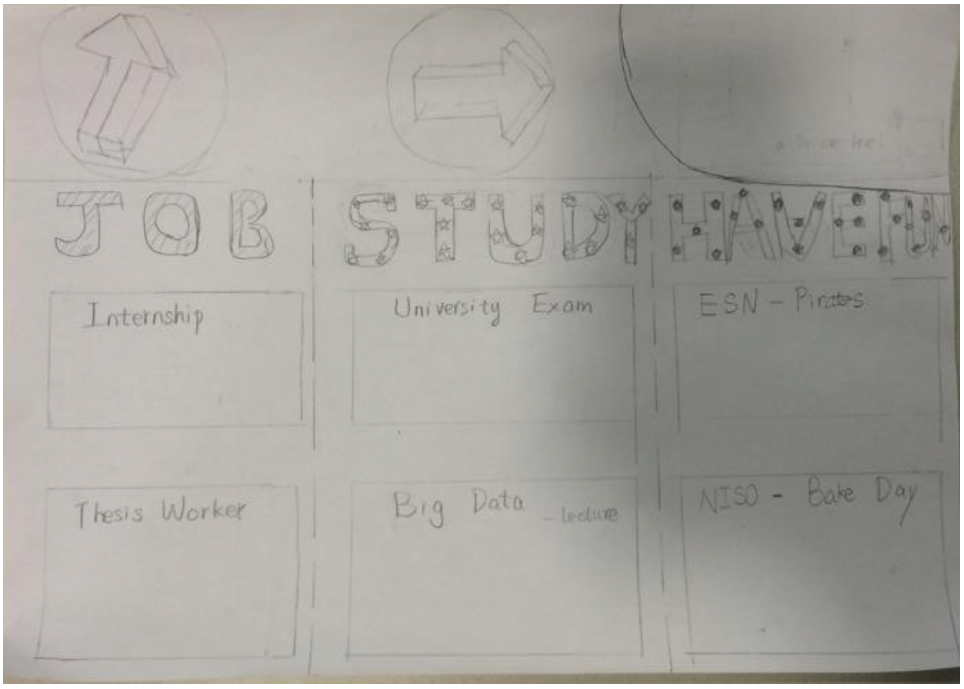

Figure 14. Second design of data organized in categories under a title.

All of this designs, although were done independently, were based on the wireframes of the third idea of the previous step. The bubble of todays events was maintained on all of them, as well as a top row for navigation. The difference in this were more focused on how to show the content. With this sketches we did some evaluations to decide which features should stay and which should go, as well as adding new features.

Paper prototypes

After evaluating the different sketches, we came up with the following paper prototypes which kept the idea of the bubble and the navigation pane, and categorized the content with titles instead of colours.

