NTNU – Trondheim
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A Location-based Mobile Service utilizing Anonymous Indoor User Location Data

An Empirical Study

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"Never trust a computer you can't throw out a window."

Steve Wozniak

Sammendrag

I de senere årene har navigasjonssystemer og lokasjonsbaserte tjenester automatisk kommet inn i folks liv. Utbredelsen av bruk av enheter med GPS-muligheter har eksplodert siden den første enheten for forbrukerne ble presentert, og de aller fleste smarttelefoner har GPS og Wi-Fi innebygget. Nye områder som utendørs og innendørs navigering og lokasjonsbaserte tjenester har kommet fra disse mulighetene. Et område som ikke har blitt mye forsket på er bruk av anonymiserte lokasjonsdata fra innendørs posisjoneringstjenester. Dette er forventet å bli en større suksess enn GPS-teknologien, gitt at folk bruker 80-90 % av deres tid innendørs. Med Cisco MSE teknologien som brukes på NTNU Gløshaugen i dag, åpner dette for applikasjoner som kan utnytte anonymiserte data fra innendørs posisjoneringstjenester.

I denne oppgaven blir det utviklet en mobiltjeneste i form av en en prototype applikasjon for Android enheter, som tar i bruk anonymiserte innendørs lokasjonsdata, rettet i hovedsak mot studenter ved NTNU. Dataene inneholder informasjon om antall enheter med Wi-Fi mottaksevner som befinner seg på Gløshaugen, enten i et bestemt rom eller område. En god fremstilling av disse dataene med kombinasjon av lokasjonsbaserte tjenester kan øke utnyttelsen av skolens områder og ressurser, men også løse et undervurdert behov; mangel på leseplasser for studenter. Prototypen ble utviklet i samsvar med generelle prinsipper for brukervennlighet for mobilapplikasjoner og sluttbrukernes innvirking for å oppnå et resultat som tilfredstiller alle involverte interessegrupper. Deretter ble det gjennomført en undersøkelse der 41 deltakere fikk prøve den endelige prototypen før de svarte på spørreskjema.

Resultatene fra evalueringen viser at det er en interesse for applikasjoner som bruker anonymiserte innendørs lokasjonsdata. Den foreslåtte løsningen har vist god nytteverdi som en mobiltjeneste i studentenes daglige liv.

Abstract

In recent years, navigation and location-based services have automatically been integrated into people's lives. The prevalence of devices with GPS-capabilities have exploded since the first device for end-users was presented, and most new smart phones have GPS and Wi-Fi capabilities. New fields such as outdoor and indoor location-based services have come from these opportunities. One area that has not been thoroughly researched is the usage of anonymous location data from indoor positioning services. This is expected to be even more successful than GPS technology since people spend 80-90 % of their time indoors. Cisco MSE utilized at NTNU Gløshaugen today, provides applications with the possibility to utilize anonymous data from indoor positioning systems.

In this Thesis a mobile service is created through an application for Android devices that uses anonymous indoor location-based data, aimed primarily towards students at NTNU. The data contains information based on the amount of Wi-Fi enabled devices located on Gløshaugen, either in a specific room or area. A good presentation of these data combined with location-based services can increase the utilization of the university's areas and resources, but also to solve an underrated need: lack of reading desks for students. The prototype was developed in accordance with general principles of user interface design for mobile applications and the end-users' influence to obtain a result that covers all the needs for all interest groups. This was followed by a study where 41 participants tested the final product.

The results of the acceptance evaluation shows that there is an interest for applications that use anonymous indoor location-based data. The proposed solution demonstrated good usefulness as a mobile service in students' daily lives.

Problem Description

NTNU partnering with Wireless Trondheim has been offering a hybrid indoor and outdoor way-finding application called MazeMap (former CampusGuide) for Gløshaugen campus since fall 2011; the MazeMap is able to locate a user's position on campus with an accuracy of up to 5-10 meters, and provides room-level way-finding and object search capabilities. Based on an extension of the underlying infrastructure, it is possible to collect anonymous location data to be able to analyze indoor mobility patterns among users at the campus.

The task will consist of developing and evaluating a prototype, utilizing anonymous indoor data and located-based features. The project is expected to follow a design science research approach, producing and evaluating an artifact (e.g. an application) in a scientifically sound manner. It is preferred that the project report is written in English. The results from a good Thesis should be possible to use as a basis for developing a scientific publication.

Supervisor: Professor John Krogstie

Preface

This document contains our research in Computer Science at the Department of Computer and Information Science (IDI), in the Faculty of Information Technology, Mathematics and Electrical Engineering (IME), at the Norwegian University of Science and Technology (NTNU). The research was conducted from fall 2013 to spring 2014 in Trondheim, with continued support from our supervisor professor John Krogstie. We would like to give our sincere thanks to Krogstie for his great insight and guidance.

We would also like to thank Åsmund Tokheim, Ole Markus With and Thomas Jelle at Wireless Trondheim for their quick support on email and letting us work in their office, helping us with technical issues during the implementation. A big thank to our friends and fellow students at Fiol for testing the application and helping us with valuable input and discussions. Finally, special mention is given to our families who always supported us during the education.

Hoang Thanh Tran

Trond Thingstad

Trondheim, June 2014

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Abbreviations

ADT	**A**ndroid **D**evelopment **T**ools
AoA	**A**ngle **of** **A**rrival
AP	**A**ccess **P**oint
API	**A**pplication **P**rogramming **I**nterface
AVE	**A**verage **V**ariance **E**xtracted
CT	**C**on**t**ext
GPS	**G**lobal **P**ositioning **S**ystem
HTML	**H**yper**T**ext **M**arkup **L**anguage
ICR	**I**nternal **C**onsistency of **R**eliability
IDE	**I**ntegrated **D**evelopment **E**nvironment
IDT	**I**nnovation **D**iffusion **T**heory
IPS	**I**ndoor **P**ositioning **S**ystem
IR	**I**nfra**r**ed
ISO	The **I**nternational **O**rganization of **S**tandardization
IU	**I**ntention to **U**se
JSON	**J**avaScript **O**bject **N**otation
LBS	**L**ocation-**B**ased **S**ervices
LLsP	**L**edig **L**ese**s**al **P**lass
LoS	**L**ine **o**f **S**ight
MMS	**M**ultimedia **M**essaging **S**ervice
MSAM	**M**obile **S**ervice **A**cceptance **M**odel
MSE	**M**oblity **S**ervices **E**ngine
MVC	**Model**-**V**iew-**C**ontroller
NTNU	**N**orwegian **U**niversity of **S**cience and **T**echnology
OPS	**O**utdoor **P**ositioning **S**ystem
OS	**O**perating **S**ystem
PEOU	**P**erceived **E**ase **O**f **U**se

PDA	**P**ersonal **D**igital **A**ssistant
PIC	**P**ersonal **I**nitiatives and **C**haracteristic
PLS	**P**artial **L**east **S**quares
PU	**P**erceived **U**sefulness
RF	**R**adio **F**requency
RFID	**R**adio **F**requency **Id**entification
RSS	**R**eceived **S**ignal **S**trength
RSSI	**R**eceived **S**ignal **S**trength **I**ndicator
SaaS	**S**oftware **as a S**ervice
SEM	**S**tructured **E**quation **M**odeling
SDK	**S**oftware **D**evelopment **K**it
SUS	**S**ystem **U**sability **S**cale
TAM	**T**echnology **A**cceptance **M**odel
TDoA	**T**ime **D**ifference **o**f **A**rrivals
ToA	**T**ime **o**f **A**rrival
ToF	**T**ime **o**f **F**light
TRA	**T**heory of **R**easoned **A**ction
TPB	**T**heory of **P**lanned **B**ehavior
TU	**Tru**st
UI	**U**ser **I**nterface
UML	**U**nified **M**odeling **L**anguage
UTAUT	**U**nified **T**heory of **A**cceptance and **U**se of **T**echnology
WLAN	**W**ireless **L**ocal **A**rea **N**etwork
XML	E**x**tensible **M**arkup **L**anguage

Chapter 1

Introduction

This chapter is an introduction to the Thesis, and will give an overview of how and why the research was performed. The first part explains the motivation behind the Thesis. Next there will be a short summary of the project, its research method and results. Last, an outline of the report will be presented.

1.1 Motivation

The success of GPS-enabled smart phones and devices has been huge and made location-based services a cornerstone in the mobile services experience. Popular applications such as Yelp[1], Google Maps[2] and Strava[3] are all powered by location services. Overall, navigation and mapping applications ranks higher than gaming, news and shopping[5]. Today accurate mapping is done by satellite based systems such as GPS which works very bad for indoor conditions - which is where people spend up to 90 % of their lives[6]. Major companies such as Apple[4], Google[5], Broadcom[6] and Nokia[7] are now working hard on expanding their indoor location technologies and services[7].

Until recently the research on indoor location tracking of people and objects has often been done with RFID based solutions[8]. This makes tracking of large numbers of people and devices over large areas expensive and impractical, because of the need for additional infrastructure and users need to carry additional trackable devices. Indoor positioning with Wi-Fi uses existing Wi-Fi access points and

[1] `http://www.yelp.com/`
[2] `https://www.google.com/maps`
[3] `http://www.strava.com/`
[4] `http://www.apple.com/`
[5] `https://www.google.com/`
[6] `https://www.broadcom.com/`
[7] `http://www.nokia.com/`

users' own phones, tablets or any Wi-Fi enabled device to locate them[8]. With this method one can obtain a much larger user base over a large area without big changes to the underlying infrastructure, which can make results of indoor mobility patterns more interesting.

As little research on how anonymous user location data from indoor positioning systems can be applied for the benefit of the public, this study examines the possibilities and proposes a mobile service solution in form of an application for Android powered devices. The application is intended to be used by NTNU students without a fixed personal desk or office, but can be extended later for other use cases. To test the acceptance factors of the application, it was evaluated with the Mobile Services Acceptance Model (MSAM) proposed by Gao and Krogstie[9].

1.2 Project Definition

A useful and possible implementation of an application for mobile devices has been developed in this project, presenting unique information about the density of people residing in an indoor area by using anonymous user location-based data collected through existing Wi-Fi infrastructure on NTNU Gløshaugen. A literature review was first performed to get an understanding of the state-of-the-art and technology before the project followed a design science research model (Section 3.2.1) where the outcome includes an artifact. The artifact is an application for Android devices which uses anonymous position data to present a service for NTNU students to find available nearby study rooms. The purpose behind this application is to utilize the anonymous data to create a new mobile service used by students in the university, utilizing modern and non-intrusive technologies. Next, an evaluation of the application was conducted and the data were used to examine the interest and evaluate acceptance factors in anonymous location-based applications. The results were used as a part to draw the conclusion of the Thesis.

1.3 Research Method

The main method of this studies' data collection tools are a survey and questionnaires taken by NTNU students - people who are expected to be the end-users of the application. Then some well-known analysis and evaluation methods were used to extract and present the most important information from the results. By following the chosen research method, the goal is to achieve knowledge and understanding of a problem domain by building an application of a designed artifact, also known as the prototype or the application. A complete explanation on how this prototype was created can be found in Chapter 6. Chapter 3 summarizes a more thorough picture of the research methods used.

1.4 Results

Results from this research will be an evaluation of a set of hypotheses and conclusions gathered from literature study, the analysis and evaluation of the prototype and the end-users opinions from the questionnaires and survey. Also, topics that provides some insight into what features and how presentation of anonymous data are relevant when designing an application are discussed. A part of the result in this research includes the development of an application based on anonymous position data with intention to offer a pleasant mobile service for the end-users.

1.5 Report Outline

This report starts with a literature study in Chapter 2. Here the background theory for the preceeding research is explained with focus on various location-based technologies and the usage of anonymous location-based data. A detailed description of the research questions, the chosen research methodology and how it was performed can be found in Chapter 3. Chapter 4 turns to the issue of confirming if finding available reading rooms is a problem from the initial web survey. A pilot study was conducted as well to prepare the implementation, and the results are presented. The problem elaboration in Chapter 5 provides insight into how the problem is from a real view by using tools such as personas and scenarios. Chapter 6 presents an overview of how the solution was implemented for the purpose of this study. An evaluation of the acceptance of the final prototype can be found in Chapter 7. The results will be used further to discuss the findings of this study in Chapter 8. Chapter 9 concludes the Thesis with its discoveries, but also outlines the potential for further research and improvements that can be made.

Chapter 2

Background

This chapter describes the current state-of-the-art technology and intends to provide the necessary knowledge to understand the parts in the study. First, there will be given an overview of which indoor and outdoor positioning technologies that are most common to understand how the anonymous indoor location data is collected, before NTNU IT and Wireless Trondheim's positioning system and data collection system - Cisco MSE is presented. Second, an introduction of relevant applications that utilize positioning systems are presented, so one can obtain a better comprehension of the application created in this Thesis. Third, an overview of known field of applications on the usage of anonymous location-based data will be presented. Finally, some important topics such as Norwegian privacy law and mobile services evolution will also be brought up during this chapter.

2.1 Positioning systems

Positioning systems are an important part of many businesses and peoples' daily lives. They have made a big contribution to the efficacy and the way people do many businesses such as construction work, offshore oil prospecting, flight navigation, and numerous scientific tasks. Positioning systems can be split into two main categories; *indoors* and *outdoors*. To attain acceptable coverage both indoors and outdoors one need to combine at least one of each systems. Outdoor positioning systems are not accurate enough or unavailable inside, and indoor systems do not have the capacity or range to cover everywhere people go.

This section consists of a set of important indoor and outdoor positioning technologies and relevant signal processing techniques, to make it easier to understand how the data is collected by Wireless Trondheim's implementation of Cisco Mobility Services Engine server, and what it can do.

2.1.1 Outdoor Positioning Systems

Outdoor positioning systems (OPS) has become an integrated part of many peoples lives. It helps people find their way when travelling, log their bike trips, and makes them able to share their location with friends or followers in social media.

The most commonly used positioning system that offer global coverage for civilian people today, utilize weak radio signals sent from satellites in space. Such systems can be highly accurate outside when there are few obstacles around, but in the city streets with tall buildings or inside buildings, the accuracy is badly affected. Inside a building the positioning system may lose tracking completely, because the radio frequency (RF)[1] signals sent from satellites are scattered by buildings, walls, ceilings, people, furniture and so on[10]. The following subsections will explain some of the most commonly used outdoor positioning systems today.

2.1.1.1 Global Navigation Satellite Systems

Global navigation satellite systems (GNSS) is a generic term for satellite based systems for navigation and positioning with global coverage. The best known outdoor positioning system today is the American made Global Positioning System (GPS). GPS is developed and maintained by the United States Department of Defense and is accessible to anyone with a GPS receiver, and is the earliest widely used modern system for civilian positioning service[3].

GPS is a satellite-based navigation system (Figure 2.1) made up of three parts: *space*, *control* and *user*. The space part is composed of 24 to 32 satellites in medium earth orbit, sending out its position and precise time. The control part is composed of a master control station and many shared ground antennas and monitor stations, while the user part is composed of millions of civil, commercial, military and scientific users. The system provides location and time information anywhere on or near Earth[3], and utilizes trilateration (Section 2.1.3.1) of RF signals, the same kind of technique used by many current indoor positioning systems.

GPS-based systems offers good positioning performance and are widely used in outdoor environments, such as automotive navigation. It can serve an infinite number of users due to its client-based infrastructure; satellites sending out weak RF signals and letting the receiving device handle the calculation of its own position. However, when the receiving unit is located indoors or behind tall buildings, GPS does not provide an acceptable performance due to its line of sight (LoS) dependent infrastructure. This is because the electromagnetic waves will be scattered and attenuated by the buildings and outdoor obstacles[10].

[1] A frequency or band of frequencies

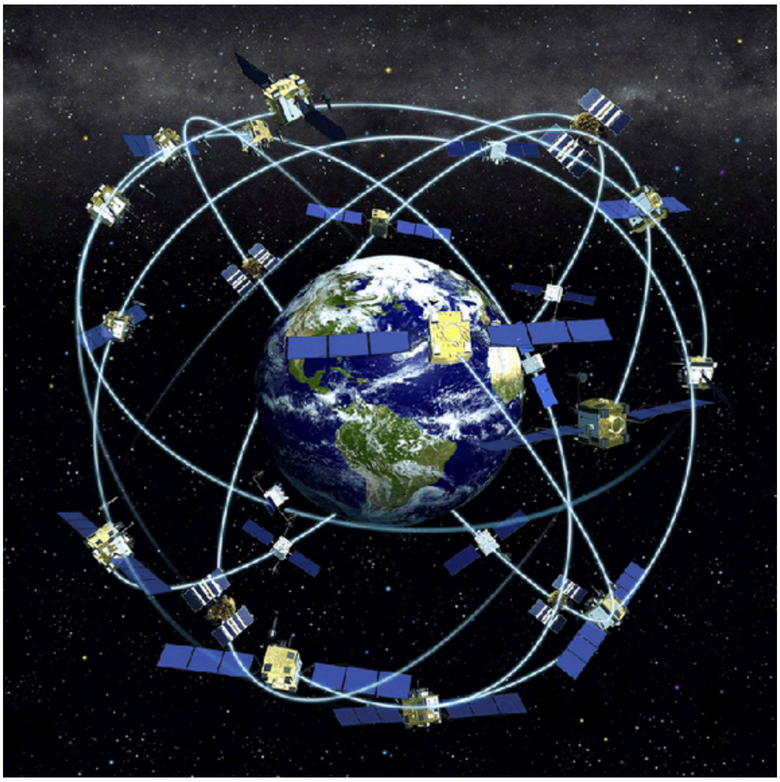


FIGURE 2.1: GPS Satellites in Orbit (www.space.com)

The Russian equivalent to GPS called GLONASS attained global coverage in 2011, while the European Union has deployed its own satellite-based system named Galileo. China and India also has their counterparts, but they do not have global coverage. One of the reasons for all these redundant systems is because of USA's ability to shut down or decrease precision of the GPS system in case of conflicts[11].

2.1.1.2 Cellular Tower Triangulation

Cellular tower triangulation is another popular and much used outdoor positioning system based on triangulation (Section 2.1.3.1) of cell phone towers RF signals as seen in Figure 2.2. This is the technique police and emergency services use to locate a person's position when he or she call 911[10].

In a cellular network, each mobile terminal can measure the time of arrival (ToA)[2], the time difference of arrival (TDoA)[3], and the angle of arrival (AOA)[4] to derive the location information. More accurate results are obtained if the mobile terminal can communicate with several nearby antennas at once.

[2]Wikipedia explains it as "the travel time of a radio signal from a single transmitter to a remote single receiver."

[3]AT&T explains it as "the location of a mobile phone by using the difference in the time of arrival of signals at different cell sites."

[4]The measured angle of and incoming signal between a mobile terminal and the AP

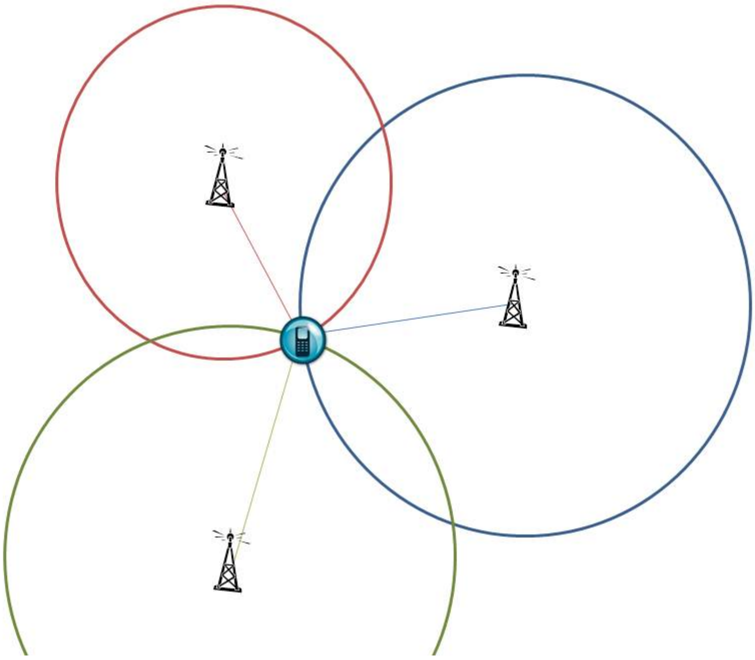


FIGURE 2.2: Cell Tower Triangulation (www.cloudetal.com)

The accuracy of network-based techniques is both dependent on the concentration of base station cells and the implementation of the most current timing methods. Still, the accuracy outdoors is a lot less precise than GPS no matter the density of cell towers[12].

2.1.2 Indoor Positioning Systems

An indoor positioning system (IPS) considers only indoor or close to indoor environments, such as inside a shopping mall[3]. Depsey[13] defines an IPS as

> *““a system that continuously and in real-time can determine the position of something or someone in physical space such as in a hospital, a school a shopping centre, etc.”*

From this definition, an IPS should work and offer tracking of people or objects in the expected area at all times and within an acceptable time delay, unless the system is switched off by the user. Figure 2.3 illustrates a typical coverage scenario of GPS vs IPS systems inside a building. The GPS locating system can only track the user down to which part of the building the user is in, while the IPS system can show which floor and shop the user is in.

FIGURE 2.3: GPS vs IPS (www.extremetech.com)

IPS can be implemented in several ways by different types of technology. The most common technologies today are based on Bluetooth, Wi-Fi (Section 2.1.2.1), RFID (Section 2.1.2.2), infrared (IR) or ultrasound. All of these technologies can provide good accuracy, but they have their own strengths and weaknesses. The biggest issue is that, all of them except Wi-Fi rely on additional hardware the user needs to carry around and extra infrastructure investments, if they are to work in large indoor areas. RFID, IR and ultrasonic requires many stationary transmitters over the whole coverage area, and they require separate units that can be tracked by these signals. Additionally, IR-based tracking tags will have to sit on the outside of clothes to be seen by the receivers. Direct sunlight can also severely limit the IR sensors[14], which is likely to happen in rooms with windows.

Most of today's IPS solutions are based on triangulation, trilateration (Section 2.1.3.1), or fingerprinting (Section 2.1.3.2) methods[3][10].

There has also been performed some studies on fusing multiple technologies to take use of each of the different technologies' advantages. E.g. inertial sensors, such as gyroscopes and accelerometers can be used in cooperation with common IPS systems. This has proven to give better results than only using one technology[15], especially when a user makes slight movements. However, this approach is rare because it requires a lot of work to optimize both technologies simultaneously and surroundings must be in place and supported.

Indoor positioning systems can not compete with GPS or cellular positioning systems in terms of universal coverage (GPS covers almost the entire earth), and usually it takes a lot of time to calibrate the IPS to perform optimally[8]. Still, indoor positioning technology has been successfully applied in many applications or systems based on tracking of objects and inventory management, such as tracing of parcels in a warehouse[16]. Inventory tracking systems mostly use inexpensive passive RFID tags, and proximity readers at specially assigned locations, e.g. by the receiving and delivery sections of the warehouse.

Other successful IPS implementations are AT&T's *Active Badge*[3] and *Active Bat*[3]. Active Badge is based on infrared beacons (the badge) worn by people, and emits a unique infrared code every 10 seconds which are detected by IR sensors located around the building. Active Bat works in a similar way, but use ultrasound instead of IR. The ultrasound results in a higher accuracy, but requires a higher amount of receivers mounted in ceilings[10].

RADAR[14] developed by Microsoft is the first implementation of an IPS system that uses existing Wi-Fi infrastructure. Below sections will explain some technologies and common techniques that are used in IPS systems.

2.1.2.1 Wi-Fi

Wireless Local Area Network (WLAN), popularly known as Wi-Fi is a technology that uses radio waves to allow high speed data communication over medium to short distances. The origin of Wi-Fi is from 1985 when a US Federal Communications Commission ruling allowed the 900MHz, 2,4GHz and 5GHz radio bands to be used by anyone. Many technology firms began building wireless networks, but one came out as the winning standard, the IEEE 802.11[5]. It has become the common standard for public data communication[17].

WLAN infrastructure location-based systems can be deployed in two ways; *infrastructure-based* or *client-based deployment*. In an infrastructure-based deployment, a group of access points (APs) "collects" the signal measurements from mobile devices and sends them to a central server to estimate the location. In a client-based deployment, the mobile devices "reports" the signal measurements from different APs and sends them to a central server for location estimation. The performance difference between these to types is that the client-based system may give better location accuracy, but the management issues such as security, distribution and maintenance are much worse to handle than the infrastructure-based[12].

The majority of wireless indoor positioning systems are based on two types of technologies; the *location positioning algorithm* and the *location sensor infrastructure*. Location positioning algorithm is a method to determine a mobile terminal's location by using various types of measurement of the signal such as time of flight (ToF)[6], AoA and signal strength measurements. Location sensor infrastructure is the communication with the tracking devices[3].

[5]`http://en.wikipedia.org/wiki/IEEE_802.11`

[6]meaning the time it takes for the signal at a known velocity to travel from a sender to the receiver

Wi-Fi is the most economical solution to use in most situations since the IEEE 802.11 specification has become the industry standard for wireless data networks in almost all indoor places. Unlike most other IPS, there is no need for additional hardware or synchronization schemes in indoor environments. There is no need to change the infrastructure to collect location-based data[18].