Public display

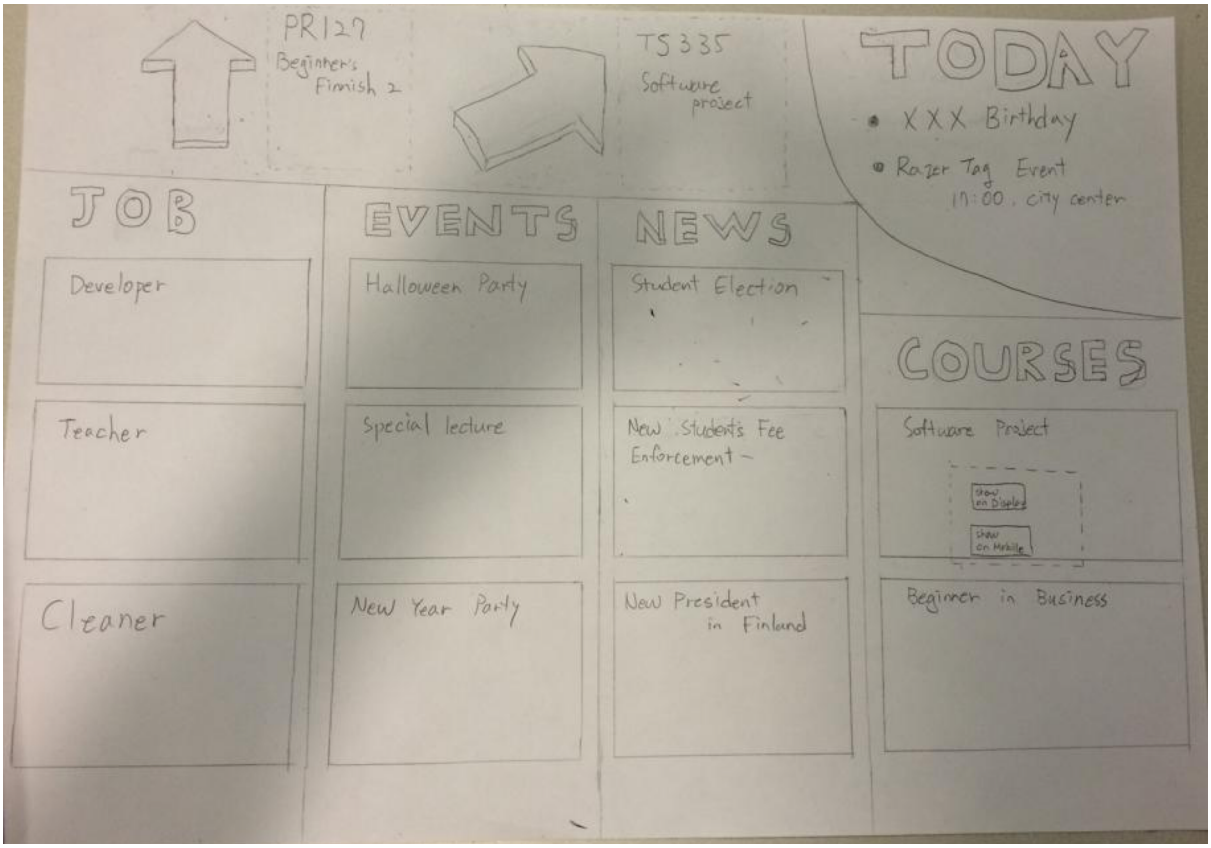

Figure 15. Paper prototype public display in a bigger size.

Figure 15 shows the paper prototype done to do some evaluations on the almost final design of the system. This was done on a big piece of paper to try to simulate the size of the public displays that will be used to deploy, although it was still smaller.

Smartphone Application

Since the project is based on personalising public displays, until this moment the UI of the smartphones that were going to be used just to personalise the content were not thought of, but since now the users would see the content on their own phones, the user experience will be highly dependant of the UI of the smartphone app. For this reason, we decided to create some paper prototypes of the phone and evaluate as well. The first time the application opens, the Home Screen is displayed (Figure 16) with a text indicating to use the public displays. A menu would appear from the left (Figure 17), which is used to go to settings (Figure 18) and there configure the content of the public displays.

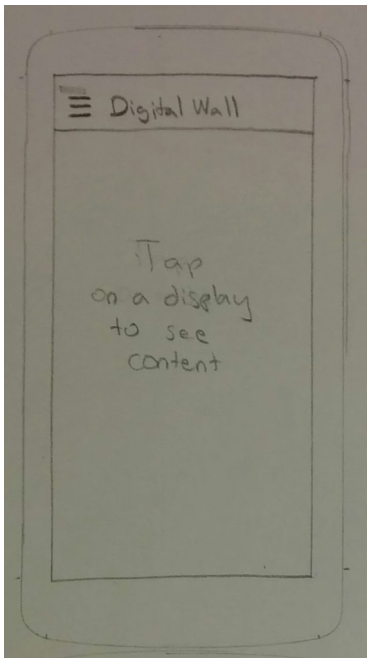

Figure 16. Home Screen.

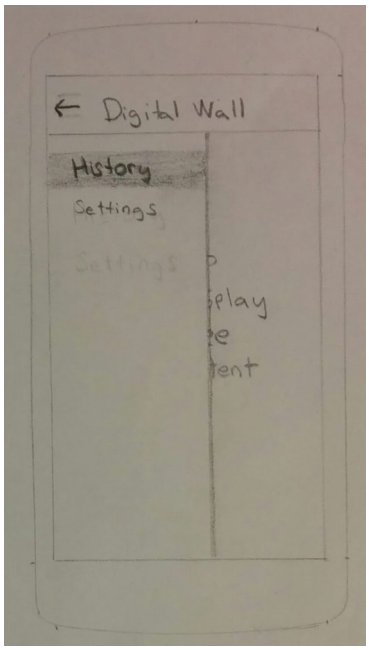

Figure 17. Menu.

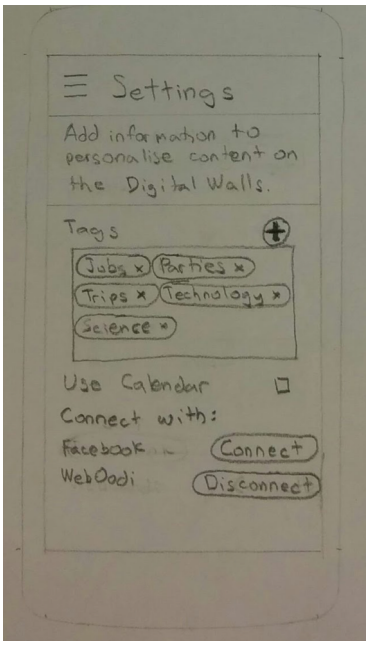

Figure 18. Settings.

From the settings screen, it is possible to add tags (Figure 19) which will be used to personalise the content of the public displays. When the user taps on a public display, a notification will be received on the user's phone (Figure 20) and when opened, the information of whatever he tapped on the screen will appear on the phone, including extra details of contact, content or directions (Figure 21).

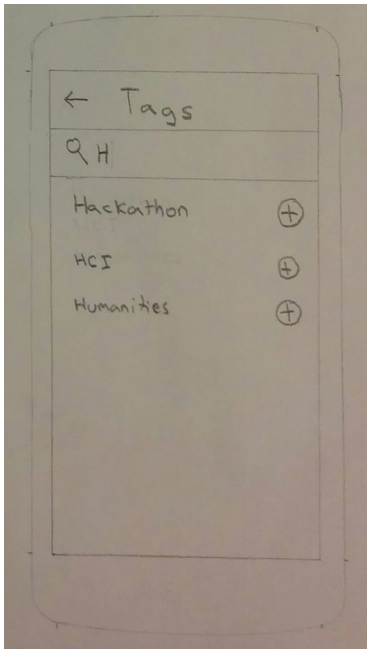

Figure 19. Tags.

Figure 20. Notification from display.

Figure 21. Information from the display.

After a user taps something on the public displays, the app won't show the same content on the Home Screen, but this one will become a History screen shown in Figure 22. This provides an easy way for users to store information to read in the future. Finally Figure 23 shows how the map guidance would look when location based content is tapped.

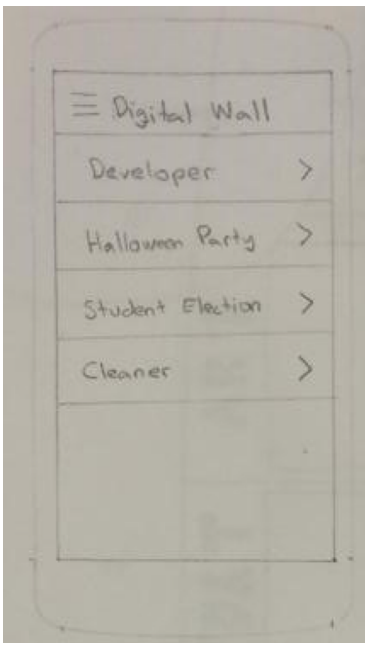

Figure 22. History.

Figure 23. Navigation system.

Evaluation

After evaluating the design with 4 people, we realized that having two main screens, one for history and one for settings was confusing. So, we changed the UI to only have one main screen which is the history of information seen, with a settings button which people can tap to configure the app and come back. We also decided to change the initial text on the application since it didn't explain they should set the application. Another change was the text that asked permission for the user's calendar in order to personalise content on the public displays. Most of our participants were lost on what this meant, so we just added the word "my" to be clear that we want to use their calendars. This changes are shown in Figures 24 to 26.