2.1.2.2 Radio Frequency Identification

Radio frequency identification (RFID) is a technology that utilizes radio waves to transmit data when an RFID tag is scanned. The most basic kind of RFID chips only output a unique id when it is scanned, while others contain encryption and control-sequences so that only authorized scanners will receive its id[19]. RFID tags can be in one of two main forms; *passive* or *active*. Passive RFID tags need a magnetic field to power the microcomputer and radio antenna inside the tag. The distance between the reader, which is emitting the magnetic field, and the passive tag must typically be less than a meter[8]. Low price per tag makes passive RFID a common technology used in many applications, like tagging of livestock, in ID-cards and clothes security alarms. Active RFID does not need the magnetic field, since it is battery-powered. It can be set to auto-transmit its signal at all time, or it can be initiated by a reader. A reader that communicates with an active tag needs to be less complicated since it does not need to transmit a strong signal to power the tag[20].

Tracking systems based on active RFID tags works in the same way as Wi-Fi based positioning systems (Section 2.1.2.1). In passive RFID systems, the readers needs to be placed at multiple points-of-interest (PoI) for the readers to detect if a passive RFID tag is nearby[16].

2.1.3 Common Positioning Techniques and Algorithms

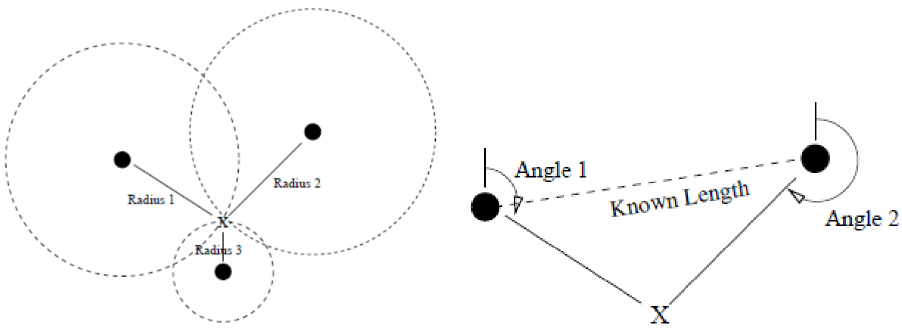
All positioning systems rely on positioning techniques to pinpoint an object's location. These techniques are based on geometrical or statistical properties, or a combination of both. This section will explain some central positioning techniques that are common for many positioning systems.

2.1.3.1 Triangulation and Trilateration

Triangulation is a geometric positioning technique based on the mathematical properties (distance measurements) of triangles, and can be subdivided into two subcategories; *angulation* and *lateration*. It is often used in indoor and outdoor positioning systems. It can be used alone, or in combination with other location estimating techniques, such as proximity sensors[1].

Lateration requires three base stations with their respective coordinates location to locate an object in 2 dimensions, and four base stations to locate an object in 3 dimensions. Trilateration is normally measured by ToF, or by *attenuation*[7]. These coordinates are used to draw circles around the transmitters (as seen in Figure 2.4a) by using the distances r_i to pinpoint the device's position on a map, before locating the position by the intersection of the three circles[21]. The trilateration technique can be used on light, ultrasound or radio signals. In environments with many obstructions (such as indoors), ToF is usually more accurate than RSSI, because signal intensity is affected by reflection, refraction and multipath, which causes the *attenuation* to correlate poorly with real distance[1].

Angulation is similar to lateration, except instead of distances, angles are used for determining the position of an object[1]. Generally, angulation in 2 dimensions requires two angle measurements, and one length measurement, as illustrated in Figure 2.4b. In 3 dimensions, one length measurement, one azimuth measurement[8], and two angle measurements are needed to specify a precise position[1].



(A) Trilateration (B) Triangulation

FIGURE 2.4: Angulation and Lateration[1]

2.1.3.2 Fingerprinting

Fingerprinting is a locating technique which is commonly used with 802.11 WLAN. The technique is based on the measurements of the RSS or RSSI[9] from wireless access points (APs) and derives an estimated position, using non-geometric algorithms[15].

There are two different stages of fingerprinting method; *offline* and *online*.
The offline stage, also known as the training phase involves building the signal

[7] often referred to as RSSI, meaning the intensity a signal arrives at the receiver
[8] Such as the angle between magnetic north and object to be tracked
[9] Received Signal Strength (Indicator) is signal strength received at the receiver and the unit of measurement can be in dBm or Watt[22]

strength database based on each reference position by mapping the WLAN signal strength from several wireless APs (i.e. creating fingerprints of the magnetic characteristics at locations).
The online stage, also known as real-time phase uses a given signal strength to match the closest collected information to figure out the estimated location.

This technique is one of the most utilized techniques in indoor localization because it is easy to implement, can handle RF signal noise and gives a higher accuracy than triangulation[18][23].

2.2 Cisco Mobility Services Engine

Cisco's Mobility Services Engine (MSE) is a server-software solution illustrated in Figure 2.5, which utilizes existing Wi-Fi network infrastructure in a location to offer real-time location services. The service used in this Thesis is called Cisco Analytics which tracks trends in customer mobility patterns. This service is simplified in the form of a web API that makes Thesis' application able to retrieve usage data from reading rooms at Gløshaugen. To find the devices' location, Cisco's MSE utilize RSSI from Probe Requests (fingerprinting) which is based on the trilateration technique and TDoA. Cisco's MSE calculates time and location and logs the MAC address[10] of devices detected in range of the wireless access points. The device need not be logged in to the network, but its WLAN card must be activated. According to [24], Wireless Trondheim's system can locate a user's indoor position with an accuracy of up to 5-10 meters.

[10]Media Access Control (MAC) address is a control address that is an unique identifier for equipments used in or can be connected to the network.

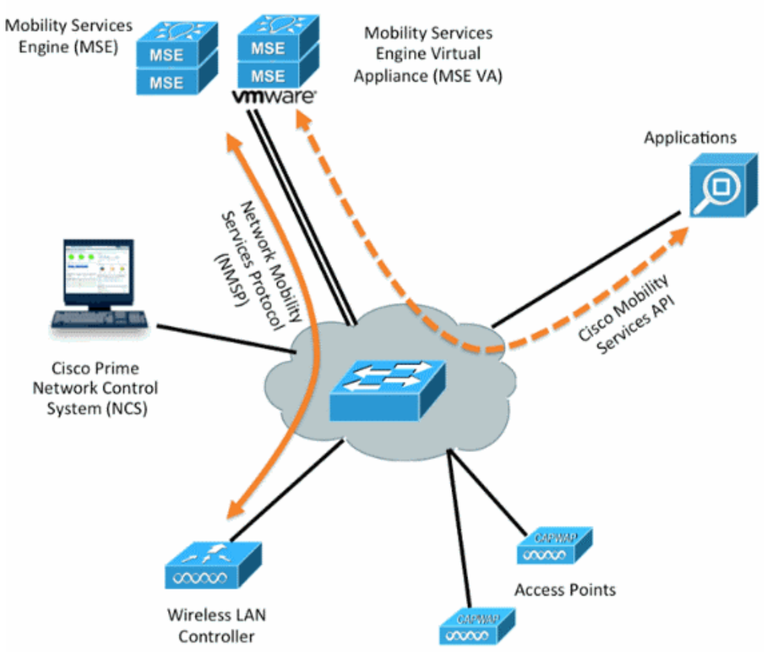


FIGURE 2.5: Cisco Mobility Service Engine (www.cisco.com)

Cisco Analytics is not designed to track a particular visitor or violate end-user privacy, and therefore only capture and store aggregate information. This information can be used e.g. to find physical bottlenecks in emergency escape routes, to uncover bad floor planning, how people move between rooms or shops. Still these data can be violating privacy if they are used in rooms that are reserved for one person, such as your boss's office.

NTNU IT and IDI Departments acquired a Cisco MSE 3350 server in August 2013 for the purpose of research in human mobility patterns. The current software version used by Wireless Trondheim is MSE v4.2.

2.3 Mobile Applications

This section first describes generally the mobile services evolution before a short explanation of location-based services. Then, some examples of relevant mobile applications offering mobile location services are summarized which can be related to this Thesis' application.

2.3.1 Mobile Services Evolution

After the smart phone[11] revolution that started with the release of Apple's iPhone in 2007[12], mobile services has become a part of "everyone's" daily life (Figure 2.6). Before, people were using cell phones for making phone calls, personal digital assistants (PDA) to store important information and computers to perform tasks such as accessing the Internet, reading email or playing games. Now, smart phones are becoming central for everything within communication and information needs, utilizing different mobile services from different applications[25]. More and newer type of services are emerging due to smart phone capabilities, and its connectivity provided by wireless infrastructure.

According to [26], more than 10 billion mobile devices will be in use by 2018. But just because a mobile service is possible to create, it does not mean it will succeed. Many services that were highly promoted, for instance wireless application protocol (WAP), group calling, and picture messaging (MMS) failed at first[25]. These services has become successful in later versions such as 3G, and image sharing services like Instagram[13]. This could be thanks to the abundance of mobile applications, and the steady evolution of smart phones being more powerful and getting larger clearer displays, increasing the need for network speed[27].

Apple's App Store opened in 2008 with 500 more or less good apps, in 2013 it had more than a million apps, and over 50 billion downloads[14]. Google's Play Store (previously known as Google Market) also opened in 2008[15], and now has approximately the same number of apps and downloads as Apple App Store.

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[11] a smart phone is a next-generation, multifunctional cell phone that provides capabilities such as facilitates data processing.

[12] `https://www.apple.com/pr/library/2007/01/09Apple-Reinvents-the-Phone-with-iPhone.html`

[13] `http://instagram.com/`

[14] `http://www.apple.com/pr/library/2013/05/16Apples-App-Store-Marks-Historic-50-Billionth-Download.html`

[15] `http://en.wikipedia.org/wiki/Google_Play`

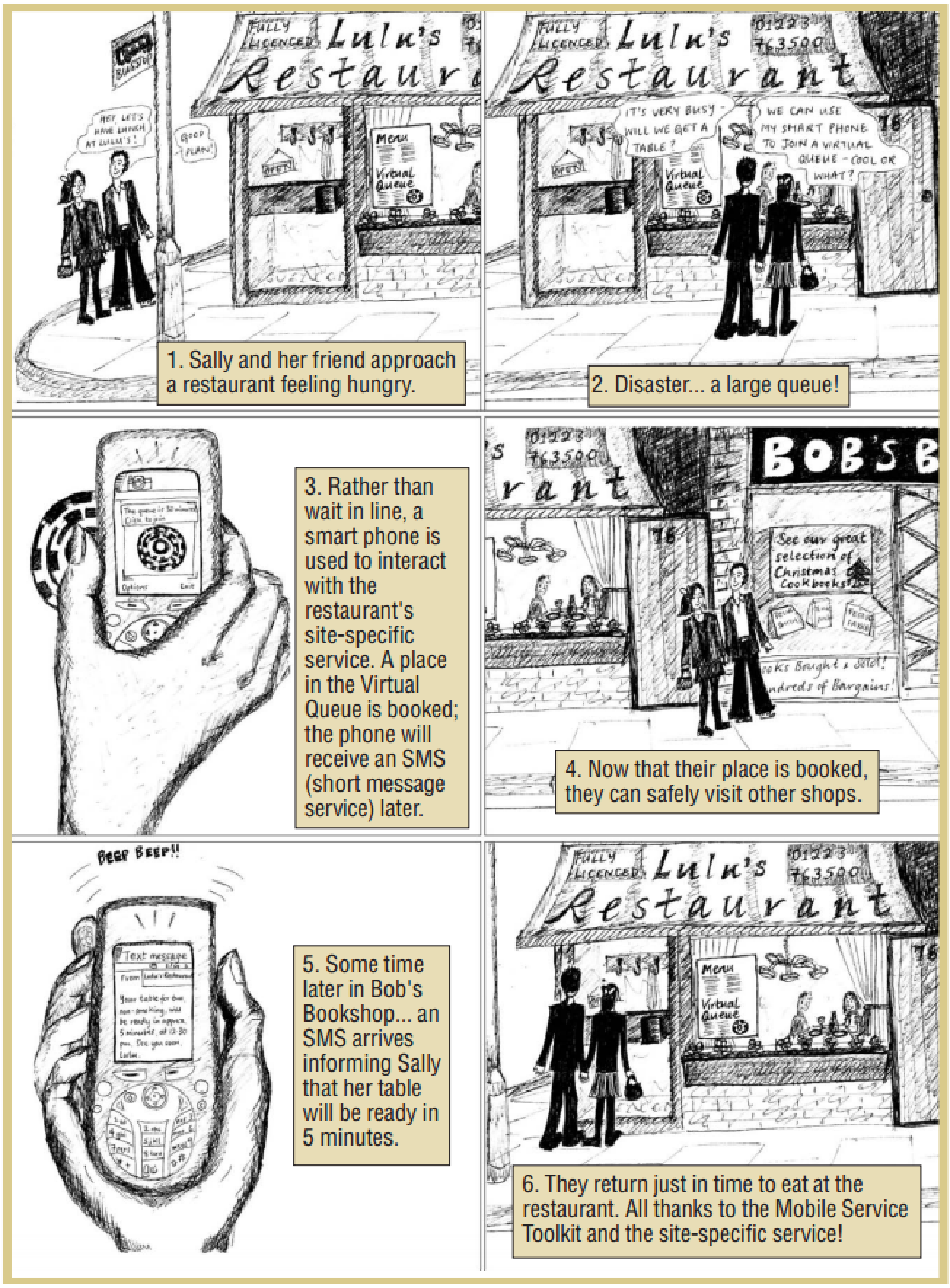


FIGURE 2.6: A Solution of Mobile Service in Peoples' Daily Life[2]

If an application or a mobile service is to be accepted by people, it has to attain certain qualities that make it desirable to use. These qualities will be described in Chapter 3.

2.3.2 Location-Based Services

The location-based services definition applies to software applications or systems that rely on users' location to provide mobile services such as presenting real-time location information, indoor or outdoor navigation and guidance, location relevant contents, tracking of property and more. The core of such a system is the positioning technologies, utilizing technologies and methods mentioned earlier in this chapter. These systems requires two elements to work: dependable positioning technologies and accurate maps[3]. Additionally any location aware computing systems must adapt an architecture like the one illustrated in Table 2.1.

The bottom layer may consist of sensors to locate the device's position. The middle layer converts the data reported from sensors into a a required presentation format, such as the Android's LocationManager API[28]. The location-based services or applications are implemented at the highest layer, which uses the context information measured and calculated by the lower layers.

Location-based Application
Software-location Abstraction
Location Sensing Systems

TABLE 2.1: Location-aware Computing System Architecture[3]

2.3.3 Mobile Applications Using Location-Based Services

Most of the mobile applications that leverage user location data today, offer some form of service. As previously mentioned popular applications such as Yelp, Google Maps, Facebook check-in and Strava are using user's location to provide a service.

According to Google, most of the the user location-based data that is collected through Android devices, is permanently deleted after a short time[29]. Only a small amount of data related to nearby Wi-Fi access points and cell phone towers is stored to help the users continue enjoy the service without server-connection, but these are not tied or traceable to a specific user[29]. Apple is also collecting anonymous location data in the same manner as Google[7]. Further, some of the most relevant applications, utilizing location-based data or positioning technologies were found during the pre-study are summarized below.

2.3.3.1 American Museum of Natural History Explorer

American Museum of Natural History Explorer (AMNH)[16] is the first "indoor GPS" navigation application shown in Figure 2.7, according to the museum. AMNH

[16] `http://www.amnh.org/apps/explorer`

was launched in 2010 and some of the features it offers are turn by turn directions to exhibits (Figure 2.7b), customizable museum tours and information about 140 specimens and objects. The application covers 500,000 square feet in total, and uses 300 Wi-Fi access points to triangulate users' position inside the museum. The underlying infrastructure is Cisco MSE, the same as used in MazeMap (Section 2.3.3.2) and Meridian (Section 2.3.3.3). The application is only available for iOS devices such as iPad, iPod Touch and iPhone[17].

(A) AMNH's home screen (B) AMNH's navigation

Figure 2.7: American Museum of Natural History Explorer

2.3.3.2 MazeMap

MazeMap[18], formerly known as CampusGuiden was developed in cooperation by Wireless Trondheim and NTNU. The application is delivered as software as a service (SaaS), and was first developed to help students and visitors to find their way indoor and outdoor on Gløshaugen, the main campus of NTNU (Figure 2.8). Gløshaugen consists of 60 buildings housing 13,000 rooms, with a total of 350,000 m^2 floor area[24].

[17] https://itunes.apple.com/us/app/explorer-american-museum-natural/id381227123?mt=8

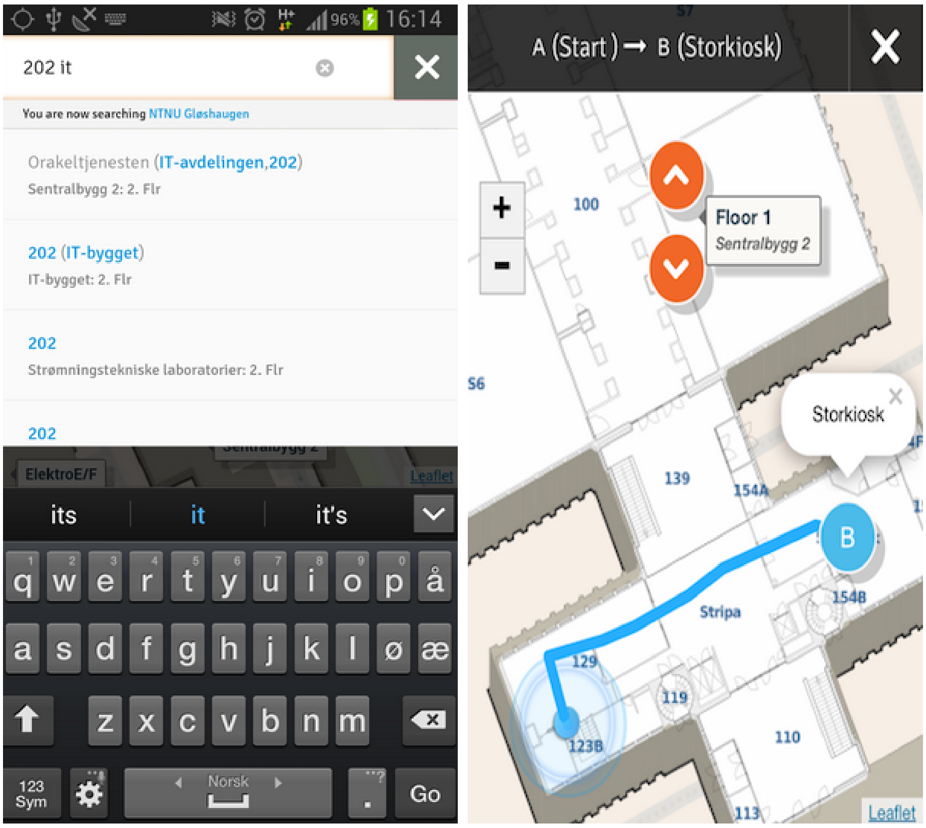
[18] http://mazemap.com/

MazeMap application is a location-based service (LBS) that utilizes the MazeMap Application Programming Interface (API) to calculate users' position and shortest path between points shown in Figure 2.8b. It also shows the usage of some design principles in a location-based application which will be beneficial for this Thesis' application.

In contrast to most navigation systems, MazeMap can be used both indoor and outdoor, but only in specific areas and buildings. For outdoor navigation on campus it uses standard GPS positioning to find the user's position as long the user's device has a GPS receiver, while indoor position is calculated from wireless access points (APs) by using trilateration (Section 2.1.3.1). NTNU has more than 1800 APs[24].

MazeMap service is available as an application at Apple AppStore and Google Play, but also from a web browser[24]. The application has now been extended to include St. Olavs Hospital in Trondheim and the university in Tromsø.

MazeMap has also made some of its information publicly available in JSON format through a web API, from now on referred to as the MazeMap API. One can read a more detailed and extensive description of the used technology in Chapter 6.



(A) MazeMap's search function (B) MazeMap's navigation

Figure 2.8: MazeMap

2.3.3.3 Meridian

Meridian[19] is a company specializing in mobile software that take advantage of GPS and other location-aware technologies (Figure 2.9). The Meridian software also uses the Cisco MSE solution where Wi-Fi triangulation is used to collect data. It provides features such as turn by turn indoor directions, promotions, personal guide and location-based notifications. Their goal is to work with companies to bring detailed location awareness to their mobile application using their Wi-Fi infrastructure as guideposts.

Meridian uses Wi-Fi triangulation to determine location indoors where GPS signals can not penetrate. Meridian's co-founder, Nick Farina explained how Meridian works in his blog[20] as

> *"Meridian's technology relies on APs to make measurements and allowing it to work on more restricted devices."*

. The people behind the AMNH application (Section 2.3.3.1) are also the founders of Meridian.

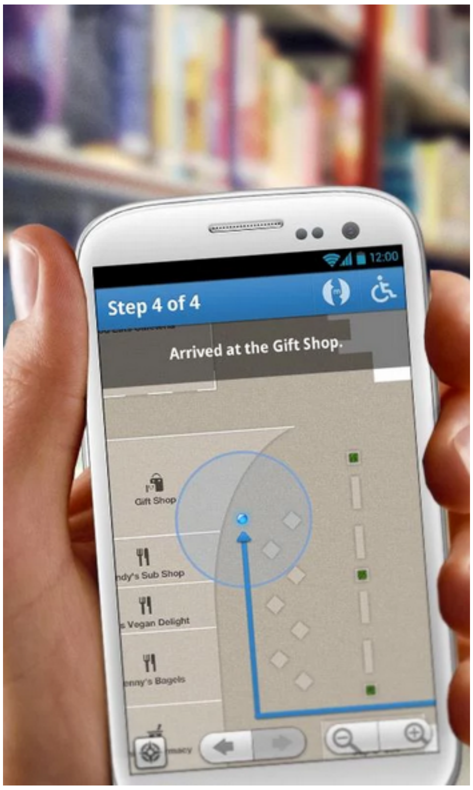


Figure 2.9: Meridian

[19] http://www.meridianapps.com/

[20] http://nfarina.com/post/50427245962/meridian-goes-to-aruba-why-wifi-networks-are-the

2.4 Usage of Anonymous Location-Based Data

This section provides first a brief description of anonymous user location-based data and some of its well-known field of applications before it also explains some Norwegian regulations that the applications need to follow to be allowed to collect user location data.

2.4.1 Anonymous User Location-Based Data

User location-based data is the location information sent from users to corporate or government servers, using location systems. For the data to be anonymous it must not be possible to tie or trace it back to a specific user. To illustrate a service utilizing anonymous location data is when a person is using an application to ask for the nearest food store, and the application ask for the person's position so it can find the nearest store. This of course assuming that the location data gathered from the search is anonymous, so it is impossible to link the data back to this person.

Positioning data are among the most sensitive data which are currently being collected since they contain the approximate whereabouts of individuals and can be used to reconstruct individuals movements across space and time[30]. The cost of storing and processing these large data sets is not a big problem for the large companies such as Apple, Google and Facebook, but it is important for the providers to keep in mind how much it costs against the benefits. The costs versus benefits issue is something this Thesis will not discuss.

Since one can not be sure if the actors collecting the data renders them 100 % anonymous, it can be a challenge to develop an application presenting these data because of the Norwegian Data Protection Authority (similar to the European), also known as Datatilsynet[21]. Datatilsynet is a government agency that ensures protection of individuals from violation of their right to privacy through processing of their personal data, by supervising companies that manages the sensitive personal information. The Norwegian privacy policy rules[31] states that one must adhere to certain rules.

2.4.2 Advertise

Today, most of the major companies are selling location-based data about its users to advertisers (Figure 2.10). Google, Facebook and Verizon[22] have long sold

[21] `http://datatilsynet.no/`
[22] `http://www.verizon.com/`

information about its users to other businesses, and AT&T[23] is now planning to sell aggregated anonymous location information collected by Wi-Fi APs and cell towers, combined with browsing, mobile applications usage and Television usage. The act of combining these types of information falls under the category "Big Data"[24] which has been estimated to grow to nearly $24 billion annually by 2016[25].

FIGURE 2.10: Location-Based Advertise (www.onbile.com)

2.4.3 Vehicle Traffic Information

TomTom[26], one of the large manufacturers of public vehicle GPS navigation devices (Figure 2.11) collects anonymous location data from its users. This is either done wirelessly if the device is Internet enabled, or when users connect their device to a computer for updating system software, and is only done if the user accepts it. The personalization of any service relies on the customers willingness to share their personal location information[32]. According to their press release[33], the data are anonymized and aggregated, and used to make routes more safe and efficient. Other major vendors such as Garmin[27] and Google Maps use their devices and applications to generate location data from end-users. Data from the end-users travelling is used to make the users' journeys faster and more predictable. Since the vendors' goal is to make profiles of the roads, one can achieve more exact arrival times, more accurate traffic avoidance and richer maps. Lately, they have expanded their services to

[23] `http://www.fiercewireless.com/story/att-prepping-sale-customers-anonymous-location-information-and-web-app-usag/2013-07-02`

[24] Data sets that are too large and complex to manipulate or interrogate with standard methods or tools.

[25] `http://econsultancy.com/no/blog/63027-are-marketers-making-the-most-of-location-based-services`

[26] `http://www.tomtom.com/`

[27] `http://www.garmin.com/`

include LIVE Services which delivers real-time journey information, such as safety cameras and traffic jam updates.

FIGURE 2.11: A TomTom Device Displaying Navigation (www.tomtom.com)

2.4.4 Privacy Policy Law and Location-Based Services in Norway

Gathering position data from peoples' devices may be problematic because of privacy laws. According to Norwegian privacy laws, collection of personal location-based data can only be done if one of these three cases apply[34]:

- If the user agrees to share their personal location data with a location-based service, e.g. "I accept that Google access my location to improve location relevant search results".
- If the location data is needed to implement an agreement, e.g. an insurance company demanding to be able to track an expensive car before they agree to insure it.
- If the service collecting data has a special permit by law to handle the data.

Most location-based services are based on voluntariness, i.e. if a person want to use the location-based service, that person need to accept that it collects his or her location. This also means that he or she can retract his or her consent to sharing the location data and stop using the service at any time. Providers must earn customers trust (Section 3.3) by letting them control their own personal information. The data must also only be used for specific purposes. In the insurance company example, they are only allowed to use the data to track the car if it is reported stolen by the owner[34]. One way to evade this regulation is to collect the location data anonymously. This can be done by aggregating the data collected by the locating system. This means that the information about who, or which device is not stored, only the fact that there was a device at a specific place at a specific time. This data can later be used to improve service or be used in scientific research.

Chapter 3

Research Design and Methodology

This chapter describes the research questions and how the research was conducted by using the design science research process methodology, followed by well-known usability principles and evaluations for the prototype, and acceptance models and hypotheses for the final version of the prototype. Then, there will be a summary of the data collection methods and tools that were used in the process of gathering data used to analyze and evaluate based on statistical data analysis methods for the application.

3.1 Research Questions

This Thesis seeks to find answers about students' intention to use the anonymous user position data by answering the following questions:

RQ1: *Is there an interest for an application utilizing anonymous indoor user position data among the NTNU students?*

One of the issue among NTNU students who attends studies at Gløshaugen today is to find an available reading room on Gløshaugen campus, especially the 4 weeks before the examination period. With more than 9000 students[1] and only around 2000 desks divided by 107 reading rooms[2] for low level (first to third) graders, students will have to "fight" for a desk to study.

By presenting a result from a survey taken by NTNU students, asking them if they are positive to using this kind of application, one can provide better insight if there is a need for this solution. Testing the ready solution will also provide a more realistic measurement of the interest.

[1] `http://www.ntnu.no/2020/tall-ntnu-hist.htm`
[2] `https://innsida.ntnu.no/wiki/-/wiki/Norsk/Leseplasser+-+Gl%C3%B8shaugen`

RQ2: *Is it possible to use anonymous indoor user position data from indoor positioning systems with location-based services to solve an "everyday" problem for students at universities?*

Given that people worldwide spend 80-90 % of their time indoors[24], helping indoor discovery become faster and easier is a natural next step when indoor venues are continuing to grow larger and more complex - making it difficult to find the information that is necessary to solve the desired need.

By gathering anonymous user position data from Wi-Fi access points, one can gain access to useful data of where and how people move inside buildings, without the user having to install or log in to any service. The need for new infrastructure is also minimal, because most public places already have Wi-Fi access points installed. Using these data with well-known location-based features (such as indoor navigation) to create an artifact that students can test in a real environment, one can get a better view of a solution.

RQ2.1: *If yes on RQ2. How can one achieve the students' acceptance to use that kind of application?*

Today, there are many different and accessible acceptance models based on social psychology theories that have been proposed from past research to test consumers' attitude and intention to adopt new technologies.

By measuring factors that affect students' intention to use the system based on an adapt acceptance model for this Thesis' application, one can see how they will accept and use it. With well-known statistical analysis methods and tools, it is possible to evaluate and present a result to answer the question.

RQ3: *How can one display these data on a mobile device so one can achieve high usability of such applications?*

There are several factors one needs to consider when creating an application with indoor positioning technology made for consumer's mobile devices. The application needs to be user friendly, highly responsive and resolve or fulfill real user needs.

By following well-known usability principles to introduce a good overview over the occupation of the reading rooms, students can easier find available desks to study. Showing good results and feedback from the user interface test, one can achieve a design which is pleasing for the users.

3.2 Research Approach

The model which was conducted and used in this research process bases its contribution to knowledge on a literature review and field research. The conclusions drawn from this work are illustrated via a product, *a prototype IT application*[35]. Following a sequence of expert activities to create and evaluate an innovative product[36], requires a structured approach to achieve results.

Peffers' design science research process[37] (Figure 3.1) is related to such a model since it focuses on developing new and innovative IT products, also called *artifacts* by extending the human and organizational capabilities[36]. It also describes how new ideas become embedded in purposeful artifacts and then how those artifacts are field tested in real-world environments in a rigorous process[4][37]. This research started with an assumption of a problem which was later confirmed by the web survey result from fall 2013. This is in accordance to Hevner's "problem identification that results in a motivation"[4][36]. According to Rossi and Sein[38], a design science research starts by identifying a need.

The final artifact was developed and evaluated spring 2014. The research follows Peffer's model[37] in a nominally sequential order from activity 1 through activity 6 based on a problem centered approach. However, it is possible to start at any of the activities in the process. In addition to Peffer's model, Hevner's seven guidelines (Table 3.1) were followed to ensure the Thesis' artifact is constructed in a suitable manner. Well-known usability principles and acceptance models were also followed during this research to ensure proper evaluation of the artifact's design, and its acceptance.

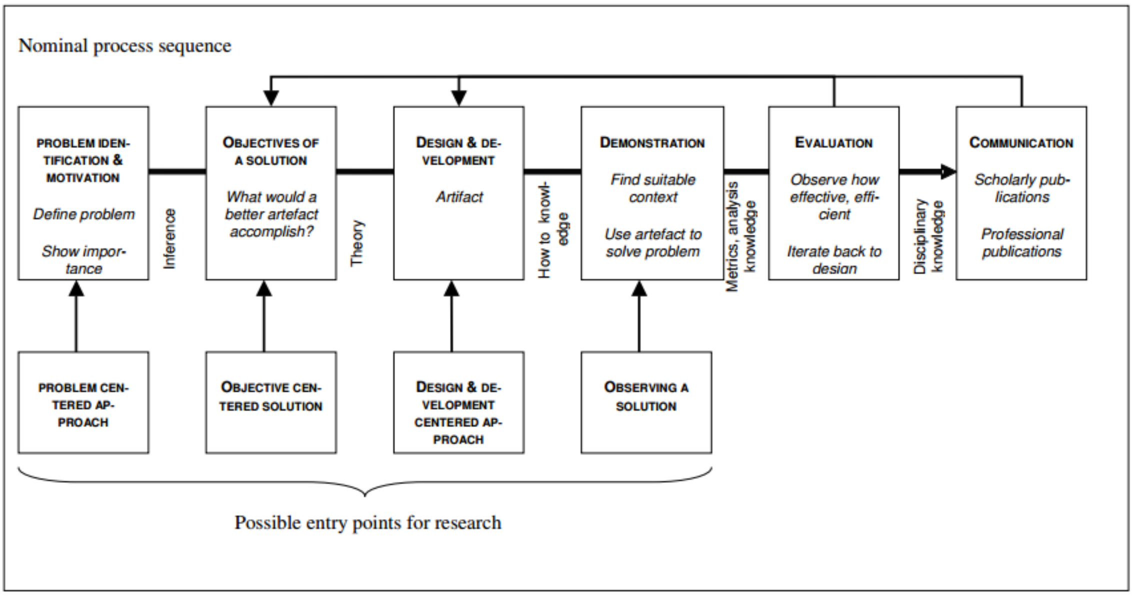


FIGURE 3.1: Peffers' Design Science Research Process Model

3.2.1 Design Science Research Process

Hevner's design science research guidelines[36] were combined with Peffers' design science process to make sure that the research was conducted in an optimal and proper manner. These are summarized in Table 3.1.

First guideline states that a viable artifact must be produced. In this Thesis, there is one artifact in form of a runnable application utilizing location-based and anonymous data which was created for an Android device.

Second guideline states that the objective is to develop technology-based solutions to solve business problems. The goal with the application is to provide a mobile service based on anonymous data as a tool in a possible business services to solve problems such as finding available study rooms or desks, better utilization of areas, thus an *everyday* problem.

Third guideline states that the artifact's design must be evaluated by using well-known evaluation methods. Well-known and regarded usability principles from software development such as Nielsen's 10 heuristics (Section 3.4.1) and SUS (Section 3.7.3) are used to evaluate the design of the artifact. MSAM (Section 3.3) and statistical analysis tools (Section 3.9.1) were also used to predict if future end-users may come to accept and use the artifact.

Fourth guideline states that the research must provide clear and verifiable contributions. One can assure this by providing the results from the acceptance testing.

Fifth guideline states that the research relies upon rigorous methods in both construction and evaluation of the artifact's design. The remainder of this chapter explains evaluation- and development methods used on the artifact and the research model.

Sixth guideline states that the design must be seen as a search process to exploit available resources to reach desired goals. This research has been conducted through an iterative process i.e. starting with an assumption of a problem and ending with a solution of the problem based on iterative processes (Figure 3.1).

Seventh guideline states that the results of the research must be properly presented. The results of this Thesis are revealed through this report, and are available through Norwegian University of Science and Technology's Intranet[3].

[3] `http://daim.idi.ntnu.no/soek/`

Guideline	Description
G1: Design as an Artifact	Design science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation
G2: Problem relevance	The objective of design science research is to develop technology-based solutions to important and relevant business problems
G3: Design evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods
G4: Research contributions	Effective design science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies
G5: Research rigor	Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact
G6: Design as a search process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment
G7: Communication of research	Design science research must be presented effectively to both technology-oriented and management-oriented audiences

TABLE 3.1: Hevner's 7 Design Science Research Guidelines[4]

3.3 Acceptance Field

The Thesis's third (RQ2.1) research question (Section 3.1) is about how one can ensure acceptance in applications that utilize anonymous location-based data. By following an acceptance model specifically made for mobile services, one can verify if the service obtains the usefulness that is needed for the end-users to solve a *business* problem, hence Hevner's second guideline. This topic has been and still is a major research field, when determining user acceptance of information systems[35]. Many models and theories have been developed for the acceptance field using factors influencing users' intention to adopt new services. Further, a brief summary of the most relevant theories and models[9][39][40][41][42] will be summarized to give the reader a deeper understanding of the model used in this Thesis.

3.3.1 Theories

Ajzen & Fishbein's Theory of Reasoned Action (TRA) is one of the earliest models to describe the adoption by explaining an individual's readiness to perform a given behavior based on a combination of attitude toward the behavior and subjective norm.

10 years later Ajzen also proposed the Theory of Planned Behavior (TPB) that explains all behaviors over which people have the ability to exert self-control based on three kinds of consideration: *behavioral beliefs*, *normative beliefs* and *control beliefs*. Attitude toward a specific act is defined as the individual's positive or negative feelings about performing a behaviour, while subjective norms refers to an individual's perception of whether people important to the individual think the behavior should be performed. Perceived behavior control describes people's perceptions of their ability to perform a given behavior[4]. The model is illustrated in Figure 3.2.

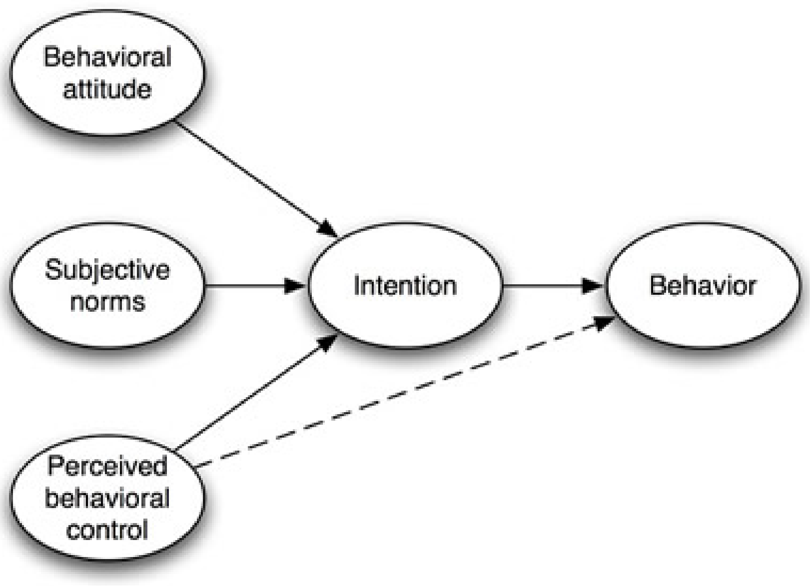


FIGURE 3.2: Ajzen's Theory of Planned Behavior

[4] `http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/SB721-Models/SB721-Models3.html`

Innovation Diffusion Theory (IDT) by Rogers is also widely known in this field. The theory includes *relative advantage*, *compatibility*, *complexity*, *trial ability* and *observables* to explain the process of decision process, factors that determines the adoption and various type of adopters.

Rogers defined the constructs[43] as:

- **Relative advantage** is the degree to which an innovation is perceived as better than the idea it supersedes. The underlying principle is that the greater the perceived relative advantage of an innovation, the more raid its rate of adoption.
- **Compatibility** is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters.
- **Complexity** is the degree to which an innovation is perceived as difficult to understand and use
- **Trial ability** is the degree to which an innovation may be experimented with on a limited basis. If an innovation is trialable, it results in less uncertainty for adoption.
- **Observability** is the degree to which the results of an innovation are visible to others. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt.

Unified Theory of Acceptance and Use of Technology (UTAUT) is another well-known model proposed by Venkatesh that explains user intentions to use an information system and subsequent usage behavior, using four constructs; *performance expectancy*, *effort expectancy*, *social influence* and *facilitating conditions*. Other variables such as *gender*, *age*, *experience* and *voluntariness of use* are used to influence the impact of the four key concepts illustrated in Figure 3.3.

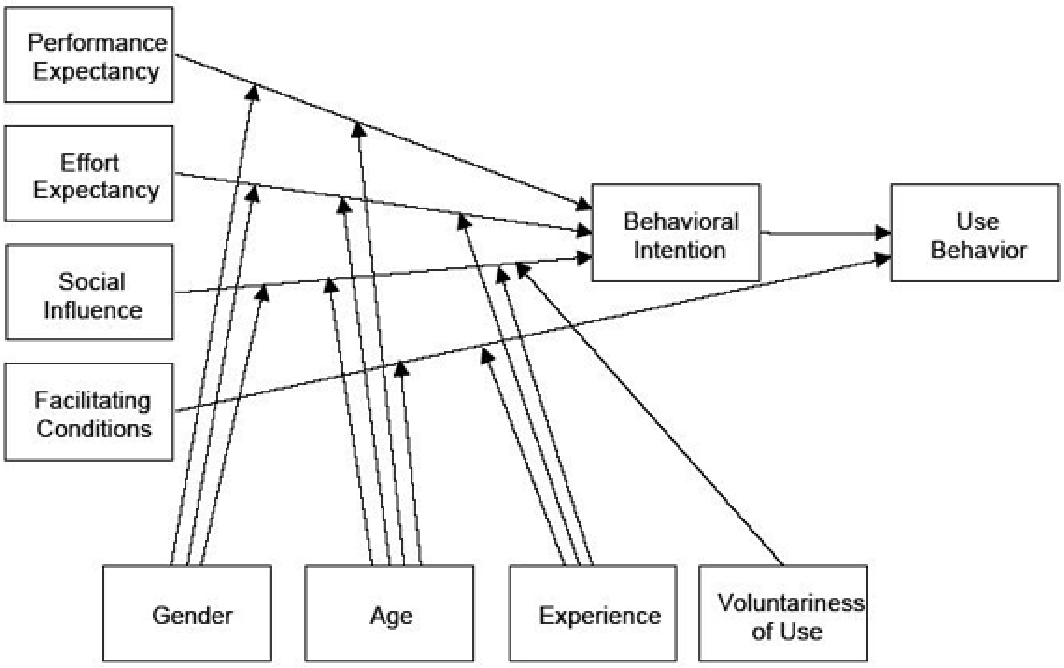


Figure 3.3: Venkatesh's Unified Theory of Acceptance and Use of Technology

The model was created with eight other models during a longitudinal field study involving four organizations and four systems.

3.3.2 Technology- and Mobile Services Acceptance Model

In this section a specific model called Mobile Services Acceptance Model[9][40][41] (MSAM) will be explained. It is designed for the kind of service that the Thesis' artifact offers, and thus is more fitting than earlier mentioned models. The model was used as it is intended for the use of contextual information such as location, time, and personal preferences to provide the user with relevant and timely information. The model itself is an extension of Davis' technology acceptance model[44] (TAM) that describes how users come to accept and use of a technology, and is created based on TAM and acceptance theories. TAM (Figure 3.4) appears to be one of the most widely accepted models and is suggesting two factors; *perceived usefulness* (PU) and *perceived ease of use* (PEOU) to determine user *intention to use* (IU) new technology. MSAM uses both of these factors with new constructs; consideration of *trust* (TU), *context* (CT) and *personal initiatives and characteristics* (PIC) factors developed by Gao and Krogstie et al.[9]. The variables are defined in Table 3.2.

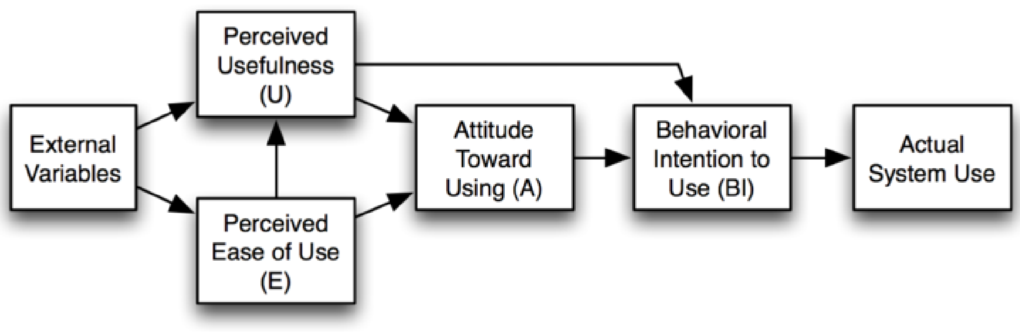


FIGURE 3.4: Davis' Technology Acceptance Model

Context

One unique attribute of mobile services is that it can be used in different contexts, i.e. the surroundings and circumstances may differ for each time the application is in use. Context provides an understanding of the way and circumstances for performing an activity[40]. Mobile services are often developed to provide an alternative or an extra channel for accessing services. When a service needs to be accessed immediately regardless of time and place, the perceived usefulness of the service should be high, which would implicitly influence users' intention to use the service. [40] believes that users' perception of the ease of use and usefulness of mobile services may vary in different contexts. Based on the context, a user can decide whether the mobile service is useful or not. According to Krogstie et al.[45], context can be divided into six categories, three of them are considered for this mobile service:

- **Spatio-temporal** context describes aspects related to time and space, e.g. direction, speed, or the absolute location of the user.
- **Task** context describes what the user is doing. It can also describe what people are interested in.
- **Social** context describes what social aspects that are relevant to the user.

Trust

The attribute trust plays a major role in mobile services as it is important for system providers to convince users to trust their services. [40] explains that the technology's reputation and knowledge from previous experience are two factors in trust, that allows users to use a service to solve problems.

For the mobile services topic, trust can be defined as; using a mobile service, users believes that it will be risk free and gain benefits in certain ways. Gaining users' trust is a time-consuming process, where trust is hard to gain, but it is easy to lose. Therefore trust is an important part of the process of adoption of mobile services.

According to [40], there are several factors that can influence users' trust in mobile services:

- **Not familiar** with mobile- services or technology.
- Unfamiliarity with mobile services **providers**, can cause an uncertainty among future users as they can believe the service is risky.
- Challenges such as **privacy and security issues** will always be included in mobile services. Users are concerned about the safety of mobile services and their safety of sensitive information.

Kaasinen[46] stated that ensuring privacy of the user is important as the users get increasingly dependant on mobile services. She also elaborated four statements why trust is important for the adoption of mobile services:

- The users should be able to rely on the overall service
- Sufficient accuracy of information
- The privacy of the user must be protected
- The user needs to feel and really be in control

Personal Initiatives and Characteristics
Personal initiatives and characteristics is the last attribute created by Krogstie et al.[9]. One of the factors that can influence the usage of mobile services depends on the users' background. Some might have different perspectives on emerging technologies, while others just want to adhere to existing technologies. [40] points out that experienced and skilled users of IT applications are more likely to try new innovative mobile services as they are able to deal with a higher level of uncertainty compared to unskilled users. Usually these users are young individuals that have a greater interest in trying new services and technologies. Another factor is the users' willingness and needs which is also highlighted in [40]. Mobile services are mainly designed for individual users who have different expectations and needs, and might perceive a mobile service in different ways - their intention to use the same mobile service might differ. All of these mentioned factors constitutes a part of personal innovativeness that is an important indicator for personal initiatives and characteristics.

The MSAM contains 6 constructs; *context*, *personal initiatives and characteristics*, *trust*, *perceived usefulness*, *perceived ease of use* and *intention to use*, illustrated in the Figure 3.5. The proposed paths between the constructs leads to seven hypotheses based on the mentioned theories and models:

H1: There is a direct positive effect from context to perceived usefulness

H2: There is a direct positive effect from context to perceived ease of use

H3: There is a direct positive effect from perceived ease of use to perceived usefulness

H4: There is a direct positive effect from personal initiatives and characteristics to intention to use

H5: There is a direct positive effect from trust to intention to use

H6: There is a direct positive effect from perceived usefulness to intention to use

H7: There is a direct positive effect from perceived ease of use to intention to use

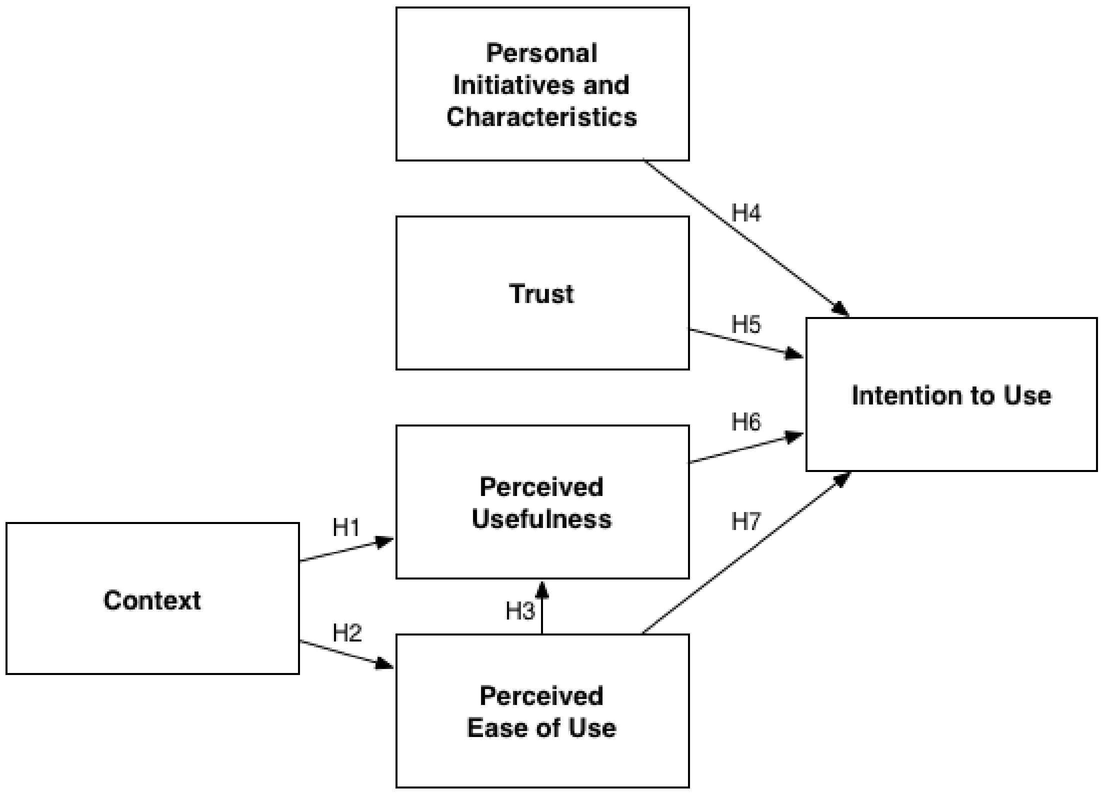


FIGURE 3.5: Krogstie, Moe and Gao's Mobile Services Acceptance Model

Construct	**Definition**
Context	Any information that can be used to characterize the situation of entities that are considered relevant to the interaction between a user and an application, including the user and the application themselves
Personal Initiatives and Characteristics	The user's willingness to experiment with new services and user's age, gender, educational background, knowledge and skills, culture and preference are important elements
Trust	The user's beliefs or faith in that a specific service can be regarded to have no security and privacy threats, that means that believing mobile applications with an expectation that it will be risk free.
Perceived Ease of Use	The extend to which a person believes that using a particular system would be free of effort. It also reflects how difficult it is to use the technology.
Perceived Usefulness	The degree to which a person believes that using a particular system would enhance his or her task. The users needs to find the mobile application to be useful to easily adopt them.
Intention to Use	The user's likelihood to engage the mobile service

Table 3.2: Definition of the Constructs

3.4 Usability Development and Design

The Thesis' fourth (RQ3) research question (Section 3.1) is about how one can ensure good enough usability in applications with anonymous location-based data. Hevner's fifth guideline states that, by utilizing and implementing the usability principles in the construction and evaluation phases of the applications user interface development process, one can achieve better results.