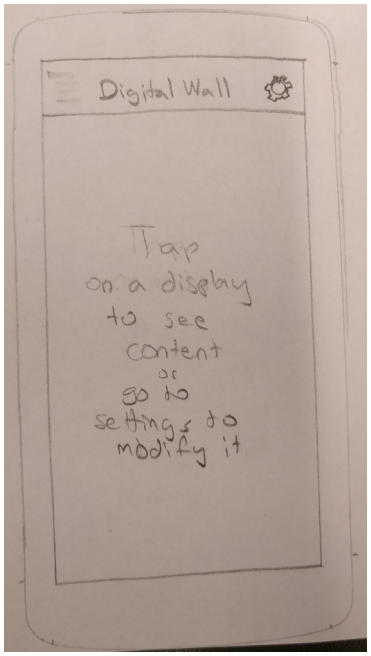

Figure 24. Home Screen with changed text and button for settings.

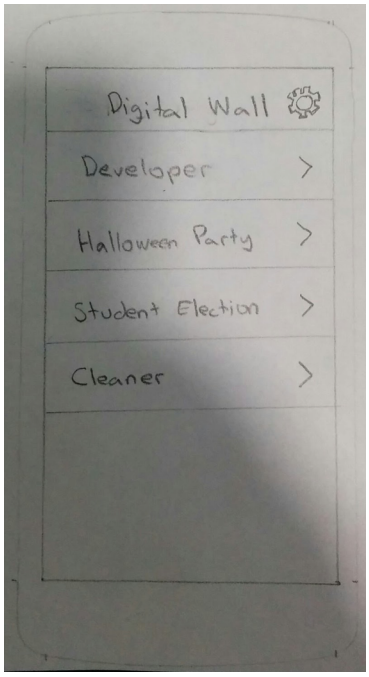

Figure 25. Previous History screen which is now the Home Screen with changed hamburger menu for settings button

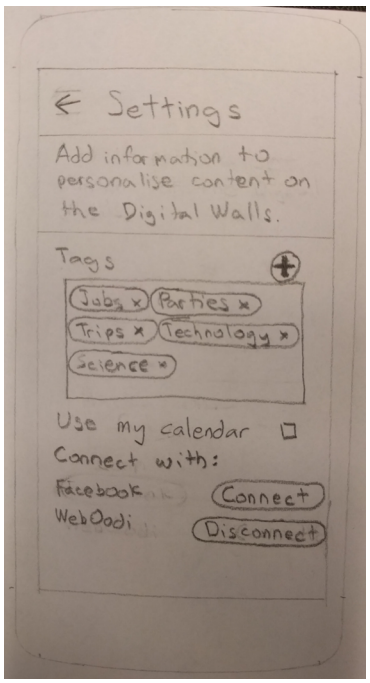

Figure 26. Settings screen with text changes.

After this iteration we created the high fidelity prototypes shown bellow.

High fidelity prototypes

Public Display

Figure 27. Public Display Prototype.

The public display designed stayed very similar to the paper prototype, since the changes necessary were first changed on them and evaluated once more.

Smartphone Application

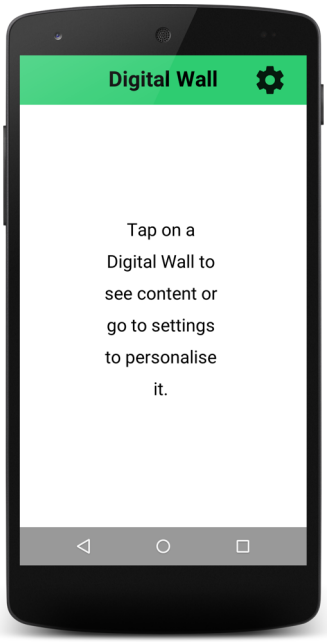

Figure 28. Home Screen Prototype.