There are several definitions of what usability is. The International Organization of Standardization (ISO)[5] is the largest developer of International Standards which gives specifications for products and services. They define usability as

[5] `http://www.iso.org/iso/home/about.htm`

> *"The extent to which a product can be used by* ***specified users*** *to achieve* ***specified goals*** *with effectiveness, efficiency, and satisfaction in* ***a specified context*** *of use"*

in their ISO9241[47] for system development. Nielsen and Hackos[48] uses five quality characteristics to define usability which is summarized below:

- **Learnability**: Easy to learn the system so the users can do some work immediately.
- **Efficiency of Use**: High level of productivity when the users are using the system.
- **Memorability**: Easy to remember so the users do not have to learn everything all over again after a period of inactivity.
- **Few and Noncatastrophic Errors**: Few errors in the system, so the users do not make many errors and the errors are not critical.
- **Subjective Satisfaction**: Satisfying users subjectively, so they like to use the system.

Both Nielsens quality characteristics and the ISO definition can be used during usability-, design-, development- and evaluation process, but they can be separated in usage. Nielsen's characteristics leans towards how the final product should be, while the ISO definition focus on finding whom and what to consider when creating the product.

Gould & Lewis[49] believes that to produce a useful and easy to use computer system, one must follow three key principles; *early and continual focus on users*, *empirical measurement of usage* and *iterative design*. The first key is to understand who the users will be and their needs rather than to identify them in an early process of the development. The second key is to let users use simulations and prototypes in an early stage of the development process to carry out real work. The third key is to use the results found from the user testing to improve the artifact, repeated as often as necessary.

According to Constantine & Lockwood[50], *usability* and *the user experience* appears as critical factors to determine the success in web applications. Poorly designed interfaces, buried key information are something that are highlighted which can be costly. Manual follow-up for technical or customer support becomes an expensive cost over a longer time.

Usability is important in software development since it measures the "ease of use" and "user friendliness" of the system[51]. It will be important to have a high degree of usability when considering the application is intended for a large audience with different types of people. In a large and random audience there can be some with only brief experience with smart phones or with non-technical background. According to the ISO statement, the specified users is the *NTNU students*, the specified goal is *to find an available study room in Gløshaugen campus* and the specified context is *the students using mobile devices to acquire the information that provides the data to solve the goal*. Typical users of the application are elaborated in Section 5.1.

3.4.1 Usability Heuristics

Nielsen's 10 general principles[52] for interaction design is well-known within system development. These were originally developed for heuristic evaluation in collaboration with Molich in 1990, but today these should not be used as specific usability guidelines, but more like a rule of thumb when creating and evaluating user interfaces. For more specific usability guidelines, Tognazzini recently presented a new and revised version of his "First Principles of Interaction Design"[6] that contains a large number of principles and is more used as a checklist for usability interface evaluation. Nielsen's 10 general principles are presented below:

- **Visibility of system status**: The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
- **Match between system and the real world**: The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
- **User control and freedom**: Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
- **Consistency and standards**: Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
- **Error prevention**: Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
- **Recognition rather than recall**: Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember

[6] http://asktog.com/atc/principles-of-interaction-design/

information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

- **Flexibility and efficiency of use**: Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
- **Aesthetic and minimalist design**: Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
- **Help users recognize, diagnose and recover from errors**: Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
- **Help and documentation**: Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

The Heuristic evaluation is a good method to identify both major and minor problems with an interface, but Nielsen also recommend to employ both the heuristic evaluation and user testing evaluation methods as they alone can not find all the problems[53]. Schneiderman[51] also proposed a collection of principles named "Eight Golden Rules of Interface Design" which are derived heuristically from his own experience. The principles are claimed to be a guide to help design and evaluate usability in user interfaces.

Android Developers have also created helpful principles for Android applications[7]. These were followed to recreate a confidence the users might have from past experience with Android applications.

3.5 Instrument Development

Feedback questionnaires, web survey, SUS and MSAM questionnaires were constructed in this research. Feedback questionnaires were used to get a deeper understanding of the participants demographics, while the web survey, SUS and MSAM questionnaires were the main instruments when measuring different items for answers to the Thesis' research questions. The web survey is a self-constructed survey

[7] `https://developer.android.com/design/get-started/ui-overview.html`

to investigate if there is a reading room problem in Gløshaugen, but also to find the requirements suggested by possible end-users. SUS questionnaire is used to get feedback on the general usability of the prototype, and MSAM questionnaire is used to measure different items related to the Thesis' artifact. The survey and questionnaires covers the 4 topics:

1. **Confirm reading room problem**

   Find demands and requirements to solve the problem

2. **Perceived usability**

   User interface

3. **Perceived acceptance**

   Context

   Personal initiatives and characteristics

   Trust

   Perceived ease of use

   Perceived usefulness

   Intention to use

4. **Background information**

All survey and questionnaires can be found in Appendices A, B and C. There are included questions about background information such as age, gender, smart phone ownership, reading room usage. The responses to these survey and questionnaires can be found as raw data in digital attachments.

In the web survey, the measures to find if there is a reading room problem are based on questions about; viewpoints around the usage of reading rooms in Gløshaugen, smart phone ownership, which grade they currently attend, and a free text answer to see what is needed of a solution. The measures to find the requirements to the prototype were based on litany of different features believed to be important to the users and that could be implemented, with a scale ranging from useless to very useful. Q9 in the web survey asks about the participant's suggestions for features for the solution, to find features that the developers had not thought of.

In the SUS questionnaire, the measures to find the usability is based on Brooke's method (Section 3.7.3). It was decided to use the Norwegian translation adapted by Svanæs[8] because the persons tested were Norwegian and to avoid confusions which may occur from language barriers.

In the MSAM questionnaire, the acceptance measures are described in Section

[8]http://www.brukskvalitet.no/wp-content/uploads/2010/01/SUS-norsk.pdf

3.3. The scales used to measure the MSAM constructs are Likert scales described by [54]. Usually such a scale is ranked from agree to disagree, or best to worst using five or seven points. In this Thesis, the MSAM questionnaire (Section 3.7.4) used a seven point scale where the score range from 1-7, meaning disagreement and agreement have three points each, and score 4 is neutral.
Statistic measures such as min, max, mode, mean and standard deviation are used to provide an overview of the responses. They are explained in Chapter 7.

3.6 Data Collection Methods

To get a foundation to answer the research questions and to evaluate the application, different data collection tools[35][51] such as web survey, feedback-, SUS- and MSAM questionnaires were conducted to gather information. This section will present data collection methods, their weaknesses and strengths before the tools are listed.

3.6.1 Survey

A survey was carried out to collect data in this research. The method can provide both qualitative and quantitative information depending on the questions asked, but often it provides quantitative information[9]. Survey is considered to be one of the most cost-effective methods of collecting information from a large number of respondents involved in the web survey, and can be associated with a census method since the respondents can remain anonymous. It is less time-consuming than other data collection methods since the participants receive a uniform resource locator (URL) where they can fill out the survey, instead of e.g. an interview where the interviewee must be present. The main purpose is to get as many answers as possible from the target user groups. By distributing to appropriate channels, one has a greater chance of receiving input from the desired type of users.

In this Thesis, a web survey was used to confirm if the assumption is a problem among the NTNU students.

[9]Information that can be counted or measured or expressed numerically. They are more objective than qualitative information[35].

Data Collection Method	**Strengths**	**Weaknesses**
Survey	Less time-consuming, most cost-efficient method, large samples, anonymity, easier to collect responses, easily manage the distribution and collection	No clarification of questions (limited), depends on technology, finds the right audience, needs to be able to read and write, relies on perceptions, questions can be misunderstood
Questionnaire	Follow-up, no technology, right audience, do not need to be able to read or write, questions can be clarified	Time-consuming, anonymity, low samples
Observation	Discover behaviors, more reliable than data gained by asking people	Time-consuming, no questions asked during observation, depends the follow-up interviews to verify observations
Interview	Questions can be clarified, not required to read or write since it is based on oral communication, richer and more detailed responses, can probe and explore questions	Requires equipment to record, time-consuming, requires quiet area to conduct interviews, interviewer bias
Prototype Testing	Easy, small samples, reliable data, cheap, involve the user in an early phase	Time-consuming

Table 3.3: Data Collection Methods

3.6.2 Questionnaire

Questionnaire is almost the same data collection method as survey. The biggest difference between these two are the perceived lack of anonymity. The developers are present and can see who the person responding is. This may induce an interviewer bias, that makes the interviewee answer in a more positive way, in order not to "hurt the interviewers feelings"[55]. Other differences are the weaknesses and strengths which is summarized in Table 3.3.

Five questionnaires were used during this Thesis. Two were used to find the demographics of who the test partcipants are, and one to get feedback of the application's design. The last two are from SUS and MSAM.

3.6.3 Observation

Observation is a data collection method that collects qualitative[10] information. This method is more reliable than data gained by asking people since the researcher is present and gets a live view of a whole situation. One gets more insight into the whole situation but the disadvantage is the amount of time it takes, and the interviewer should not ask questions during observation to interfere with the people or situation. Sometimes, the researcher can be a participant observer where he or she is taking part in the situation in order to understand the work situation or the social phenomenon.

In this Thesis, observation of the participants was used during the user interface- and acceptance testing, to see what difficulties they had with the design, and which features were easy to use.

3.6.4 Interview

Interview is another qualitative method where one can receive a broader and richer knowledge. There are three types of interview methods to choose from [35]:

- **Structured** interview where one have a preset list of questions to ask the interviewee and all interviewees answers the same set of questions in the same order.
- **Semi-structured** interview gives the interviewer opportunities to change the order of the questions the possibility to add additional questions as the interview goes on.
- **Unstructured** interview provides the freedom for the interviewee to talk freely around a main topic that is introduced by the interviewer.

The difference between these are that semi-structured and unstructured methods are great for discovery research while structured is mainly for checking information[35].

[10]Information that can be arranged into categories that are not numerical and is sometimes referred to as categorical data. They are time consuming but the benefits from them is that the information is richer and has a deeper insight into the phenomenon under study[35]

The semi-structured was used in this Thesis during the user interface testing since it allows the interviewer to adapt depending on the interviewee and environment during the interview. Interview should be fairly informal so participants feel they are taking part in a conversation or discussion rather than in a formal inquiry.

3.6.5 Prototype Testing

Prototype testing is a method to test a system, involving the end-users of the system. This method is used frequently within software development to get feedback of the users' opinions of a system. Feedback of software design, usability and if the software fulfills users' wishes are usually qualitative data. According to Nielsen[11], one only need to test with 5 users to find 90 % of the problems with usability. The testing should be executing several times in small tests. Nielsen suggests that it should be at least 3 testers from each type of users[56].

In this Thesis, two prototype tests were used to get users' evaluation, one for the user interface and one for the acceptance. Both tests were conducted on two different type of users with different needs; *with* own desk and *without* own desk, therefore it was minimum 6 testers (3 in each group) in the user interface test.

The user interface testing was with students from the developers' network while hallway testing[12] was conducted during the acceptance test. This method is a general method of usability testing where random people are asked to test a product or a service.

3.7 Data Collection Tools

This section will present the data collection tools used. The web survey was conducted to see whether there was an interest for the application and if there was a need here in Gløshaugen. It was also performed to check what functionality the users want in the application. The prototype tests were performed to see if the design of the application follows the Android Operating System (OS) design principles and to get feedback of the usability by using a standardized SUS[13] test, but also to see the end-users' acceptance. The feedback questionnaire is to see if the test participants were satisfied with the usability of prototype version, but also to find out more who the testers are, and if they are relevant users of the application.

[11] `http://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/`

[12] The term means that the testers should be random people who pass by in the hallway

[13] ISO 9241 is a standard that covers ergonomics of human-computer interaction (`http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=52075`)

3.7.1 Web Survey

The web survey is based on the survey method (Section 3.6.1) with questions that provide both qualitative and quantitative data. The survey was made with Google's Form service[14], and the survey's URL was posted through NTNU's Intranet "Innsida"[15], Studentservice NTNU's Twitter page[16] and NTNU's area in Its-Learning[17]. By using these distribution channels, one can easier reach out to the target audiences which are the students from NTNU. The survey's goal is to identify the needs of the application and possible future user's viewpoints, and to map their intentions to use the application. The complete web survey is found in Appendix A.

3.7.2 Prototype

During the prototype tests (Section 3.6.5), the interviewers observes (Section 3.6.3) the test participants to identify critical events. The prototype used in this testing is the artifact that was made during this Thesis. The presentation of the application is found in Chapter 6. After observing the test and the questionnaires, it is natural to have an informal interview (Sections 3.6.4) with the participant to elaborate the answers from the questionnaires or having free talk about relevant topics. The complete user interface test is found in Appendix B and acceptance testing is found in Appendix C.

3.7.3 System Usability Scale

All participants who conducted the user interface testing, took a SUS test. SUS is an objective questionnaire method (Section 3.6.2) used to assess the overall usability and design of a system. It was originally developed by John Brooke in 1986 as a "quick and dirty" tool for measuring the usability. The scale consists of 10 questions with five options ranging from "strongly disagree" (equivalent to 1) to "strongly agree" (equivalent to 5). The biggest benefits with SUS testing is that it can effectively differentiate between usable and unusable systems, and gives reliable results. The output of the test is a scale between 0-100. It is important not to interpret them as percentages, but to *normalize* the scores, and create a percentile ranking. Each question gives a score number, which one needs to summarize, and then multiply the sum with 2,5 to get a final score. A SUS score below 68 is under

[14]https://docs.google.com/forms/d/1TsV5I7Cjg3c8HjC57kkziz0VRLgqOTk2a3dBw7OFvDY/viewform

[15]https://innsida.ntnu.no/

[16]https://twitter.com/NTNUstudent

[17]https://www.itslearning.com/

average and above is over average. SUS is also an evaluation tool that is often used in software development projects. The tool is easy to use, free and the result is objective and reliable[57]. The complete System Usability Scale is found in Appendix B.

3.7.4 Mobile Services Acceptance Model System Scale

The participants who conducted the acceptance testing did also take the MSAM questionnaire. The MSAM scale is also an objective questionnaire method (Section 3.6.2) used to verify the acceptance of a new mobile technology. The measures for different constructs are based on items that were adopted and elaborated from prior studies[40][58], or based on conceptualizations and theories found in Section 3.3 if none could be found in previous literature. Then, some items were modified to fit the domain of the Thesis' mobile service. The scale consists of 4-6 questions per construct, except IU ("Intention to Use") construct which only has two. Each question has seven options ranging from "strongly disagree" (equivalent to 1) to "strongly agree" (equivalent to 7). The complete MSAM questionnaire is found in Appendix C.

3.7.5 Test Subject Feedback Questionnaire

The feedback form is also a questionnaire (Section 3.6.2) method which was handed out to the participants after both of the tests. The questionnaires consists of questions related to smart phones, reading rooms, tester's background, application's design, application's functionalities and usefulness of anonymous user location-based data. These questions verifies if the application covers the end-users' needs and has a good design which are the Thesis' goals. The complete feedback questionnaires are found in Appendices B and C.

3.8 Test Environment

This section presents how the user interface- and acceptance testings are conducted by describing the test participants for both of the prototype tests, and explaining the execution of the tests.

3.8.1 Test Subjects

The test subjects for both of the tests are students from NTNU, more specific students from Gløshaugen campus. It is important to test the prototype on different types of users, such as age, smart phones skills or technology skills of students to get diverse answers.

The participants in the user interface test were chosen based on different experience with technical devices, but also different grades and study specialization. Nielsen recommends 3-4 users per category when testing several types of users. The students should preferably have an experience with finding reading rooms on Gløshaugen, so they could relate to the situation during the tests. The most important consideration was to see the experience in the use of smart phones to find usability problems. The prioritizing for user interface participants:

1. Experience with technology devices
2. Lower level grade
3. Do not have personal reading desk

In the acceptance testing, the prioritizing order was reversed. The goal here was to find the factors which determine intention to use of an application that applies anonymous location-based data for finding available reading rooms. Therefore it was most important to find students that do not have their own reading desk. The prioritizing order for acceptance test participants:

1. Do not have an own reading desk
2. Lower level grade
3. Experience with technology devices

3.8.2 Test Execution

Both of the tests were executed on Gløshaugen campus at the Norwegian University of Science and Technology. The user interface testing in week 6-7 and the acceptance in week 13-15, 2014.

Date	Type of testing	Description	Number of test users
February 3rd-11th 2014	User Interface	Testing the usability, using dummy data	10
April 1st-15th 2014	Acceptance	Testing intention to use's factors of the application	41

Table 3.4: Test Environment

By using the the developers' network, it was not hard to find students that matched the wanted requirements to test the prototype's user interface after explaining them the project. In the user interface test, the test subjects borrowed a Huawei G700[18] to run the prototype. An introduction was given to the participants so they could put their minds into the situation. Then, the participants followed the given task instructions (Appendix B), said what he or she does and thinks out loud, so the observer and test leader can understand the idea behind the actions performed by the testers[51]. The observer noted any difficulties or other details the participant mentioned during the test. The partcipants were allowed to ask questions, but the test leader or observer were not allowed to help the participants with performing the tasks. After the test, all of the participants were handed a questionnaire about the design which is described in Appendix B. The user interface testing was executed in the following order:

1. Test Subject Questionnaire - Demographics
2. Introduction of the test from test leader
3. Testing the prototype
4. System Usability Scale
5. Test Subject Questionnaire - Usability
6. Discussions between the test leader, observer and test subject

The average time spent per participant in the user interface test was around 15-30 minutes; 5-10 minutes to test the prototype, 5-10 minutes to fill out the questionnaires, 5-10 minutes with interview and discussion.

[18] `http://www.gsmarena.com/huawei_ascend_g700-5633.php`

In the acceptance test, the test subjects borrowed either an LG Optimus 2x[19], HTC Desire HD[20] or HTC Desire S[21] with the Ledig Lesesal Plass application pre-installed. All participants were found in hallways in buildings around Gløshaugen campus, and they were provided with an information sheet describing Ledig Lesesal Plass, so the participants got some basic ideas about the application's features. The introduction sheet and cases can be found in Appendix C. The participants were then free to move around campus and find reading rooms, checking if the capacity indicated by the application was correct. After they had finished the tasks, the participants returned the devices, and were given a feedback questionnaire to complete. The results from this questionnaire were used to analyze if the mobile service would be accepted by students at Gløshaugen.

In the acceptance test, some of the tests were performed involving groups of friends; one male-only group and one female-only group. A downside with group testing is the phenomenon called group thinking where opinions from the dominant person(s) can manipulate the result, leading to less creative answers[59]. Another factor is that 7 of the participants were first graders, which means they have only been through 1 examination period and have less experience with the reading room situation on Gløshaugen. This could of course have both positive and negative effects on the results. The positive is that one get a fresh view if students have already noticed in their first year a problem with finding reading rooms, and the negative is that they may not yet have been introduced to the issue and are therefore a less reliable source of information. The acceptance testing was executed in the following order:

1. Introduction to the application and test
2. Testing the prototype
3. Test Subject Questionnaire - Demographics
4. Mobile Services Acceptance Model Questionnaire

The average time spent for one participant in the acceptance testing was approximately 25-35 minutes; 20-25 minutes to test the prototype (depending on where the test subject was located), and 5-10 minutes to fill out the questionnaires.

[19] http://www.gsmarena.com/lg_optimus_2x-3598.php
[20] http://www.gsmarena.com/htc_desire_hd-3468.php
[21] http://www.gsmarena.com/htc_desire_s-3776.php

3.9 Data Analysis

This section explains how the data collected from the MSAM questionnaire were analyzed with statistical tools to be able to verify or reject the hypotheses stated in Section 3.3.

3.9.1 Statistical Tools Used to Analyze Data

The data collected from the MSAM questionnaire were analyzed with two different statistical programs, IBM SPSS version 21[60], and SmartPLS 2.0[61]. IBM SPSS software was used to extract descriptive results, by calculating Cronbach's alpha coefficient on each of the constructs, to check the internal consistency of reliability (ICR) of the acceptance test. Smart PLS 2.0 software was used to to do path modelling, using partial least squares (PLS) analysis to create path coefficients (paths seen in Figure 3.5) so one can validate or invalidate the seven hypotheses in Section 3.3.

3.9.2 Partial Least Squares

Structured Equation Modeling (SEM) techniques such as LISREL and PLS are data analysis techniques that can be used to test the extent to which information systems research meets recognized standards for high quality statistical analysis[62]. Covariance-based SEM is the best known version of SEM, and is implemented in software programs such as LISREL, EQS, AMOS, and is a tautology to SEM for many social sciences researchers. A less known way of doing SEM analysis is the PLS technique. PLS places less restriction on the measurement scales, such as sample size and residual distributions[63]. SEM enables researchers to answer a set of interrelated research questions in a single, systematic and comprehensive analysis, by modeling the relationships among multiple independent and dependent constructs simultaneously[62]. Another advantage of PLS is that it supports both confirmatory and exploratory research. This makes PLS-based SEM a suitable solution for testing the hypotheses in this Thesis.

A SEM-analysis assesses two models at the same time:

1. **The structural model:** also known as the inner model, consisting of the assumed causation among a set of dependent and independent constructs.
2. **The measurement model:** also known as the outer model, consisting of loadings of observed items on their expected latent variables (constructs).

Analyzing these two models combined enables researchers to make measurement errors of the observed variables an integral part of the model. It also enables factor analysis to be combined in one operation with the hypotheses testing. This results in a more rigorous analysis of the research model and a better tool to assess the results, than first generation regression tools[62].

3.9.2.1 Assessing Reliability and Validity

Reliability

The individual items in a Likert scale collected through the MSAM questionnaire can be described as ordinal data[54], i.e. they have no significance beyond its ability to establish a ranking over a set of data points. Although, when more Likert items are combined to form indexes, parametric procedures can be used in the statistical analysis of the data if the scales pass the Cronbach's alpha test[54], which measures the ICR.

The **Cronbach's alpha** test provides a useful lower bound on reliability and it will generally increase when the correlations between the query items increase. Usually the values are between 0 to 1, but sometimes it can be negative. Obtaining a valid Cronbach's alpha can be hard as there are a number of reasons why it can get many different values from the same test, but with different users. "Reverse coding" and "multiple factors" are two reasons[64].

The Cronbach's alpha value should be above 0.6 for exploratory research according to [62]. John P. Robinson et al. [65] also stated that the Cronbach's alpha value should not be lesser than 0.6, as this is the lowest acceptable limit. Hair et al.[64] also recommended that the values from 0.6 to 0.7 were considered as the lower limit of acceptance.

The **Average Variance Extracted** (AVE) measures the amount of variance that is captured by the construct in relation to the variance due to random measurement error. If AVE is less than .50, the variance due to measurement error is larger than the variance captured by the construct, and the validity of the individual indicators as well as the construct is questionable[66]. In Section 7.3.3.1 the items in each construct were assessed to check the reliability of the measurement model.

Convergent and Discriminant Validity

Convergent and discriminant validity are assessed by investigating if the AVE of each construct is larger than its correlation with the other constructs, and if each item has a higher loading on its assigned construct than on the other constructs.

For **convergent validity**, this is determined by examining the factor loadings of the outer model. To measure the significance of the loadings, one need to look at the t-values. A t-value > 1.96 indicates that the loading is significant at a probability level of $p < 0.05$. A t-value > 2.576 is significant at $p < 0.01$, and $t > 3.29$ is significant at $p < 0.001$[67]. In Section 7.3.3.2 the convergent validity is assessed.

Discriminant validity is shown if the measurement item correlates strongly with its *theoretically assigned construct*, and at the same time correlates weakly with the *unrelated constructs*. The square root of the AVE for each latent variable[22] should be larger than the inter-construct correlations, and the lowest acceptable value is 0.5[63]. The latent variable should be larger than the inter-construct correlations by an order of magnitude[66]. E.g. if the latent variable has a value of 0.7, all the other inter-related constructs should have a value < 0.6. In Section 7.3.3.3 the discriminant validity result is presented.

[22]Latent variables are opposite to observable variables. They are rather inferred through mathematical models from other variables

Chapter 4

Confirming the Problem

This chapter presents the results from the web survey (Appendix A) that was conducted to evaluate if there is a problem of finding available reading rooms in Gløshaugen and what kind of solution is needed to solve it. It begins with a description of the demographic data of the web survey participants before the results from the survey is elaborated. The results are presented in tables with several attributes, that will be described later.

4.1 Demographics

This section presents the demographic profile of the web survey respondents. The web survey aims to gain an overview of the participants experience and ownership with smart phones and their thoughts of the study room situation at NTNU Gløshaugen. By collecting the participants information, one can get a greater picture of the response in the context of the user and get a better understanding of who the future users of the Thesis' application are.

Attributes *Characteristic*, *Description* and *Item* explains the details of the demographic questions. *N* is the number occurrences, *%* is the percentage of occurrences. Some of the questions use a scale point system based on different statements to see to what degree they like or dislike the topic.

4.1.1 Participants Information

Table 4.1 provides the demographic profile of the participants by gender, student status and grade level. Most of the respondents (98.6 %) are NTNU students, something one could assume due to the distribution channels used. Around 64 % of these are students from the first three years of their education, so another assumption based on the developers' experiences, is that they do not have a personal desk.

Characteristic	**Item**	**N**	**%**
Gender	Male	99	63.5
	Female	47	36.5
Student	Yes	144	98.6
	No	2	1.4
Grade	1st	23	15.8
	2nd grade	53	36.3
	3rd grade	18	12.3
	4th grade	28	19.2
	5th grade	22	15
	PhD student	2	1.4

Table 4.1: Web Survey Participants Information

4.1.2 Participants' Daily Use of Study Rooms and Smart Phones

Table 4.2 provides statistics of participants' daily usage of smart phones and study rooms at Gløshaugen. 97.3 % of the participants owns either a smart phone or a tablet, which indicates that the participants could possibly be the end users of the application. 85.6 % use reading rooms at Gløshaugen, where 32 % uses 1-5 hours per week, around 24 % 6-10 hours per week, 25 % 11-20 hours per week and 21-31+ hours is around 19 %. In Q8 ("If you do not use reading room, why?"), the respondents answered: "stressful to find an available desk", "better conditions at home", "reading rooms are not so much available", "hard to find rooms", "cold", "better coffee at home", "do not know where the rooms are", "never available desks". Hopefully the Thesis' application can solve some of these problems by implementing additional features that supports it. In Q4.1 about hours spent at study rooms, there was 15 test participants that did not respond. The percentages are calculated based on 146 students.

Description	Item	N	%
Smart phone or tablet ownership	Yes	142	97.3
	No	4	2.7
Use of smart phone per day	Less than 1 hour	29	19.8
	1-2 hours	61	41.8
	3-5 hours	37	25.4
	More than 5 hours	19	13
Use of study rooms at Gløshaugen	Yes	125	85.6
	No	21	14.4
Hours spent at study rooms per week	1-5	42	28.8
	6-10	31	21.2
	11-20	33	22.6
	21-30	15	10.3
	31+	10	6.8

Table 4.2: Participants' Use of Study Rooms and Smart Phones

4.2 Perceived User Interest and Needs

This section summarizes the most important information retrieved from the web survey evaluation - the participants interests and needs.

4.2.1 Participants' Interest of an Application to Find Available Rooms

Table 4.3 provides the most important data, the interest of using such an application from the survey. 85.6 % of the 146 respondents would have liked to use the application. If one takes a closer look at the survey answers of the 14.4 % who replied no, one can divide them into two groups; those who do not have smart phones and those who have their own personal study room, office or desk - which are not the Thesis' target group. This means that the application will not cover their needs as they do not have any need for the application.

Description	Item	N	%
Interest of using an app like this	Yes	125	85.6
	No	21	14.4

Table 4.3: The Interest of Using Such an Application

The result confirms that finding an available study room is a ***major*** problem in Gløshaugen, when 125 of 146 participants would have used the application if it was available. 21 of the participants who replied no are not a part of this Thesis' targeted group as they do not have a smart phone or have a personal desk. That is also the same number of people who do not use study rooms at Gløshaugen, seen in Table 4.2. This may be related and according to the survey, one can see a correlation between them - but an important factor is that all the respondents who own a smart phone and have their own desk confirmed that they would have used the service during the first three years if the application existed.

4.2.2 Participants' Possible Functionalities

Tables 4.4 and 4.5 provides the partcipants' intentions to use the application and their opinions of the proposed features. Suggestions from them about features are summarized later. Some of the suggestions are not feasable to implement, such as the integration with social networking services and teacher or student assistant-tracking due to Norwegian privacy policy laws (Section 2.4.4). Another feature which is hard to implement is the integration with NTNU's room booking system and the system that shows who has access to which buildings and study rooms. The application would have to cooperate with the booking system[1] and the building access system[2]. None of these services has an easily accessible endpoint, making good integration nearly impossible.

[1] `https://romres.ntnu.no`
[2] `https://innsida.ntnu.no/adgangskort`

Description	Item	N	%
Q6: Application that displays the nearest study rooms and number of persons in it			
	Completely useless	6	4.1
	Not particularly useful	14	9.6
	Somewhat useful	62	42.5
	Very useful	64	43.8
Q7: Show the nearest study rooms (if you are on campus)			
	Completely useless	4	2.7
	Not particularly useful	5	3.5
	Somewhat useful	45	30.8
	Very useful	90	61.6
	Not sure	2	1.4
Q7: Step-by-step navigation to chosen study room			
	Completely useless	5	3.5
	Not particularly useful	26	17.8
	Somewhat useful	45	30.8
	Very useful	65	44.5
	Not sure	5	3.4
Q7: Information about study rooms (e.g size, type of chairs and desks)			
	Completely useless	7	4.8
	Not particularly useful	20	13.7
	Somewhat useful	53	36.3
	Very useful	64	43.8
	Not sure	2	1.4

Table 4.4: Possible Feature Answers From Q6 & Q7 - Part 1

Description	Item	N	%
Q7: Usage statistics (which hours/days are most crowded etc.)			
	Completely useless	3	2.1
	Not particularly useful	14	9.6
	Somewhat useful	38	26
	Very useful	88	60.2
	Not sure	3	2.1
Q7: Functionality: Store favorite rooms that show up first in the app			
	Completely useless	6	4.1
	Not particularly useful	8	5.5
	Somewhat useful	47	32.2
	Very useful	82	56.2
	Not sure	3	2.1
Q7: Functionality: User reviews of study rooms			
	Completely useless	15	10.4
	Not particularly useful	38	26
	Somewhat useful	64	43.8
	Very useful	24	16.4
	Not sure	5	3.4

Table 4.5: Possible Feature Answers From Q6 & Q7 - Part 2

From Q6 ("How useful do you think that an app that displays the nearest study rooms and number of person in it?") and Q7 ("What do you think of these proposed features?") in the web survey, a large proportion picked either "very useful" or "somewhat useful". Only feature where "somewhat useful" got more votes than "very useful" is the user review of the study rooms feature. A rating system would require to set up a server to store the reviews, which was deemed unnecessary for this Thesis' research. The application's main feature is based on the anonymous user location data, so the users have to be anonymous as well. A rating system with anonymous users can generate lots of spam in the rating fields.

It was also asked an open question what features the end-users could imagine in the application in Q9 ("Do you have any suggestions for features you think this app should support? Or other app-ideas that benefits from using anonymous user position data."). Below the suggestions of the proposed features are listed:

- Implement the NTNU's room reservation service[3]
- A feature to review the study rooms
- Implement this app for study rooms at Dragvoll
- Display who has access to the study rooms
- Display general information such as temperature, noise level and closing-time.
- Implement a friend (an online social networking service) system to stalk where friends are.
- A feature that use the anonymous location data to find out the best place (most people are) to hang up posters.
- A feature to see which room teaching or student assistant are
- A feature to show the number of desks in each room
- An application that does not show the number of users, only closest reading rooms and reviews.
- Include computer rooms, not just reading rooms

With all these suggestions, one has a basis to start the process of making requirements for the Thesis' application which can be found in Section 5.4.1.

[3]https://romres.ntnu.no

Chapter 5

Problem Elaboration

This chapter aims to provide a detailed understanding of the problem to be solved. By using methods such as personas and scenarios, one can get more insight of the problem. Personas and scenarios are descriptions of *specific users* with *specific goals* in a *specific environment* based on ISO9241 (Section 3.4). Two relevant personas are constructed, before scenarios where they act are presented. SUS and MSAM tasks were created based on the personas and scenarios. A set of requirements are introduced to aid prioritizing in the development process, and use cases are created to give a better understanding of the solutions to the problems.

5.1 Personas

Personas are common to make in interaction design to get a better understanding of the relevant problems an application should handle, and the features it should support. A persona is a made up person with a set of abilities, knowledge and skills that the system developers sees as a target user of the system being designed. They also hold information about their goals, motives and concerns. The purpose of the persona is to simulate a real life situation. When a persona is used in a use case scenario it is important that he or she acts in accordance with his or her skills[68]. Below 2 personas will be presented.

5.1.1 Freshman Student Computer Science, Janne

Janne is a new student who began the study program "Computer Science" at Gløshaugen, NTNU this fall. She is 19 years old and considers herself very technical. She has several gadgets such as a Samsung Galaxy S4, Macbook Pro, and iPad, and she became a part of Abakus'[1] "Webkom" committee, a committee that updates Abakus' web site. She likes to see technical details in applications and software.

5.1.2 3rd Grade Student From Dragvoll, Gustav

Gustav is 25 years old, and has moved to Trondheim from Bergen. He has been working in a warehouse for a couple of years before deciding to study "Social Anthropology". He recently acquired a smart phone and is therefore new to mobile applications and touch screen user interface. He considers himself non-technical and does not like viewing advanced settings or statistics.

5.2 Scenario

Scenarios are tools to describe how users interact with a product. The tool helps to create a better understanding by exploring risky scenarios, discovering new user stories and capturing the relationship between stories and the requirements. The scenarios consist of a persona and a relevant story in relation to the application.

Below, 3 scenarios will be presented, i.e. types of scenarios that are most relevant to describe the events. The events unfolds in Gløshaugen at the Norwegian University of Science and Technology in Trondheim.

5.2.1 Scenario 1: Without the Application

First year student Janne has been told from older students that it is impossible to find an available desk during the self study exam period, unless she shows up at the opening of library, at 08:00 am. Considering she lives at Ila, it takes around 40 minutes by walking so she needs to wake up around 06:30 every morning to be exactly 08:00 at the libraries.

During a semester, Janne finds available desks for studying at the library in the building "Sentralbygget" in Gløshaugen by using NTNU's Intranet[2]. When exam period begins in the middle of November, all the desks are occupied when she arrives at NTNU around 09:00 in the morning.

One day when she tries to arrive at the opening hours which is 08:00, the first she sees is a line of people outside - waiting for the library to open. She picks up her smart phone to look for reading rooms at NTNU's Intranet and open the MazeMap to guide her to a new building with reading rooms since she has never visited other

[1]Student organization for Computer Science studyprogram

[2]`http://innsida.ntnu.no/lesesal`

buildings before. When she arrives, all of the desks are occupied. The time is now 08:47 which means she has already used 47 minutes to look for a new room. She goes back home and studies there instead.

5.2.2 Scenario 2: With the Application

Janne has been told from older students that finding an available desk in a study room between November and December is near impossible, unless she is at the Gløshaugen campus by 08:00 am. But Janne knows a secret the older student do not know. She has installed the new application called "Ledig Lesesal Plass" (LLsP) for Android.

While she is walking to Gløshaugen campus, she brings up her phone and launches LLsP. The application instantly shows her a list of reading rooms to choose between in Gløshaugen campus. It contains the names of the building and reading room, but also indicates how much percentage that has been occupied with a color and the distance from her position to the reading rooms.

She uses the search feature and looks for reading rooms at Sentralbygget, by searching for "Sentra". Here she sees rooms with different indicators, one with a green icon, one with yellow and the last with red. She finds a room with a green indicator and clicks on it to find exactly how many desks are left. Here she sees that only 2 of 10 desks are occupied. In the same screen, she can also see that there is less activity in the morning the previous days, so she adds the room to her favorite list by clicking on the star.

When she arrives at 10 am at the selected room she finds that there is only one student in the room (with one laptop computer and texting on his phone). She finds a desk near a window and starts studying.

5.2.3 Scenario 3: With the Application in an Unfamiliar Campus

Student Gustav has been studying in NTNU Dragvoll[3] for the past three years and he is not happy with the reading room situation at Dragvoll. The rooms are always full or has poor air quality so he prefers to study at home even though he feels he could be more productive at university campus.

However, Gustav has heard there are some rooms at Gløshaugen that are public, and that there is an application called "Ledig Lesesal Plass" where he can find available study rooms. He has been told that using his phone when it is not connected to a Wi-Fi network, may be expensive because of data-transmission costs. He waits

[3]NTNU's Human Sciences faculty

until he arrives at campus before he launches LLsP. He enables his Wi-Fi and selects which type of study program he attends in the settings screen, and the application shows him the nearest study rooms. The two nearest rooms have a red symbol telling him they are full or very crowded, but a third room has a yellow symbol. He selects the "yellow room", clicks the "MazeMap" button and it guides him to the selected room. He follows the directions LLsP gives him and just as the application predicted there are a lot of people there, but there are still available desks. Gustav finds a desk and is happy he decided to go to Gløshaugen campus today.

5.3 Create Testing Tasks

This section shows the connection between personas, scenarios and the created tasks in SUS and MSAM. It is important to take into account users' skill level and their task goals, when creating the tasks to perform. There are usually 3 different type of users described in [51]:

- Novice or first-time users
- Knowledgeable intermittent users
- Expert frequent users

In Section 5.2, two personas are presented. Gustav can be placed in the novice group as he is unfamiliar with the campus and the usage of smart phones. However, Janne can be placed between knowledgeable and expert group as she has lots of previous experience of using a smart phone but is not completely familiar with the campus.

5.3.1 System Usability Scale Tasks

The tasks for SUS is presented in Appendix B.

The first task ("Find the closest reading room that has available desks. How many desks are **occupied** and how many are available?") is created by using scenario 3. In scenario 3, Gustav is looking for the nearest study rooms which is available (immediate information) in Gløshaugen campus from his position as the campus is an unfamiliar place for him.

The second task ("Add this reading room to your favorite list. Go back and find your new favorite room in the list and information of which **building** and **floor** it is located in. At the same time, when **the information was last updated.**") and the third task ("You need a desk to study every **Friday** between **10:00-12:00**. Find how many people were in your favorite room Friday **05.01**, at **10:00**") are created by using scenario 2. In scenario 2, Janne finds a room with available desks, and checks the statistics log that there is not usually much activity in the selected room, so she adds the room to her favorite list.

The last task ("Send a message to the developers about incorrect number of people in the room") is created by using scenario 2. In scenario 2, Janne finds out that LLsP shows 2 desks are occupied in her new favorite room. But when she arrives to the selected room, there is only one student there with a laptop and a smart phone.

5.3.2 Mobile Services Acceptance Model Tasks

The tasks for MSAM are presented in Appendix C.

The first task ("Find the reading room named **Lise** and check what the application indicates about the available desks there. If you are far away from Lise, scroll down the list or use the search feature.") is created by using scenarios 1 and 2. In both scenarios, Janne is looking for an available reading room (scheduling information) in Sentralbygget while she is on the way to university, using either the search function or browsing through the rooms. Reading room Lise is located in Sentralbygget.

The second task ("Find your way to the reading room, and see if it is true that there are available desks there. If you do not know where **Lise** is, check its floor and building, or use MazeMap map solution (orange button on the top left).") is created by using scenario 3. In scenario 3, the Gløshaugen campus is an unfamiliar place for Gustav therefore he uses the MazeMap navigation to show him the direction.

The subtask ("Add **Lise** to your favorite list if your study program has access to it. Check if Lise is in your favorite list now.") is also created by using scenario 2. In scenario 2, Gustav is selecting his study program so all the reading rooms that are available for his study program will appear on the list. **Lise** is a reading room available for all study programs.

The last task ("You find that **Lise** is a good reading room. Check how many people used the room for three days ago, at the same time of day so you have an overview of when the desks are available.") is created by using scenario 2. In scenario 2, Janne adds the room to her favorite list since the room is not frequently used.

5.4 Requirements

Requirements are created to describe the behaviour of a developed system or application. The list should contain all necessary requirements that are required to describe all the functionalities for the application, and how they are intended to work. They reflect the needs of users for a system that serves a certain purpose such as controlling a device or finding information. The term *requirement* is simply a high-level abstract statement of a service that a system should provide or a constraint on a system, but it can be seen as a detailed formal definition of a system function[69]. Davis once explained the difference as

> *"If a company wishes to let a contract for a large software development project, it must define its needs in a sufficiently abstract way that a solution is not pre- defined. The requirements must be written so that several contractors can bid for the contract, offering, perhaps, different ways of meeting the client organi- zation's needs. Once a contract has been awarded, the contractor must write a system definition for the client in more detail so that the client understands and can validate what the software will do. Both of these documents may be called the requirements document for the system."*

Davis (1993)

The requirements are prioritized to ensure that the most important functions are mostly focused upon.

5.4.1 Determining the Requirements

A requirements analysis was made during the process of designing the requirements. By retrieving information from the web survey (Chapter 4), taken by students who may be the end-users of the application, one can determine their needs and conditions relative to the application. The first step was to identify the relevant data from the survey. By extracting results from web survey's Q6 ("How useful do you think that an app that displays the nearest study rooms and number of person in it?"), Q7 ("What do you think of these proposed features?") and Q9 ("Do you have any suggestions for features you think this application should support? Or other app-ideas that benefits from collecting anonymous user positioning data."), one could uncover aspects of the functionalities for such an application which led to create wanted requirements. The functionalities that were repeated most times in the web survey are listed below in prioritized order, where the top is the most desirable:

- Possible to display approximate number of persons in study rooms.

- Possible to display the nearest study rooms in relation to user's location.
- Possible to display statistics (which hours or days are most crowded, etc.).
- Possible to store favorite rooms.
- Possible to display general information about study rooms (size, temperature, who has access, type of chairs and desks, accessibility to sinks, toilets).
- Possible to communicate with NTNU's room service for booking group rooms.
- Possible to display step-by-step navigation to chosen study room.
- Possible to give review of the study rooms.

The first functionality is the purpose behind this Thesis since it uses the anonymous data. This functionality creates opportunities to implement the rest of functionalities so the priority for functional requirements which involves anonymous data will be set as high. Functional requirements are rated medium or low priority if they are very difficult to implement in this project's time scope, or the requirement is not considered useful or very useful by the students. More features to implement and more systems the application need to interact with, makes the development more complicated and harder to develop properly. Therefore the distinction between these three prioritization levels are the amount of effort that will be put into implementing it in the application.

An important requirement that is not requested from the participants, was not to store the anonymous data in the Thesis' application. The reason behind not to store the data in the application is that the data belongs to NTNU IT, and to avoid privacy issues. The requirement came from the providers of the data, Wireless Trondheim.

5.4.2 Attributes

Requirement attributes are very important when creating requirements since they capture additional information of each requirement with importance information such as a source, an ID and a relative importance. The attributes used to create these requirements are listed below:

- **ID**: Classifies and distinguishes each of the requirement type
- **Description**: A short description of requirements
- **Priority**: Defines the priority of requirements. There are three levels; low, medium and high (explained in Section 5.4.1).

- **FR**: Functional Requirement
- **NFR**: Non-Functional Requirement

5.4.2.1 Functional

Functional requirements specifies what a system is supposed to do, how it should react to particular inputs or how the system should behave in particular situations[69]. Sometimes it can also state what the system should not do. Usually they depend on the type of software being developed, but since the application being created is not too complex and there are few stakeholders[4] who are involved, these functional requirements will be based on the developers and the end-users' opinions of the application. These are summarized in Table 5.1.

[4]A stakeholder is a person or role that is affected by the system in some way and different stakeholders have different needs

ID	Description	Priority	Solved
FR1	Application shall present *immediate* information about the selected reading room using anonymous data	High	Section 6.1.1
FR1.1	- show how many desks are occupied in number- and percentage format	High	Section 6.1.1
FR1.2	- show the reading room's capacity	High	Section 6.1.2
FR1.3	- show the reading room's relevant details	High	Section 6.1.2
FR2	Application shall present *scheduling* information about the selected reading room using anonymous data	High	Section 6.1.1
FR2.1	- show how many desks are occupied throughout the day	High	Section 6.1.1
FR2.2	- show how many desks were occupied in previous days	High	Section 6.1.1
FR3	Application shall show the nearest study rooms	Medium	Section 6.1.3
FR4	Application shall store the chosen favorite rooms	Medium	Section 6.1.7
FR5	Application shall show navigation to the study rooms	Medium	Section 6.1.6
FR6	Application shall automatically show the distance between the user and all study rooms	Medium	Section 6.1.3
FR7	Application shall store the users' review of the study rooms	Low	Not implemented
FR8	Application shall support NTNU's booking room service	Low	Not implemented

Table 5.1: Functional Requirements

5.4.2.2 Non-Functional

Non-functional requirements specifies how a system or application is supposed to behave[69]. They often apply to the system as a whole rather than individual system features or services. As the name illustrates, these requirements are not directly concerned with the specific services delivered by the system to its users. Non-functional requirements are more critical than individual functional requirements since failing to meet a non-functional requirement means that the whole application or system might be unusable. The application's non-functional requirements are summarized in Table 5.2.

ID	**Description**	**Priority**
NFR1	Application (All application functions) must be intuitive to use even for a non-technical person after few minutes of training	High
NFR2	Application must be easy to understand (even for a non-technical person), first time using it	High
NFR3	Application must not contain any system errors	Medium
NFR4	Application must be adapted for use by end-users with different usage skills in smart phones and touch screens	Medium
NFR5	Application's performance must satisfy the end users	Medium
NFR6	Application's interoperability must work when all the environment are present	Medium
NFR7	Application can not store the anonymous data	High

Table 5.2: Non-Functional Requirements

5.5 Use Case

A use case is a methodology from unified modeling language (UML)[5] used in system analysis to identify, clarify and organize the functional requirements by a set of possible sequences of interactions between systems and users in a particular environment and related to a particular goal with a software modeling technique. It should contain all system activities that have significance to the users. There are three basic elements that constitutes a use case; *actors*, *system* and *goals*[70]. The use cases are related to the functional requirements (Section 5.4.2.1). An overview of the application's use case is illustrated in Figure 5.1.

The textual use case elements are taken from the Derek Coleman's template[71] and are summarized below:

[5] `http://www.uml.org/`

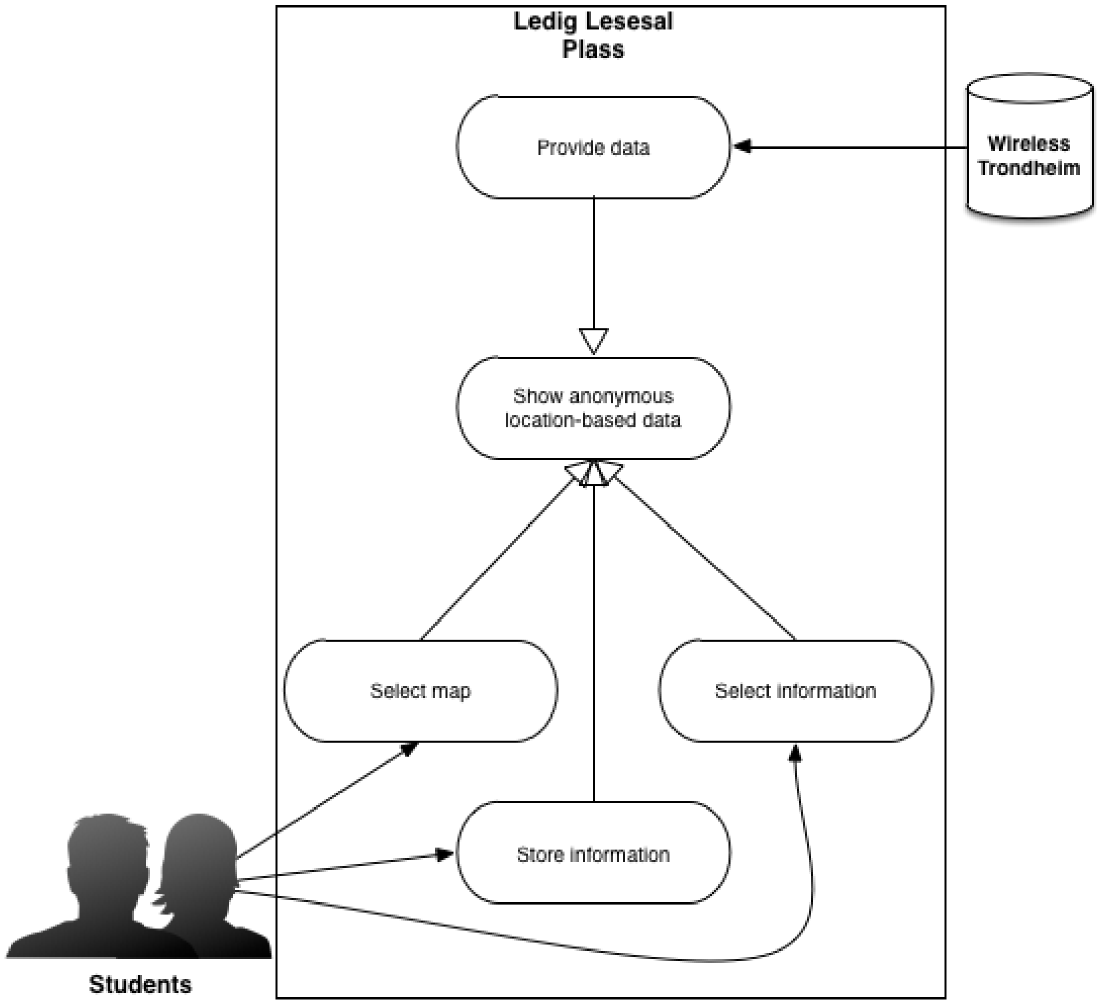


FIGURE 5.1: Use Case Overview

- **Use Case**: Use case identifier and reference number and modification history
- **Description**: Goal to be achieved by use case and sources for requirement
- **Actors**: List of actors involved in use case
- **Assumptions**: Conditions that must be true for use case to terminate successfully
- **Steps**: Interactions between actors and system that are necessary to achieve the goal
- **Variations**: *Optional* - Any variations in the steps of a use case
- **Non-Functional**: *Optional* - List of non-functional requirements that the use case must meet
- **Issues**: - List of issues that remain to be resolved

5.5.1 Use Case 1: Start Application

The application loads a good overview of the anonymous user location-based data from the server and different buttons for management. The use case ("Start application") can be found in Table 5.3.