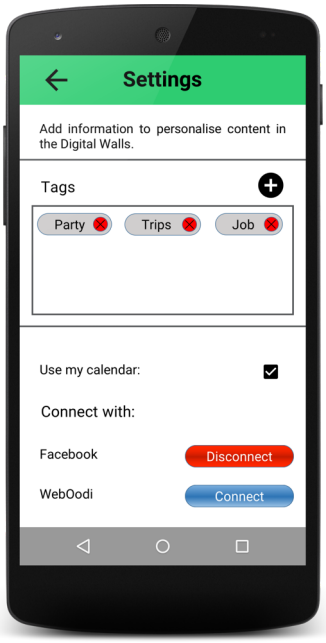

Figure 29. Settings Prototype.

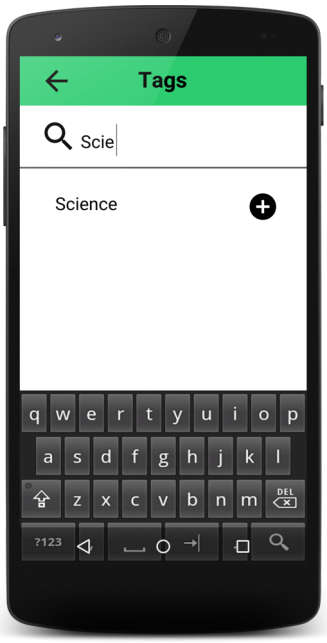

Figure 30. Tags Prototype.

Figure 31. Home Screen with content High Prototype.

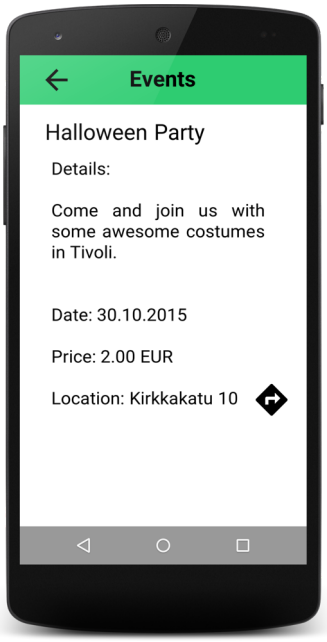

Figure 32. Event screen showing information from the public display.

Evaluation Analysis

It is suggested that Heuristic evaluation and Thinking-aloud protocol have different properties and deliver different feedbacks with respect to evaluation in user interface design [13], therefore we decided to perform both evaluation methods to achieve fruitful usability experience.

As the devices closely cooperate each other within the system, we fulfilled one unified evaluation for the web user interface and mobile user interface.

Heuristic evaluation

Heuristic evaluation [33]was performed on the early-wireframes as it is a quick, cheap, and easy evaluation method of user interfaces.

Method

Participants - The evaluators were three of our classmate taking master's degree programme together in the department of computer science and engineering who had not taken part in the interface design. The evaluators had substantial previous experience in performing Heuristic evaluation.

Design - We created five goals for the evaluators to perform.

Goal 1 - Users should be able to obtain information of "navigator" on the display onto their mobile application

Goal 2 - Users should be able to obtain information of contents of interest on the display onto their mobile application

Goal 3 - Users should be able to connect/disconnect social media data with the system

Goal 4 - Users should be able to find history of prior contents that were opened once or more

Goal 5 - Users should be able to add/remove tags for the preference in data personalization

Materials - The early-wireframes were hand drawn on paper. Printed copies of the 10 Usability Heuristics for User Interface Design was also provided. An A4 paper with the list of goals was used to take notes during the evaluation.