Use Case 1	**Start Application**
Description	The application loads the default data without any errors
Actors	User
Assumptions	The device is on and has Internet-connection
Steps	1. Application presents the anonymous data
Variations	1a Application crashes during data loading 1b Application quit when the device has no Internet-connection 1c Application loads up without the anonymous data since the server is down
Non-Functional	#NFR3
Issues	None

Table 5.3: Use Case 1: Start Application

5.5.2 Use Case 2: Select Information

The application retrieves the chosen information such as number of persons in a study room in a specific time (statistic logs), general information about a specific study room and display the selected information for the user. The use case ("Select information") can be found in Table 5.4.

Use Case 2	**Select Information**
Description	The application loads data from the chosen room without any errors
Actors	User
Assumptions	Use case 1: "Start application""
Steps	1. Application shows a list that contains reading rooms with information 2. User clicks the button of the chosen room to retrieve 3. Application fetches correct data from server 4. Application displays the data in a satisfactory manner
Variations	1a Problems with information retrieval from server 2a No information appears due to problems with server 3a Application has problems with fetching due to connection of server 4a No information appears due to problems with server
Non-Functional	#NFR1, #NFR2, #NFR3, #NFR4, #NFR5 and #NFR6
Issues	None

Table 5.4: Use Case 2: Select Information

5.5.3 Use Case 3: Select Map

The application retrieves user's position from a server and displays either the nearest study rooms or navigation to chosen study rooms for the user from the corresponding location. The use case ("Select map") can be found in Table 5.5.

Use Case 3	**Select Map**
Description	The application loads up user's position and displays the chosen service
Actors	User
Assumptions	Use case 1 and 2: "Start application" and "Select information". Wi-Fi is turned on.
Steps	1. Application shows the "MazeMap" button 2. User clicks the button of the chosen service to retrieve 3. Application fetches selected data from database 4. Application displays user's location in a satisfactory manner
Variations	1a Problems with information retrieval from database 2a Nothing appears due to problems with server 3a Application has problems with fetching due to problems with server 4a Nothing appears due to problems with server
Non-Functional	#NFR1, #NFR2, #NFR3, #NFR4, #NFR5 and #NFR6
Issues	None

Table 5.5: Use Case 3: Select Map

5.5.4 Use Case 4: Store Information

The application stores the information such as user's favorite rooms and displays the rooms in a favorite list for the user next time he or she opens the application. The use case ("Store information") can be found in Table 5.6.

Use Case 4	**Store Information**
Description	The application stores the user's favorite rooms and recalls it the next start-up
Actors	User
Assumptions	Use case 1 and 2: "Start application" and "Select information".
Steps	1. Application displays study rooms 2. User clicks the button of a chosen study room 3. User clicks the button to store the study room as favorite 4. User terminates and starts up the application and sees that his or her favorite study room is in the favorite list
Variations	1a Problems with information retrieval from server 2a Nothing appears due to problems with server
Non-Functional	#NFR1, #NFR2, #NFR3, #NFR4, #NFR5, #NFR6 and #NFR7
Issues	None

Table 5.6: Use Case 4: Store Information

Chapter 6

Presentation of the Application

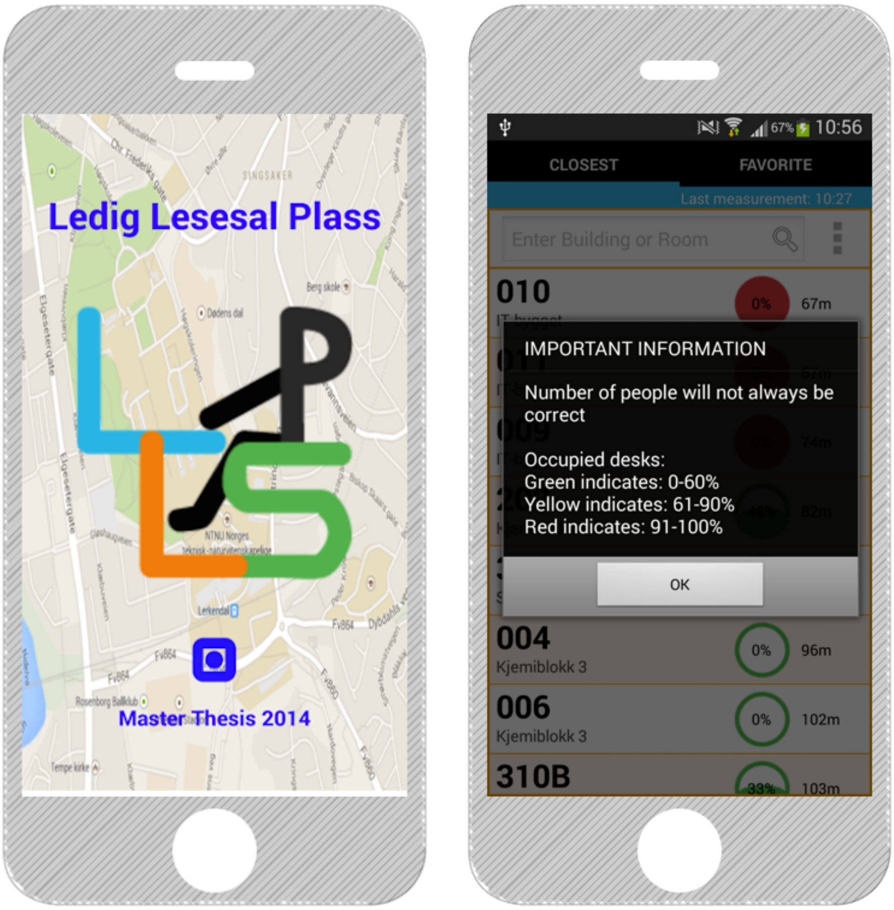
This chapter presents this Thesis' application, "Ledig Lesesal Plass" which was developed as a part of the Thesis, spring 2014. The application utilizes anonymous user location data, which is retrieved from Wireless Trondheim's Cisco Analytics server. The server collects data from Wi-Fi access points around Gløshaugen, logging MAC-address, location and time of every Wi-Fi enabled unit in the vicinity of the access points. The goal of this application, is to offer a mobile service by presenting these data in a simple and elegant way to solve the issue of finding available reading rooms. Also with the possibility of adding more functionalities that can be relevant to illustrate with these data. The chapter begins with an overview of the implemented functionalities, followed by technical details of the application.

6.1 Overview of Functionality

In this section all of the working features; both visible and invisible of the application are disclosed. The visible features that includes searching for reading rooms by name or building, selecting statistics of a specific day, storing or removing a specific reading room as favorite, reporting wrong data to developers and displaying navigation to a specific reading room - are activities users can achieve through their input. However, the invisible features such as retrieving the anonymous user location data, retrieving general room information data, retrieving the user's current position and sorting of the list - are activities that can not be modified by the users. This means that the activities are automatically done in the background and can not be controlled by users input or actions.

The usability of the application has been a focal point during development. Nielsen's heuristic principles (Section 3.4.1) and a similar user-centered process (Section 3.2.1) have been followed during the designing of the application. One of the goals was to present the retrieved data in a simple way with a clean design for all users, for those with limited, and those with extended smart phone skills.

When starting the application, the first meeting is a “Splash” screen shown in Figure 6.1a. The icon indicates abbreviation of the name of the application which is Ledig Lesesal Plass (LLsP), but also indicates a person sitting at a desk in a reading room. In the background a separate process is retrieving data from Mazemap API and Analytics API, joining data from these API’s to find the right information for all the reading rooms. It is also calculating distances from the user’s location to all of the available reading rooms. This is where most of the invisible features are active. When the loading is done, which typically takes around two to three seconds, the user sees a hint box. This box shows some hints to understand the occupation symbols, and concept of the application in the main screen. This help shown in Figure 6.1b is only displayed the *first* time the application is started.



(A) Splash screen (B) Hint

FIGURE 6.1: Ledig Lesesal Plass’ first run

The “Main” screen shown in Figure 6.2 provides an overview of the different items a user can see in the application. Purple items are indicators shown in Table

6.1 to help the user to understand the displayed information. Blue items are buttons shown in Table 6.3 and orange are views shown in Table 6.2 to show what the user can do here. Following is an explanation of the different items.

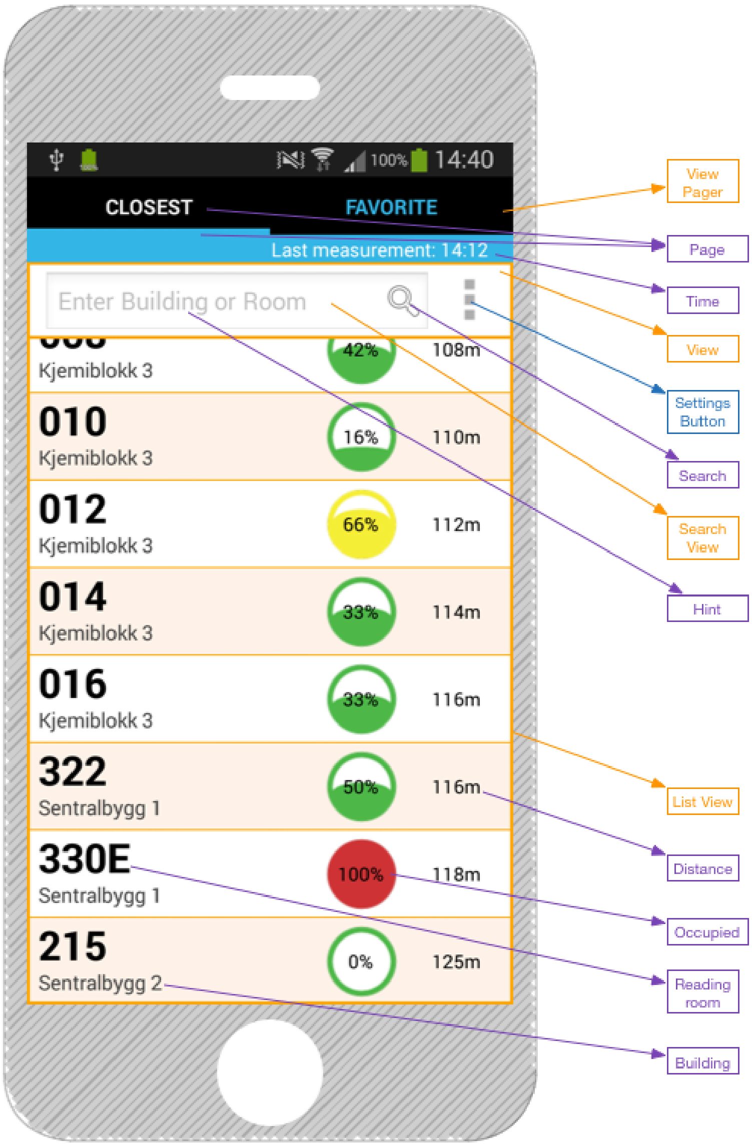


FIGURE 6.2: Main screen displaying the data in a ListView

Indicators	**Description**
Page	indicates which tab the user is in.
Time	indicates the latest updated data from servers.
Search	indicates there is a search bar available here.
Hint	indicates the keywords the user can search for.
Distance	indicates how far away the user is from reading room and is shown in meters or kilometers.
Occupied	indicates percentages of desks that have been occupied, with five filling ratio icons: 0 %: unfilled circle, 1-30 %: 25 % filled, 31-60 %: 50 % filled, 61-90 %: 75 % filled, 91 %+: 100 % filled. The colors symbolize the filling ratio: green: 0-60 % filled, yellow: 61-90 % filled, red: 91 %+ filled.
Reading room	indicates the name of the room.
Building	indicates the name of the building the reading room is located in.
Floor	indicates which floor the room is in.
Study Programs	indicates which study programs have access for the reading room.
Day	indicates which day the statistics log is showing.
Occupied Log	indicates number of people in the room the chosen day.
Time Log	indicates the time of day in the room the chosen day

TABLE 6.1: Indicators as Purple Items

Views	**Description**
View Pager	tabs are clickable and the entire screen is swipeable.
View	different added items are clickable.
SearchView	displays keyboard
ListView[1]	scrollable and each row item is clickable (not clickable in “Room information” screen).

TABLE 6.2: Views as Orange Items

Buttons	**Description**
Setting	goes to "Settings" screen. The icon is taken from the guidelines section in Android Developers web page[2]. One can also go to the "Settings" screen with the default settings button, a hardware button which some Android devices have.
Up	returns to the previous screen. The *up* icon is a guideline from the Android Developers page, and works as described.
MazeMap	starts a MazeMap instance with the selected reading room filled in the search bar.
Add or Remove Favorite	adds or removes the reading room to the favorite list.
Report	opens the default email program with an automatically generated text: room-name, building and current time, as title in the email.
Spinner	gives the user opportunities to pick the last 14 days for the statistics log.

Table 6.3: Buttons as Blue Items

The "Information" (Figure 6.3) will be presented for the selected room. In this screen, the user have the option to store the room as a favorite, show where it is located in Gløshaugen through MazeMap, or choose which day to see hourly population statistics. The user can also see which field of study that have access to the room, and report errors, such as wrong number of desks and wrong field of study displayed.

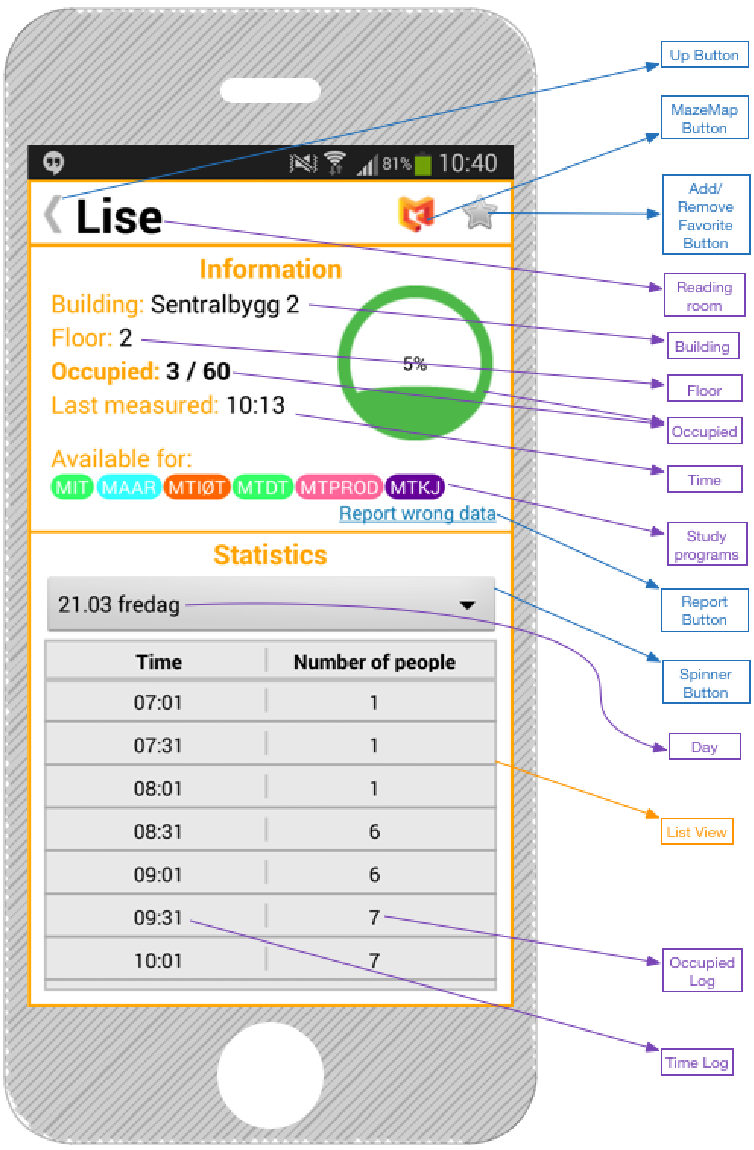


FIGURE 6.3: Information screen displaying room's data

As one can see, it is easy to see Nielsen's heuristics (Section 3.4.1) in the application's usability. The first principle ("Visibility of system status") to keep the user informed about what is going on is displayed in the application. An example, is when the user adds a reading room to his or her favorite list. This makes the star shine and a temporary pop-up textbox will inform what he or she just did. The principle that the system should speak the user's language ("Match between system and the real world") is also something which has been taken into consideration. An example is items such as filling ratio pictures. Its color are adjusted to something people could relate to, such as well-known objects like traffic lights. The same heuristic is used for the distance indicator, to indicate the users' distance from the nearest reading rooms. Users often choose functions by mistake and will want to leave the unwanted state ("User control and freedom"), is another principle from Nielsen. The use of this guideline can be illustrated by the implementation of the default *up* button[3] that enables *back* functionality in the "Information" screen (Figure 6.3). Some of the same icons and colors are used in several screens in the application to fulfill the ("Consistency and standards") principle.

If the device that runs LLsP does not have an active Internet connection, an error message will display, making users aware of what they have to do to make the application work properly. This covers ("Error prevention and Help users recognize") and ("diagnose and recover from error") principles. It is possible to list most of Nielsen's heuristics through the application's usability, but the most important are discussed - which demonstrates that there has been an iterative process to design the application to reach a certain level of usability based on the chosen research process (Section 3.2.1).

6.1.1 Presenting Anonymous User Location Data

Both screens in main ("Closest") and ("Favorite") and the room "Information" screen, presents immediate information from the MazeMap API and anonymous user position data from the Cisco Analytics' server. To gain access to the anonymous location data, one need to log in to their secure server with an authorized user. As mentioned, this is automatically done while the "Splash" screen is showing.

In the "Main" screen (as seen in Figure 6.2), the illustration with a percentage number utilizes this anonymous data to display the percentages of desks occupied. In the "Information" screen, there is also indicated the total number of desks available in a room, how many are occupied, and a statistics log. The user can not manipulate these data except from choosing which data to be displayed from the "day selector" in statistics log. When a day is selected, a request is sent to the server and the correct data is retrieved and displayed.

As mentioned in Section 5.4.2.2, Wireless Trondheim required that the application should not store any anonymous user position data. It was only allowed to retrieve the data from the API the instance they needed to be presented.

In this version of the application, it is only possible to extract the last 14 days from 07:00 AM to 19:00 PM, but the number of hours and days and can easily be changed by increasing the number of iterations run by a for-loop, summarized in Code 6.1.

These features were implemented to solve FR1, FR1.1, FR2, FR2.1 and FR2.2 seen in Table 5.1.

[3] `http://developer.android.com/design/patterns/navigation.html`

Code 6.1: Days in InformationActivity.java

```
public void putDatesInSpinner(){
    ....
    // Decide how many days the user can select from in statistics
    for(int i=1; i<=14; i++){
        Calendar cal = Calendar.getInstance();
        cal.add(Calendar.DAY_OF_YEAR, -i);
        Date date = cal.getTime();
        datesForSelector.add(date);
        String dateString = formatter.format(date);
        stringsForSelector.add(dateString);
    }
}
```

6.1.2 Presenting General Information Data

The application applies the same approach here as with the anonymous user location data, retrieving all necessary data when the application is started. This was done so that the application changes the number of rooms in synchronization with changes done in the MazeMap- and Analytics API. The Analytics API currently does not contain information about which building a room belongs to. Therefore the application joins information from the Analytics API with data from MazeMap API based on *floor-ID*, which is a shared data-field between these API's. Currently neither Analytics- or MazeMap API contain information about the capacity or number of desks in each room as the data field containing the capacity for each room is currently set to null.

To find the number of desks in each room, it was decided to do a manual count, and store these numbers in a local file in the application. These data are also joined with the correct room during the initiation of the application. If later, the capacity field from the API is set to a different value than null, it will be used instead of the static values stored in the local file in the application.

These features were implemented to solve FR1.2 and FR1.3 seen in Table 5.1.

6.1.3 Automatic Location Retrieval

To illustrate the distance from the user's location to the reading rooms as shown in "Main" screen, automatic location retrieval was implemented. This feature was needed to solve some of the requirements in Section 5.4.2.1 that the users asked for. In this application, two different methods were used to provide the location. To display the distance indicator between the user's location and the reading rooms, wireless network signal is used if the device is connected to Wi-Fi. If no Wi-Fi connection is available, cell tower location will be used. As mentioned in Section 2.1.1.2, the cell tower accuracy can be quite coarse, but this was deemed to be acceptable, given that accurate distance to reading rooms is only crucial when on campus, and the entire Gløshaugen campus is covered by Wi-Fi network. It was decided not to use GPS since the application will mostly be used indoors, and it can take quite a long time to get an accurate GPS fix. The distance indicator shown in Figure 6.2, calculates the distance to the closest reading rooms every 10 seconds (Code 6.2), and sorts the list with the closest rooms accordingly.

For the map navigation functionality, the application uses the MazeMap client through a WebView[4] in the application. This feature employs both Wi-Fi and GPS for positioning.

These features were implemented to solve FR3 and FR6 seen in Table 5.1.

Code 6.2: Location Update in ClosestFragment.java

```
public void onCreate(Bundle savedInstanceState){
    ....
    timeBetweenUpdates = 10000; // 10 000 milliseconds = 10 seconds
    this.locationManager.requestLocationUpdates(LocationManager.NETWORK_PROVIDER,
        timeBetweenUpdates, 0, locationListener);
}
```

6.1.4 Search View

After retrieving all available reading rooms from Analytics API, it was found that the API contains information for 96 reading rooms. To improve the usability for the user - instead of scrolling down the whole list to find a specific reading room - a search bar was implemented as shown in Figure 6.4. As indicated by the "pre-typed" text in the search bar, it searches for the keywords: building name and reading room name. The search feature also searches in sub-strings, so users do not have to remember the whole name of the room or building. Also, searching is done in real-time, so the user can instantly see what rooms appear (or disappear) for each letter that is typed.

As with most search features for touch enabled devices - when something is typed in the search bar, the magnifying glass icon is replaced by a cross icon. This x button clears the text in the search bar for the user, making erasing of long words an easy task.

[4]WebView is a View that displays web pages (http://developer.android.com/reference/android/webkit/WebView.html)

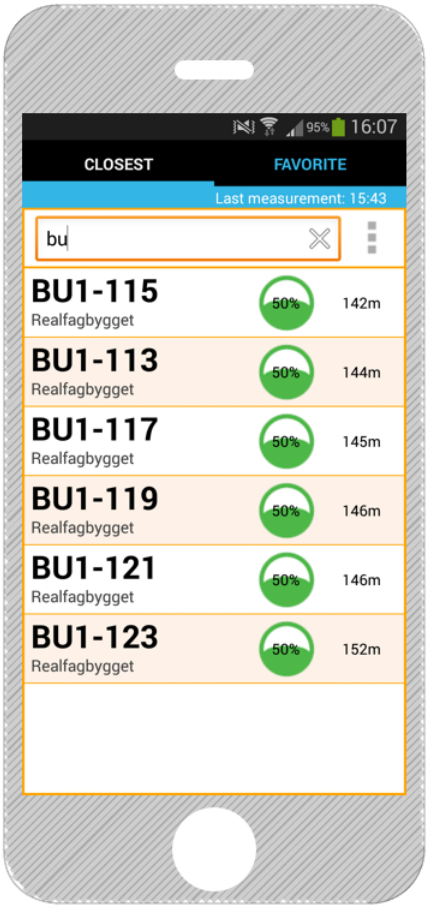


FIGURE 6.4: Ledig Lesesal Plass' searchbar

6.1.5 List View

Figures 6.2 and 6.4 show usage of the ListView. The tab selector indicates to the user that he or she is in the "Closest" or "Favorite" screen. The "Closest" screen signifies that the first element in the list is the closest room from the users' device location. The row items are sorted in the following priorities listed below:

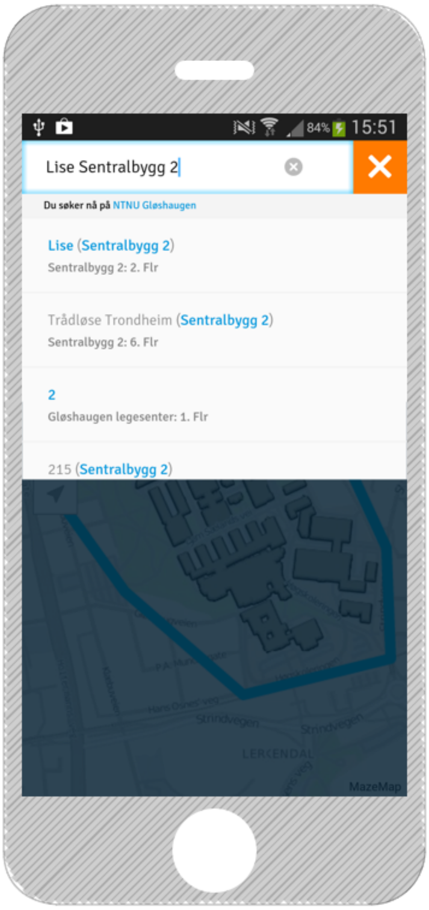
1. Shortest distance in meter or kilometers (Location)
2. The filling percentage
3. The reading room name

If the search feature is used, the list is only sorted by the reading room's names and buildings. The reason for not sorting after location during search, is because most likely the user will want to retrieve results based on the most relevant name that is searched upon rather than the closest room that may contain any of the letters in the search phrase. If a user know which building the reading room is in and its first letter, it will be easy to search for the building and look at the first letter in an alphabetized list shown in Figure 6.4.

6.1.6 Display Navigation

Another feature requested by the users, was to display navigation to the chosen reading room. The method used, was creating a WebView to the MazeMap application shown in Figure 6.5b, loading the URL to their JavaScript enabled web page (`http://use.mazemap.com/`) with an additional string that contains the room and building name shown in Figure 6.5a. The right room is then shown in the first result in the MazeMap's search bar. When the user clicks on the room, his or her current location is shown, and a blue line marking the quickest route to the destination room. This is important for users that are not familiar with the rooms and buildings on campus. The feature can be found by clicking the MazeMap logo in the room information screen. One advantage of using the webview solution is that the map feature is always updated with the latest version of MazeMap. A disadvantage is that JavaScript is tough on older devices, making the map a bit "sluggish" (as discussed in Section 8.6.7).

This feature was implemented to solve FR5, seen in Table 5.1.



(A) Map screen with the additional search string

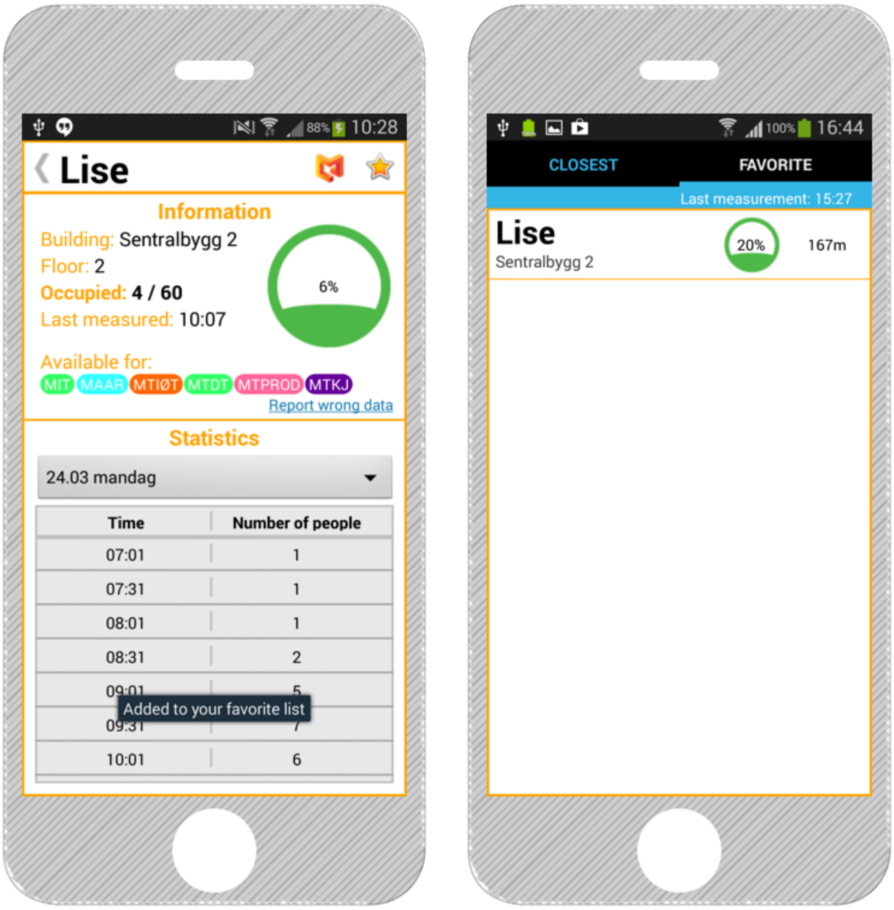
(B) WebView with MazeMap's navigation

FIGURE 6.5: Ledig Lesesal Plass' navigation

6.1.7 Storing Favorite Rooms

By storing reading rooms to a favorite list, experienced users can quickly check the status of the rooms they frequently visit, instead of having to search for or browse through all the available rooms (96 currently available). This may increase the effectiveness and usability for returning users. The adding and removing feature shown in Figure 6.7a indicates through a star that shines when the room is stored as a favorite, and when the star is not shining, indicates the room is not stored. The added reading rooms will be shown in the user's favorite list presented in Figure 6.7b.

This feature was implemented to solve FR4, seen in Table 5.1.



(A) Adding a reading room (B) Favorite screen

FIGURE 6.6: Ledig Lesesal Plass' storing

6.1.8 Contact Developers

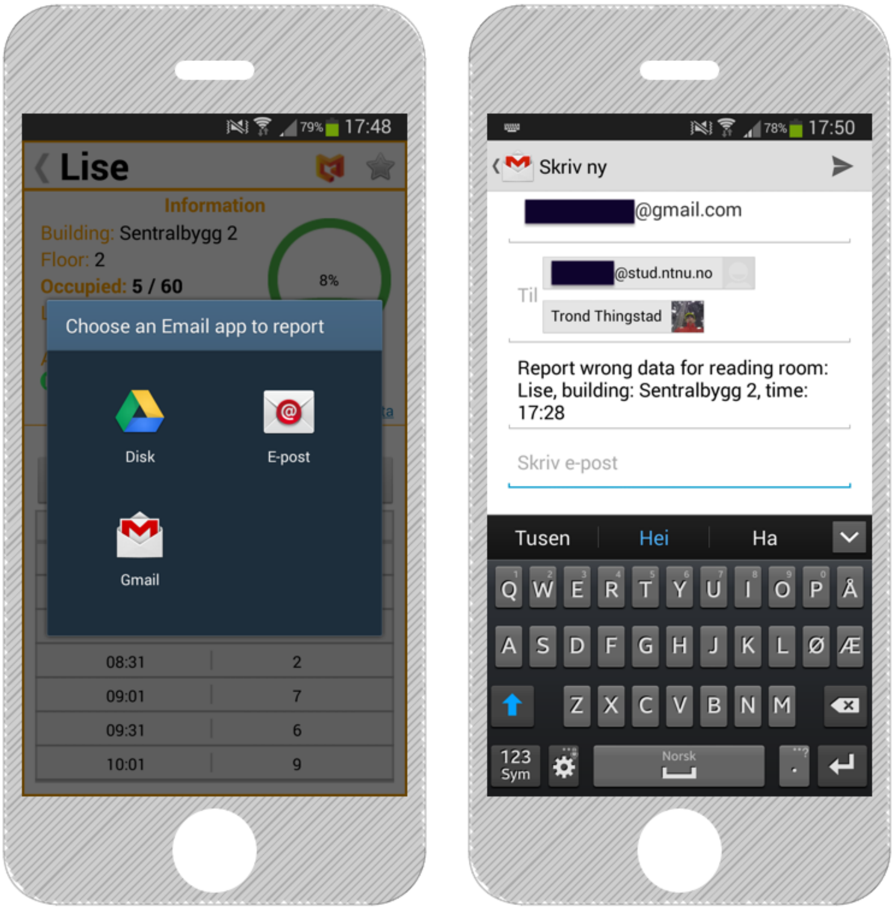
As the application is dependent on devices utilizing Wi-Fi, the data shown to users is not 100 % reliable since a person can either have multiple or no devices. There is also a possibility that room access policies change, or the number of desks are changed.

According to Wireless Trondheim, there are still bugs in NTNU IT's customized Cisco system (Section 2.2). Sometimes the server does not get data, so the number of people fluctuates and is unstable. Right now, the system measures the expected number of stationary[5] Wi-Fi devices given positions with confidence regions.

Therefore, a useful feature for the administrators of the application or the Analytics API is for users to have an easy opportunity to contact the developers or maintainers if data is incorrect. LLsP provides the opportunity through a feature

[5]Measures only people who are immobile in order to reduce noise in the data because of people walking passed rooms.

that opens the user' email application with a pre-filled text containing which room is concerned and the timestamp it was clicked, as shown in Figure 6.7.



(A) Options to choose an email application

(B) The chosen email application with added room details

FIGURE 6.7: Ledig Lesesal Plass' email message

6.2 Technical Details

In this section, a brief description of the technical aspects in a higher level of detail is described. After that, an overview of which programming language is used. Then, a description of the architecture pattern, and how it was used. Finally, a summary of frameworks and API's that were utilized by the application.

6.2.1 Programming Language

The application is written in Java, using the Android Software Development Kit (SDK) and Android Development Tools (ADT) to build the Android application. SDK tools includes set of development, debugging tools that offers framework while the ADT plugin is an add-on for the Eclipse IDE that provides additional features for development of Android applications.

Since Java was used to create and develop the Thesis' application, this means that the application is native[6], and is only available for Android devices. Native applications also has the advantage of running faster than e.g. emulated applications.

Java is a well-known object-oriented language which was released in 1995, designed by Gosling[7]. The syntax is derived from C++ where most of the code is written inside a class and is an object instance, except the primitive data types like integers.

6.2.2 Architecture of Application

The application's architecture is inspired by the Model-View-Controller[72] (MVC) pattern. The *model* represents the application's state (holds the most recent data) and dispatch events when the state changes. The *view* represents the UI and objects that the users interact with. Usually they bind to the model by being observers. When a state changes in model, the view is notified and will update its state. All the interaction and events between users and views are sent to the *controller*. Controller's main responsibility is handling most of the logic done by the users input. This means it treats the users' movements, updates model and replies back to view. A sketch of the parts in MVC is illustrated in Figure 6.8.

The MVC architecture decouples system logic and data, thus decreasing dependencies in the code. By separating the handling, displaying and updating of data, parts of the software can more easily be changed or updated without having to do major changes in the code. The MVC architecture is often used for similar applications as the application in this Thesis, where some of the requirements (Section 5.4.2.1) are to reuse pieces of code to display timely information (immediate and planning) and details for the end-users.

[6] An executable program coded in the machine language of the hardware platform it is running in

[7] `http://en.wikipedia.org/wiki/Java_(programming_language)`

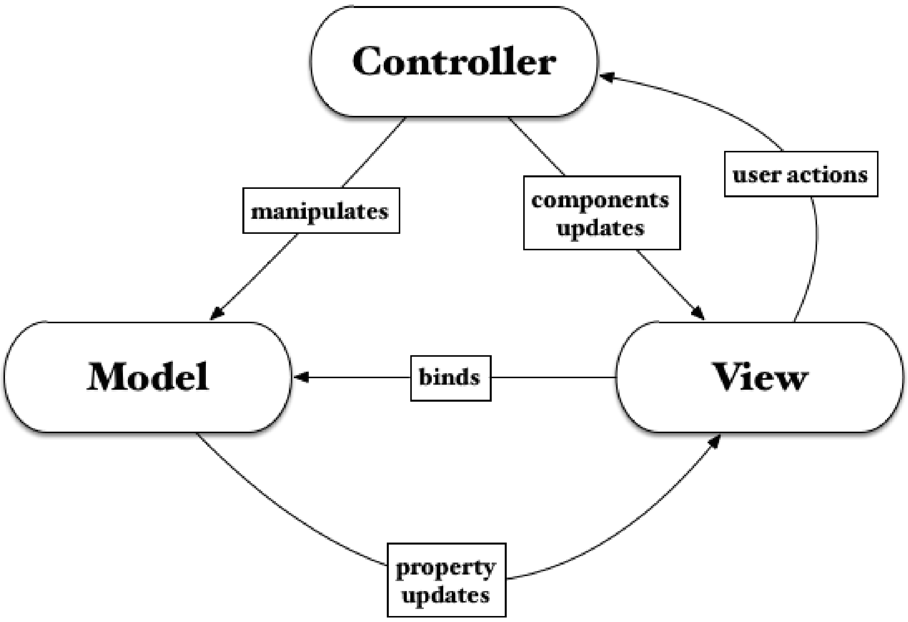


FIGURE 6.8: Model-View-Controller

6.2.2.1 Android

The Android structure can be pointed out to resemble MVC because of how it works. One can find many MVC characteristics in the current Android structure. Some examples that can be done in Android which is comparable with the MVC concept is:

- define all user interface with XML.
- define all resources with XML.
- extend different classes in Activity and Fragment such as ListActivity and ListFragment.
- use a lot of ready-made Utils such as SQLlite, HTML and JSON.
- create infinite classes for model structure.

An interpretation in this Thesis' application is that the delegation in activities and fragments can be seen as controllers, XML layout file as views and objects as the models.

6.2.2.2 Supporting Multiple Screens

Since the Android operating system is free to use for hardware manufacturers[8], there are many devices that runs Android, with various screen sizes, resolutions and pixel densities. The Android ADT (Section 6.2.1) provides support to control application's user interface (UI) design for different screen configurations. By optimizing an application for different screen sizes and densities, the user experience will be enchanced since the icons and images scale as though the application was designed for their devices. To ensure that the Thesis' application supports this, there are five terms[9] one must deal with. These are:

1. **Screen size** is the physical size, measured as the screen's diagonal.
2. **Screen density** is the quantity of pixels within a physical area of the screen; usually referred to as dpi (dots per inch).
3. **Orientation** of the screen from the user's point of view. This is either landscape or portrait, meaning that the screen's aspect ratio is either wide or tall.
4. **Resolution** is the total number of physical pixels on a screen.
5. **Density-independent pixel** also known as dp is a virtual pixel unit used to define UI layout, to express layout dimensions or position in a density-independent way.

[8] `https://source.android.com/`
[9] `http://developer.android.com/guide/practices/screens_support.html`

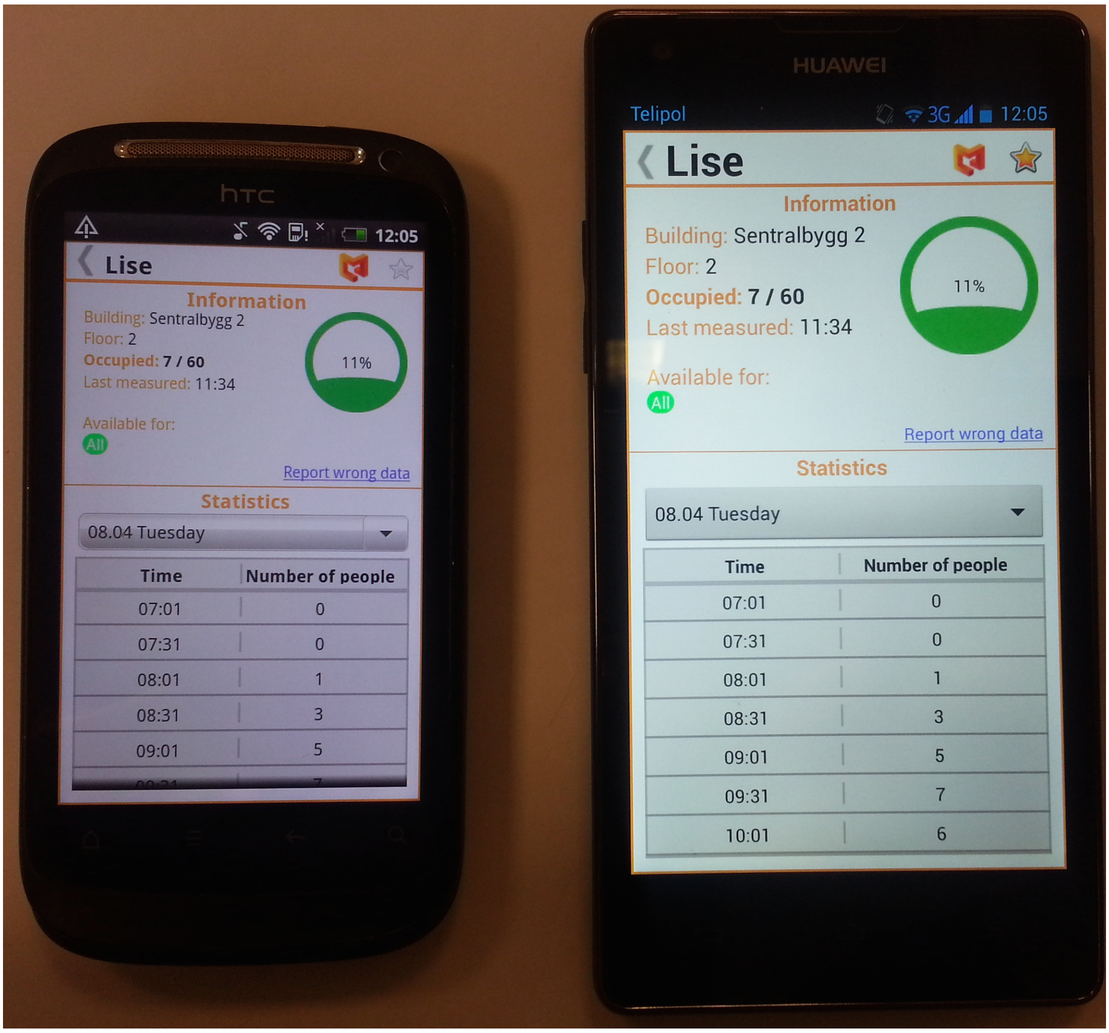


FIGURE 6.9: HTC Desire S (v2.3.5, 3.7”) & Huawei G700 (v4.2.1, 5”)

Ledig Lesesal Plass was developed for use in the portrait mode. One of the main reasons is the device’s position. Vertical position for device is a more natural position to a hand than horizontal. Information that is displayed does not require much horizontal space, as most of the information is in a tabular form with one or two columns. To support different screen sizes, there were implemented different layouts. The application will be most optimized for devices with a display in 720x1280px (Developers’ own phones) and 480x800px (The test phones supplied by NTNU) shown in Figure 6.9, but it also works on bigger devices, such as tablets. The biggest device the application was tested on is a Sony Xperia Tablet Z, which has a screen size of 10.1 inches and a resolution of 1200x1920px.

The layout files are either modified in wrap_content, fill_parent or weight which is recommended from the Android Developer to scale the application so it supports multiple screens.

6.2.2.3 Supporting Multiple Android Versions

The Android ecosystem is said to be fragmented. This means that there are several versions of Android a developer needs to take into account when developing a mobile service. The different versions of Android supports different API's and methods, thus it is not implicit that an application which runs well on a device powered by Android 4.2, also runs on a device powered by Android 2.3.

This was experienced in this Thesis. The prototype was first developed to support devices running Android 4.0 or above. This was because the developers' devices were running Android 4.2, and as indicated by Android Developers[10], most of the phones in the Android ecosystem is now running 4.0 or above. When the developers found out the phones for acceptance testing were powered by Android 2.3, a lot of code had to be re-written to make everything run fluent on both old and new versions.

6.2.2.4 JavaScript Object Notation

JavaScript Object Notation also known as JSON is an independent text-data format that is readable by both humans and machines. The language is designed for fast storing and exchanging text information. Advantages with JSON in Android is that the Android platform includes json.org libraries used for parsing the data. MazeMap API (Section 6.2.3.3) and Analytics API (Section 6.2.3.2) provides data formatted as JSON files for efficient transfer over the Internet.

6.2.2.5 Extensible Markup Language

Extensible Markup Language (XML) is a markup language, designed to transport and store data and is readable both by human and machine. In Android, the XML language[11] is used to create user interface layouts as it decouples the business logic from the design.

6.2.3 Framework and API

Frameworks and Application Programming Interfaces (API) are two common concepts within software development. Both are ready-made pieces of code, created by others to solve a specific problem. Developers can make use of other peoples programs by interfacing with an API, which leads to reduced time spent in the development process. The difference between a framework and an API is that an

[10] `https://developer.android.com/about/dashboards/index.html?`

[11] `http://developer.android.com/guide/topics/ui/declaring-layout.html`

API refers how it should interact with other software or systems while a framework is a reusable code, ready to serve as a support or guide for building something the developer needs. In this Thesis' application, ViewPagerIndicator[12] framework is applied to create the swipeable tabs[13], Analytics API is used to retrieve the anonymous user location data and MazeMap API[14] for finding building names and navigation to a specific reading room.

6.2.3.1 ViewPagerIndicator Framework

ViewPagerIndicator framework is used to create the swipeable tabs in Ledig Lesesal Plass. The idea behind this framework is to provide a clear indicator for users as it is not always obvious to them that additional views exist, or that they can navigate between views by clicking or swiping sideways. The framework is compatible with the originally ViewPager from the Android Support Library. The advantages of this framework is the implementation. It is easy to adapt the framework to ones own applications by including the widget in a view and binding the widget to a ViewPager as summarized in Codes 6.3 and 6.4.

Code 6.3: ViewPager in activity_main.xml

```
<!-- Including TabPageIndicator widget -->
<com.viewpagerindicator.TabPageIndicator
    android:id="@+id/titles"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content" />
<!-- Titles: Closest, Favorite -->
<android.support.v4.view.ViewPager
    android:id="@+id/pager"
    android:layout_width="match_parent"
    android:layout_height="0dp"
    android:layout_weight="1"/>
```

Code 6.4: ViewPager in MainActivity.java

```
//Create the adapter that will return a fragment for each of the two
//primary sections of the app.
SectionsPagerAdapter mSectionsPagerAdapter = new SectionsPagerAdapter(
    getSupportFragmentManager());

//Bind the ViewPager with the sections adapter.
ViewPager mViewPager = (ViewPager) findViewById(R.id.pager);
mViewPager.setAdapter(mSectionsPagerAdapter);

TabPageIndicator tabIndicator = (TabPageIndicator) findViewById(R.id.titles);
tabIndicator.setViewPager(mViewPager);
```

In the Thesis' application, the framework was modified by removing a label, when using the TabPageIndicator widget.

[12] http://viewpagerindicator.com/
[13] http://developer.android.com/design/building-blocks/tabs.html
[14] http://use.mazemap.com/

6.2.3.2 Analytics API

Analytics API provides the anonymous user location data for this Thesis' application. The API retrieves the raw data by utilizing technologies described in Chapter 2. The data on the server are updated every 20 - 25 minutes, meaning the data are not completely real-time. To access the data, LLsP needs to log in to the service by sending a username- and a password string to Wireless Trondheim's Cisco Analytics login server. If the login is successful, the http-client object is stored (Code 6.5) and used to preserve the login state throughout the time the application is running. This object is used to retrieve e.g. the data summarized in Code 6.6.

Code 6.5: Login in GetLogin.java

```
//Password and username stores
List<NameValuePair> postParams = new ArrayList<NameValuePair>();
postParams.add(new BasicNameValuePair("username", username));
postParams.add(new BasicNameValuePair("password", password));
//Create Apache objects
private URI uri_login = new URI(url_to_login);
private HttpPost httpPost = new HttpPost(uri_login);
private HttpResponse httpResponse = httpClient.execute(httpPost);
private StatusLine statusLine = httpResponse.getStatusLine();
int code = statusLine.getStatusCode();
//HTTP Response Codes for successful login
if(code == 200 || code == 201 || code == 202){
    return httpClient;
    } else {
    return null;
    }
}
```

For collecting room information, JSON files that contains data (Code 6.6) were retrieved from Analytics API and parsed with different conversion methods summarized in Code 6.7. It is important to understand which data fields that provides what, so the application retrieves the correct and necessary data. In the example below (Code 6.6), there are many missing data fields such as room capacity, building name of the specific reading rooms and scheduling data (statistics). Also the population information is not present here, and must be retrieved by a different API-call. The Code 6.8 demonstrates how to parse some of the necessary data in Code 6.6.