Procedure - The Heuristic evaluation (below HE) was performed in a quiet office to ensure an undisturbed evaluation environment. The web UI wireframe was hung up on the whiteboard to emulate the physical display. This was conducted as a group evaluation (3 evaluators) as it was suggested that it is encouraged to perform HE as a group of evaluators, which would likely bring more variety in feedback and error findings, also the evaluators were allowed to discuss among themselves. The evaluators were seated and provided with the early-wireframe interfaces (mobile). The evaluation session took approximately 30 mins to complete. One of the interface designers took an adjacent seat and was responsible for guiding the navigation. This was necessary as the wireframes were pencil drawings and not instructive in nature. The evaluators were asked to achieve the goals by working their way through the tasks respectively. They decided to break each of the goals down into their appropriate tasks, and

test each in turn. They were encouraged to report all problems irrespective of the severity level. After the evaluation, the evaluators aggregated individual opinions and come into a few suggestions that could enhance user experience and provided general feedback.

Thinking-aloud

Thinking-aloud (originally proposed by Clayton Lewis, 1982) was performed on the early-wireframes as it is cheap, robust, flexible, and easy to evaluate interface.

Method

Participants - The evaluators were four of our classmate taking master's degree programme together in the department of computer science and engineering who had not taken part in the interface design. All the evaluators had substantial previous knowledge in generic computer system.

Design - We created five tasks for the evaluator to perform, at the end of the evaluation we handed over a questionnaire for the evaluator to answer.

Task 1 - change the configuration on the mobile (specific type of configuration was varied each time however, on the same screen)

Task 2 - find information of Halloween party

Task 3 - attain navigator for the beginner's Finnish 2 course

Task 4 - find information of Halloween party using your mobile

Task 5 - remove some of the contents in the history

Materials - The early-wireframes were hand drawn on paper. An A4 paper with printed list of tasks was used to take notes during the evaluation.

Procedure - The Thinking aloud (below TA) was performed in a quiet lobby in the department of computer science and engineering to ensure an undisturbed evaluation environment. The evaluation was conducted individually for each evaluators and each of session took around 20mins. The evaluators were seated and provided with the early-wireframes of the mobile interface, and of the web interface that was hung up on the whiteboard to emulate the physical display. The experimenters were three of our team members who designed the UI, they took seats around the opposite, and both sides of the evaluator. The experimenter who took the opposite seat from the evaluator instructed the evaluation with providing list of tasks and navigating the whole process. This was necessary as the wireframes were pencil drawings and that might provide no clues for the evaluator how the system operates as a whole. On the other hand the other one or two experimenters was (were) responsible for observing behaviour of the evaluator and writing down the comments. After each actions he made as a step to complete the task, he provided comments in regard to design problems and bottlenecks that are appeared to be against his understanding of the system based on the given UI design, this was entirely appropriate sign of which the evaluation is on the right track as suggested that TA is more likely to provide preference of

the evaluator' towards the design [13]. After the evaluation was done, the evaluator suggested his opinion on the given UI design in conjunction with general feedback.

Risk assessment

This chapter contains brief description, likelihood, impact, and actions for possible risk we might encounter during the project. The risks are quite general and cover mostly the abstract for one type of risk.

Schedule flaws

Our project contains multiple parts and not all of them are easy to estimate. For example device sensing module could be implemented in one day or it could take more than week depending on platform, interfaces, libraries, etc. Likelihood for this kind of risk is fairly common and impact could be major in the worst case scenario. To prevent this kind of risks happening we need to do thorough background work. To correct this kind of risk the project manager has to make decision to drop or put more manpower to that task.

Communication problems

If the team members fail to communicate with each other as much as is needed or the team fails to communicate with TA the course of project might shift and people end up doing wrong tasks. For our group this is unlikely and because of that it impacts would be minor and easily corrected. To prevent this team needs to schedule enough meetings.

Technical risks

This kind of risks usually occur when product is complex and modules are hard to integrate. These risks might lead to failure in functionality or in performance and the likelihood of it happening in this project is unlikely but impact of it might be major if not handled right away. This can be prevented with good and thorough system architecture and technological choices. When facing this kind of risk it is crucial to identify the risk as soon as possible and make the necessary changes immediately while the impact is still minor.

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Contributions

Date	Start time	End time	Total time (hours)	Description	Yifei	Haejong	Henri	Camilo
05/10/15	14:00	15:15	1,25	Meeting	X	X	X	X
05/10/15	16:00	17:20	1,33	Setting workspace to work				X
06/10/15	14:00	14:36	0,60	Literature Review				X
06/10/15	17:00	19:00	2,00	Literature Review		X		
07/10/15	22:00	23:00	1,00	Literature Review			X	
11/10/15	19:26	21:00	1,57	Literature Review	X			
11/10/15	15:00	16:30	1,50	Literature Review		X		
12/10/15	08:39	09:00	0,35	Group Meeting	X			X
12/10/15	09:00	09:30	0,50	Meeting with Simo	X	X		X
12/10/15	09:30	09:58	0,47	Group Meeting	X	X		X
18/10/15	23:00	23:59	0,98	Literature Review				X
18/10/15	18:03	19:54	1,85	Literature Review	X			
18/10/15	16:00	18:00	2,00	Literature Review		X		
19/10/15	09:00	10:00	1,00	Literature Review				X
19/10/15	10:30	11:30	1,00	Group Meeting	X	X	X	X
22/10/15	09:30	12:00	2,50	Wireframe design				X
22/10/15	15:00	16:30	1,50	Wireframe design				X
25/10/15	20:32	21:04	0,53	Wireframe design	X			
25/10/15	22:00	00:00	2,00	Wireframe design		X		
26/10/15	09:06	09:32	0,43	Wireframe design		X		
26/10/15	14:00	15:30	1,50	Meeting	X	X	X	X
29/10/15	15:00	18:40	3,67	Design Phase		X		X
29/10/15	15:00	16:00	1,00	Meeting (Design)	X	X		X

29/10/15	16:00	17:08	1,13	Meeting (Design)		X		X
29/10/15	17:08	18:40	1,53	Meeting (Design)	X	X		X
03/11/15	15:00	15:40	0,67	Evaluation				X
03/11/15	16:00	18:40	2,67	Forming questions for evaluation		X		
04/11/15	17:00	18:00	1,00	Evaluation for initial design decision		X		
05/11/15	18:30	20:15	1,75	Meeting (Paper Prototype)	X	X		X
12/11/15	15:00	17:00	2,00	High fidelity UI design		X		
13/11/15	15:00	16:30	1,50	Evaluation (Paper prototype)		X		X
16/11/15	15:00	16:40	1,67	Meeting and evaluation		X	X	X
16/11/15	20:00	20:45	0,75	Writing evaluation report on drive			X	
18/11/15	11:00	12:00	1,00	Report writing		X		
18/11/15	20:00	21:30	1,50	Report writing		X		
19/11/15	10:00	10:40	0,67	Report writing		X		
21/11/15	17:00	19:30	2,50	Report writing		X		
21/11/15	12:00	15:00	3,00	Designing system architecture			X	
22/11/15	00:30	03:00	2,50	Report writing		X		
22/11/15	14:10	18:00	3,83	Report writing		X		
22/11/15	19:20	21:00	1,67	Report writing		X		
22/11/15	14:30	21:30	7,00	Report writing and system design chart			X	
22/11/15	17:00	20:00	3,00	Report writing				X
23/11/15	14:00	17:00	3,00	Report writing		X		
24/11/15	12:30	14:20	1,83	Report writing		X		
24/11/15	18:00	21:00	3,00	Report writing				X
25/11/15	12:00	13:45	1,75	Wireframe design			X	
25/11/15	21:00	23:59	2,98	High fidelity prototype				X
26/11/15	18:00	22:00	4,00	Report Writing				X

27/11/15	12:00	15:00	3,00	Report writing		X		
28/11/15	22:00	23:59	1,98	Use case design		X		
29/11/15	00:00	00:50	0,83	Use case design		X		
29/11/15	21:00	23:59	2,98	Report Writing				X
30/11/15	00:00	04:00	4,00	Report Writing				X
30/11/15	14:00	19:00	5,00	Report Writing		X		
30/11/15	17:00	20:42	3,70	High Fidelity Prototype				X
30/11/15	20:43	22:00	1,28	Report Writing				X
30/11/15	22:00	23:15	1,25	Presentation				X
30/11/15	21:00	23:00	2,00	Report Writing, Presentation		X		
Total Hours					13	62	19	52