Code 6.6: Example of a JSON file from Analytics API

```
{
  "campusId": 1,
  "captureRegions": [
    {
    "campusId": 1,
      "capacity": null,
      "floorIdent": "357",
      "geometries": [
        {
          "captureRegionId": 10609,
          "floorId": 355,
          "geometry": {
```

```
            "coordinates": [
              [
                [
                  10.407826747353461,
                  63.41732421516652
                ],
                [
                  10.40795792500165,
                  63.41735126437797
                ],
                [
                  10.408034143056003,
                  63.41727725860315
                ],
                [
                  10.407902965407814,
                  63.41725020938219
                ],
                [
                  10.407826747353461,
                  63.41732421516652
                ]
              ]
            ],
            "type": "Polygon"
          },
          "id": 10610,
          "usageApriori": null
        }
      ],
      "id": 10609,
      "identifierId": 32899,
      "itemIdent": "131",
      "name": "131",
      "predictionGroupId": 1
    },
}
```


Code 6.7: Conversion Methods in GetRoom.java

```
URI uri_getallRooms = new URI(url_to_list_of_all_rooms);
HttpGet httpGet = new HttpGet(uri_getallRooms);
    try {
        //Retrieves static data about all reading rooms
        HttpResponse httpResponse = httpClient.execute(httpGet);
        HttpEntity entity = httpResponse.getEntity();
        //Convert HTTP InputStream to String
        InputStream stream = entity.getContent();
        allRoomsString = convertStreamToString(stream);
        }
//Convert String to ReadingRoom objects with the necessery data fields
convertToReadingRooms(allRoomsString);
```

Code 6.8: Retrieving Necessary Data in GetRooms.java

```
private static void convertToReadingRooms(String param){
//Name of the floor
String itemIdent = "";
//Name of the room
String name = "";
//id of the room
int id = 0;
//Id of the floor to find buildingName
int floorId = 0;
try {
        JSONObject jsonObject = new JSONObject(param);
        JSONArray captureRegionsArray = jsonObject.getJSONArray("captureRegions");
        //Parses necessary data
        for (int i = 0; i < captureRegionsArray.length(); i++){
                id = captureRegionsArray.getJSONObject(i).getInt("id");
                name = captureRegionsArray.getJSONObject(i).getString("name");
                String tempItemIdent = captureRegionsArray.getJSONObject(i).
                    getString("itemIdent");
                //Find floorname
                if (isNumber(tempItemIdent.charAt(0))){
                        itemIdent = tempItemIdent.substring(0, 1);
                } else {
                        itemIdent = tempItemIdent.substring(0, 2);
                }
                //Geometry coordinates
                JSONArray geometriesArray = captureRegionsArray.getJSONObject(i).
                    getJSONArray("geometries");
                floorId = geometriesArray.getJSONObject(0).getInt("floorId");
                JSONObject geometryObject = geometriesArray.getJSONObject(0).
                    getJSONObject("geometry");
                JSONArray coordinatesArray = geometryObject.getJSONArray("
                    coordinates");
                double longitude = coordinatesArray.getJSONArray(0).getJSONArray(0)
                    .getDouble(0);
                double latitude = coordinatesArray.getJSONArray(0).getJSONArray(0).
                    getDouble(1);
                //Add object ReadingRoom with the data to a temporary list
                resultList.add(new ReadingRoom(id, name, itemIdent, floorId,
                    latitude, longitude) );
        }
} catch (JSONException e) {
        Log.e(TAG, e.toString());
}
}
```

6.2.3.3 MazeMap API

MazeMap API described in Section 2.3.3.2 is used to attain building name of a specific room, and its navigation feature for this Thesis' application. The data-field *floorId* is unique for all floors at Gløshaugen and can be found in both Analytics API and MazeMap API, thereby the application can join the data from these two API's to retrieve name of building. Code 6.9 demonstrates the details for retrieving building names and floorID's from MazeMap.

Code 6.9: Storing Buildingname in GetBuildings.java

```java
//Create HashMap <FloorID, BuildingName>
HashMap<String, String> result = new HashMap<String, String>();
        try {
                //Retrieves the JSON file from MazeMap url
                JSONArray featureArray = new JSONArray(resultString);
                        //Iterate through buildings
                        for(int i = 0; i < featureArray.length(); i++){
                                JSONObject properties = featureArray.getJSONObject(i).getJSONObject("properties");
                                JSONArray floorsArray = properties.getJSONArray("floors");
                                //Iterate through all floors in a building and put floorId and buildingname in HashMap
                                for (int j = 0; j < floorsArray.length(); j++){
                                        String floorIdString = floorsArray.getJSONObject(j).getString("id");
                                        String buildingName = featureArray.getJSONObject(i).getJSONObject("properties").getString("name");
                                        result.put( floorIdString, buildingName);
                                }
                        }
    }
```

As for the navigation, the solution was to send a URL with room- and building name summarized in Code 6.10 into (`use.mazemap.com`)'s search bar. MazeMap's web client uses HTML and JavaScript, which can be a bit sluggish on older phones. This was the only possible solution for implementing the functionality with the time scope of this Thesis.

Code 6.10: Navigation in Map.java

```java
Intent intent = getIntent();
Bundle bundle = intent.getExtras();
//Get the name and buildingname for the chosen reading room
ReadingRoom room = Model.getRoomByID(bundle.getInt("roomID"));
String romName = room.getName().replaceAll(" ", "%20");
String buildingName = room.getBuilding().replaceAll(" ", "%20");
.
.
wv.loadUrl("http://use.mazemap.com/?&v=1&campusid=1&search="+romName+"%20"+buildingName);
```

Chapter 7

Results

This chapter presents the results from the user interface and acceptance tests that were conducted, so one can evaluate the usability and the acceptance of the application. To begin with, it starts with a description of the demographic data of the participants in both of the tests before the results from the tests are elaborated. Finally, the results are presented in tables and a graph.

The SUS questionnaire use a 5-point Likert scale, ranging from “strongly disagree” to “strongly agree”, which is represented by the numbers 1 to 5. MSAM also employs a Likert scale, but instead it uses a 7-point scale where the numbers range from 1 to 7 (Section 3.5).

7.1 Demographics

This section presents two different demographic profiles; the user interface and the acceptance participants. Both of the tests have a questionnaire where the goal is to gain an overview of the participants' experience with smart phones, mobile services applications, and their profile information. By collecting these information, one can get a bigger picture of the response in the context of the user and it will be easier to understand the answers from SUS and MSAM questionnaires. SUS is used to see if there are errors with the application's user interface. While MSAM indicates if the Thesis' application solves the problem of finding available reading rooms, and all their needs from this problem are fulfilled, which is the acceptance of the application.

Attributes *Characteristic* and *Item* describes the details of the demographic questions in following tables. N is the number occurrences and $\%$ is the percentage of occurrences.

7.1.1 User Interface Test Participants Information

Table 7.1 lists the demographic profile of the participants by gender, age, study program and grade level. All of these are NTNU students from developers' network and some have a background from IT-technology studies. 50 % of the participants are attending the first three years of their study.

Characteristic	**Item**	**N**	**%**
Gender	Male	6	60
	Female	4	40
Age	21	3	30
	22	1	10
	23	3	30
	24	1	10
	25	2	20
Study program	BGEOL	1	10
	MTDT	3	30
	MTTEKGO	1	10
	MTKOM	2	20
	MTPROD	1	10
	MIT	1	10
	MTEL	1	10
Grade	1st	2	20
	2nd grade	1	10
	3rd grade	2	20
	4th grade	3	30
	5th grade	2	20
	PhD student	0	0

Table 7.1: User Interface Test Participants Profile information

7.1.2 User Interface Test Participants' Daily Use of Study Rooms and Smart Phones

Table 7.2 describes the user interface testers usage of study rooms at Gløshaugen and their profile of smart phone. All of them owns a smart phone and most of them have a normal, average experience of the smart phone usage. 70 % of them use study rooms at Gløshaugen, where the average is around 11-20 hours, so most of the partcipants can be identified as the Thesis' target audience.

Characteristic	Item	N	%
Smart phone ownership	Yes	10	100
	No	0	0
Use of smart phone per day	Less than 1 hour	5	50
	1-2 hours	4	40
	3-5 hours	1	10
	More than 5 hours	0	0
Experience with smart phones usage	1 (Novice)	0	0
	2	1	10
	3	4	40
	4	5	50
	5 (Expert)	0	0
Use of study rooms at Gløshaugen	Yes	7	70
	No	3	30
Have own desk place	Yes	4	40
	No	6	60
If yes,	Yes	1	25
problems to find reading room earlier?	No, never been searching	1	25
	No replies	2	50
Hours spend at study rooms per week	0	3	30
	1-5	1	10
	6-10	2	20
	11-20	3	30
	21-30	0	0
	31+	1	10

Table 7.2: User Interface Participants Smart Phone and Reading Room Information

7.1.3 Acceptance Test Participants Information

Table 7.3 lists the demographic profile of the acceptance test participants by gender, age, belonging academic department and current grade level. The first thing to notice is that the participants gender distribution ratio is closer to 1/3 females and 2/3 male. The reason most likely is because there are more male students in Gløshaugen than female students (based on gender school points by admission). 36.6 % of the participants is either from IDI (Department of Computer and Information Science) or IME faculty, which implies that they have a certain amount of IT knowledge. 75.6 % is from the first three grades which is very relevant and important for the end result.

Characteristic	**Item**	**N**	**%**
Gender	Male	25	61
	Female	16	39
Age	Under 20	3	7.3
	20-25	32	78
	Over 25	6	14.7
Belonging academic department	IDI or IME	15	36.6
	Other department	26	63.4
Grade	1st	7	17.1
	2nd grade	10	24.4
	3rd grade	14	34.1
	4th grade	9	22
	5th grade	1	2.4
	PhD student	0	0

Table 7.3: Acceptance Test Participants Profile

7.1.4 Acceptance Test Participants' Experience with Smart Phones and Applications

Table 7.4 describes the acceptance testers level of experience with smart phones and applications. All of the participants have used smart phones before and most of them have 2 years or more experience. Around 33 % have used applications that are *similiar* to LLsP (according to them) such as Google Maps, CampusGuiden, MazeMap and @BI. Most of the applications mentioned here utilizes the location-based features, something LLsP also provides, but none can think of an application that illustrates how many people are present in an indoor area.

Characteristic	Item	N	%
Have experience with smart phones	Yes	41	100
	No	0	0
How much experience with apps	None	0	0
	0-1 year	4	10
	2-5 years	28	68
	5+ years	9	22
Have experience with similiar apps	Yes	16	39
	No	25	61
If Yes, Which?	Google Maps	3	7.3
	CampusGuiden	1	2.4
	MazeMap	13	31.7
	@BI	1	2.4

Table 7.4: Acceptance Test Participants Experience with Smart Phone and Apps

7.2 User Interface Evaluation

This section provides the test results from user interface testing, using the standard SUS questionnaire, and two self-made questionnaires to collect demographics. Brooke's calculation method, covered in Sections 3.7.3 and 7.2.1 is used to measure the usability of the application. A questionnaire was also used to see if the idea of such an application is a good solution to solve the task of finding available reading rooms and to get a wider perspective for the design problems that participants faced during the test. The respondents in SUS rated the SUS items from 1 to 5, where 1 is "strongly disagree" and 5 "strongly agree". It is also important to point out that the SUS test was executed when the development of the prototype was not yet finished, so improvements has been made afterwards.

7.2.1 Perceived Usability

Because the SUS questionnaire uses alternating wording, where odd questions are positively worded and even questions are negatively worded, one need to use Brooke's calculation method to make the scores comparable. This means that for odd questions one must subtract 1 from the user's response, and for even questions one subtracts the users response from 5. This gives a score of minimum 0 and maximum 4 for each item, where 4 is the best achievable score.

The result from Table 7.5 shows that all 10 questions scored above average (which is 2) in all questions. The distinction is Q1 ("I think that I would like to use this system frequently") where the whole scale point system was utilized, but the total score is still above average with 2.50. Q4 ("I think that I would need the support of a technical person to be able to use this system") scored a perfect result where 10 of 10 testers selected "strongly disagree", indicating a positive direction towards the goal of creating an ease to use application meant for all students with varying smart phone and application experience.

	0		1		2		3		4		
ID	N	%	N	%	N	%	N	%	N	%	**Mean**
Q1	1	10	1	10	1	10	6	60	1	10	2.5
Q2	0	0	0	0	1	10	4	40	5	50	3.4
Q3	0	0	0	0	0	0	6	60	4	40	3.6
Q4	0	0	0	0	0	0	0	0	10	100	4
Q5	0	0	0	0	1	10	4	40	5	50	3.4
Q6	0	0	0	0	0	0	4	40	6	60	3.6
Q7	0	0	0	0	0	0	2	20	8	80	3.8
Q8	0	0	0	0	0	0	4	40	6	60	3.6
Q9	0	0	1	10	2	20	3	30	4	40	3.0
Q10	0	0	0	0	0	0	3	30	7	70	3.7

TABLE 7.5: System Usability Scale Results

7.2.2 Calculated SUS Score

By summarizing the normalized responses for each user and multiplying the total score with 2.5 for converting the score scale to 0-100 instead of 0-40, makes it easier to evaluate. The result is shown in Table 7.6 for each test participant. In Table 7.7, the lowest score has a value of 72.5, max 95, a mean of 86 and standard deviation of 8.756.

Test participant	1	2	3	4	5	6	7	8	9	10	Average
SUS score	72.5	90	77.5	82.5	85	75	95	92.5	95	95	86

TABLE 7.6: System Usability Scale Participants Score

According to Jeff Sauro[73], 68 is an average score from the 500 studies he has investigated. The Thesis' application scored an average of 86, which is quite high. The minimum score is 72.5 which is even higher than Sauro's average score. The scores provide a good sign of a sufficient result for usability based on Bangor et al. research[74]. Although the score was high based on the results from Tables 7.6 and

7.7, the application is still a prototype, meaning it is possible to improve the score. Also the map feature was not tested during the user interface test (because it was not readily implemented), so the scores only measure the usability of the presentation of anonymous indoor location data.

Description	N	Min	Max	Mean	Median	Mode	Std.Dev.
Calculated SUS Score	10	72.5	95	86	87.5	95	8.756

Table 7.7: Total Calculated Score of SUS

7.2.3 Usability Questionnaire

This section provides a summary of the most frequently answered responses to the "User Interface Test Questionnaire - Usability" (questions can be found in Appendix B.3). The responses are translated from Norwegian to English and is found in table 7.8

Question	Responses
Q1	Missing a map to find where the room is, and directions to the room.
Q1	Sort the list based on the closest reading rooms.
Q1	No.
Q2	30 % Yes: Graph instead of table in the log
Q2	70 % No.
Q3	20 % Yes: Which study program has access to the rooms.
Q3	80 % No.
Q4	80 % Yes: Larger occupancy icons.
Q4	20 % No: Day statistics is unnecessary, most recent data is enough, direct link to room in map.
Q5	50 % Yes: More "fresh" colors, map icon in room information page.
Q5	50 % No.
Q6	90 % Yes: Nice and clear application.
Q6	10 % No.
Q7	80 % Yes: Very good application and idea!
Q7	20 & No. I have my own personal desk or office.

Table 7.8: Responses from Usability Questionnaire

As one can see, most of the participants were happy with usability, but some felt that the map feature should be implemented in the room information screen instead of in a separate tab. Features such as the reading room list, should be sorted after the closest reading rooms and its filling level. At the time the test was performed, the application had its own map screen in the swipeable screen beside “Closest” and “Favorite”, and the context aware sorting feature was not yet implemented. One person would rather have a graph instead of tables in the statistics log while another one felt the statistics log is unnecessary as the person only needed to know the reading room’s most recent available status. Most requirements of the functionality (Chapter 6) (except automatically updating the room access policy for different study programs) were implemented after the user interface testing as the interface design process is an iterative process (Section 3.2.1, Hevner’s guideline 6).

A question that did not make it into the questionnaire but was asked later during the semi-structured interview (Section 3.6.4) was if users have Wi-Fi enabled on their smart phone. 90 % replied yes, but they turned it off if the battery level is low. 1 person replied no because the person’s device had bad battery performance and she did not need Wi-Fi on the phone at university.

7.3 Acceptance Evaluation

This section shows the test results from acceptance testing, using an MSAM questionnaire that was developed with inspiration from Gao[40] and Haugstvedt[58]. IBM’s SPSS and SmartPLS, covered in Section 3.9.2.1 are used to measure the reliability and validity of the responses. The descriptive- and statistical results will be elaborated in this section.

7.3.1 Descriptive Results

Descriptive results that is collected from the MSAM questionnaire, is presented here. A total of 41 persons tested the finished prototype. The MSAM questionnaire contains 6 constructs: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Trust (TU), Personal Initiatives and Characteristics (PIC), Context (CT), and Intention to Use (IU). The questionnaire can be found in Appendix C (in Norwegian).

Each construct contains between 2 - 5 questions called items, which measures factors relevant to the construct. The scales of the questionnaire ranged from 1-7, horizontally aligned answers, based on the Likert scale principle, where the leftmost answer indicates “strongly disagree”(score 1) and the opposite end of the scale indicates “strongly agree” (score 7).

Attributes *Min* and *Max* are the minimum and maximum occurring answer. *Mean* is the arithmetic average of a set of numbers, which is computed by adding up all the values and dividing the score by the number of values, while *Median* is described as the number found at the exact middle of the ordered set of values. *Mode* is also used, it is defined as the number in a list that occurs with the greatest frequency. *Std. dev.* stands for standard deviation and is calculated as the square root of variance. *N* is the number occurrences and *%* is the percentage of occurrences. Values in red Color indicates a negative or insufficient direction.

7.3.1.1 Perceived Usefulness

Table 7.9 shows responses to the items measuring the construct perceived usefulness of the application. The results are further summarized in Table 7.10. The first to notice is that the respondents did not use the entire scale, the lowest score given was 3. In the first two items, only 4 - 7 of the scale's points were used, and 3 - 7 on the last three. Items PU1 ("Using the application, I can quickly and easily find an available reading room") and PU3 ("Using the application, it is more likely that I will find a reading room I did not know of before") received a higher score than the other items with a mean score over 6. Items PU2 ("Using the application, I quickly find a nearby reading room") and PU5 ("Using the application, it will be easier to schedule which reading room I will go to before I go to campus") scored a mean score just below 6 and PU4 ("Using the application, it is more likely that I use reading rooms in Gløshaugen") received a score of 5.29. All of the items scored a mode value between 6 and 7, meaning the majority thinks the application has high usefulness.

	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
PU1	0	0	0	0	0	0	2	4.9	9	22	15	36.6	15	36.6
PU2	0	0	0	0	0	0	4	9.8	10	24.4	12	29.2	15	36.6
PU3	0	0	0	0	1	2.4	4	9.8	3	7.3	7	17.1	26	63.4
PU4	0	0	0	0	4	9.8	6	14.6	12	29.2	12	29.2	7	17.2
PU5	0	0	0	0	1	2.4	2	4.9	13	31.7	14	34.1	11	26.9

TABLE 7.9: Frequency Table Showing Perceived Usefulness

Item	N	Min	Max	Mean	Mode	Std. Dev.
PU1	41	4	7	6.05	6	0.882
PU2	41	4	7	5.93	7	0.997
PU3	41	3	7	6.29	7	1.110
PU4	41	3	7	5.29	7	1.194
PU5	41	3	7	5.78	6	0.976

TABLE 7.10: Statistical Summary of Responses to Items Measuring Perceived Usefulness

7.3.1.2 Context

Table 7.11 shows the descriptive results from the items measuring context from the MSAM questionnaire. The results are further elaborated in Table 7.12. In this construct the whole scale was used, and there where quite a lot of variation in the items. E.g. CT1 ("I would use this app before going to campus") used the entire scale except the lowest response, had a mean of 4.83 and a mode of 6. CT2 ("I would use the application while I am on campus") was more positive, with a lowest score of 4 and mean of 6.22, indicating that most users would like to find available reading rooms when they are on campus, not when they are at home. CT3 ("I would use the app if the university recommends the students to use it") was more in the centre of the scale, with a mean of 4.9 and mode of 4, indicating the university's recommendation of using applications does not influence the students very much. CT4 ("I would use the application if it were available on mobile devices") got a very high score, with a lowest score of 5, a mean of 6.46, and a mode of 7. CT5 ("I would like to use the application if it were available on a PC") was the only item where the respondents used the entire scale. CT5 had a mean of 4.41, a mode of 4, and the standard deviation is at 1.667. This shows that the majority would like to use this service on their mobile device, instead of on a computer.

	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
CT1	0	0	5	12.2	2	4.8	8	19.5	10	24.4	12	29.3	4	9.8
CT2	0	0	0	0	0	0	1	2.4	4	9.8	21	51.2	15	36.6
CT3	0	0	0	0	2	4.8	15	36.6	12	29.3	9	22	3	7.3
CT4	0	0	0	0	0	0	0	0	3	7.3	16	39	22	53.7
CT5	2	4.8	4	9.8	5	12.2	11	26.9	8	19.5	5	12.2	6	14.6

Table 7.11: Frequency Table Showing Context

Item	N	Min	Max	Mean	Mode	Std. Dev.
CT1	41	2	7	4.83	6	1.463
CT2	41	4	7	6.22	6	0.716
CT3	41	3	7	4.90	4	1.031
CT4	41	5	7	6.46	7	0.628
CT5	41	1	7	4.41	4	1.667

Table 7.12: Statistical Summary of Responses to Items Measuring Context

7.3.1.3 Personal Initiatives and Characteristics

Table 7.13 shows responses to the items measuring the construct personal initiatives and characteristics. These are further elaborated in Table 7.14. Similar to perceived usefulness, the respondents did not use the entire scale, but the variations in the range of the scale is bigger. The lowest score was 2 in item PIC2 ("I prefer to be the first one using the application") with a mean value of 5.66, while both of the items PIC1 ("I am able to use this application") and PIC4 ("Using this application is a good idea") have a score of 5 as the lowest, and a mean value of 6.56 for the former, and 6.51 for the latter. Item PIC3 ("Using this application will give me an advantage over those who do not") scores a mean value of 6.29 and the lowest score given was 3.

75 % of the items have a mode value of 7, and PIC2 has a mode of 6.

	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
PIC1	0	0	0	0	0	0	0	0	2	4.8	14	34.1	25	61.1
PIC2	0	0	1	2.4	0	0	7	17.1	7	17.1	15	36.6	11	26.8
PIC3	0	0	0	0	1	2.4	1	2.4	3	7.3	16	39	20	48.9
PIC4	0	0	0	0	0	0	0	0	2	4.8	16	39	23	56.2

Table 7.13: Frequency Table Showing Personal Initiatives and Characteristics

Item	N	Min	Max	Mean	Mode	Std. Dev.
PIC1	41	5	7	6.56	7	0.586
PIC2	41	2	7	5.66	6	1.181
PIC3	41	3	7	6.29	7	0.890
PIC4	41	5	7	6.51	7	0.589

Table 7.14: Statistical Summary of Responses to Items Measuring Personal Initiatives and Characteristics

7.3.1.4 Trust

Table 7.15 demonstrates responses to the items relating to the trust construct. These are further summarized in Table 7.16.

Here as well, the respondents did not use the entire scale, and the variation is not as high as in perceived usefulness. Items TU1 ("I could use the application if I have a clear conception of the functionality of the application"), TU3 ("I could use the application if I feel confident that I can keep the application under control") and TU4 ("I could use the application if I feel data from the application is reliable") scored from 4 to 7, with mean values between 6.05 and 6.37. Item TU2 ("I could use the application if it protects the privacy of its users") received 6.05 in mean value, with the lowest score of 3.

	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
TU1	0	0	0	0	0	0	1	2.4	6	14.6	19	46.3	15	36.7
TU2	0	0	0	0	1	2.4	6	14.6	3	7.3	11	26.9	20	48.8
TU3	0	0	0	0	0	0	2	4.8	9	22	15	36.6	15	36.6
TU4	0	0	0	0	0	0	1	2.4	6	14.6	11	26.8	23	56.2

Table 7.15: Frequency Table Showing Trust

Item	N	Min	Max	Mean	Mode	Std. Dev.
TU1	41	4	7	6.17	6	0.762
TU2	41	3	7	6.05	7	1.168
TU3	41	4	7	6.05	6	0.882
TU4	41	4	7	6.37	7	0.819

Table 7.16: Statistical Summary of Responses to Items Measuring Trust

7.3.1.5 Perceived Ease of Use

Table 7.17 presents responses from the items measuring perceived ease of use from the MSAM questionnaire. These are further summarized in Table 7.18. In this construct all the responses ranged from 4-7, with the exception of one user responding 3 to PEOU1 ("I think the application is clear and easy to understand"). The responses of PEOU1 where overall positive, with a mean of 5.73 and a mode of 5. The rest of the items have almost identical results, with a mean of roughly 5.7, and a mode of 5 and 6. The standard deviation is low, approximately 0.9 for all items in this construct. This indicates that most users perceives the application to be fairly easy to use, but there is room for improvement.

	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
PEOU1	0	0	0	0	1	2.4	0	0	17	41.5	14	34.1	9	22
PEOU2	0	0	0	0	0	0	5	12.2	9	22	20	48.8	7	17
PEOU3	0	0	0	0	0	0	4	9.8	15	36.6	13	31.6	9	22
PEOU4	0	0	0	0	0	0	5	12.2	10	24.4	18	43.9	8	19.5

Table 7.17: Frequency Table Showing Perceived Ease of Use

Item	N	Min	Max	Mean	Mode	Std. Dev.
PEOU1	41	3	7	5.73	5	0.884
PEOU2	41	4	7	5.71	6	0.890
PEOU3	41	4	7	5.66	5	0.927
PEOU4	41	4	7	5.71	6	0.917

Table 7.18: Statistical Summary of Responses to Items Measuring Perceived Ease of Use

7.3.1.6 Intention to Use

Table 7.19 summarizes responses from the items measuring the construct intention to use. Like most of the constructs, the respondents did not use the entire scale. The results are further shown in Table 7.20. IU1 ("If I have access to the application, I want to use it") received a mean value of 6.12 while IU2 ("If I have access to the application, I intend to use it") a mean value of 5.80. Both have a mode of 6, where 54 % rated 6 in IU1, and 41 % in IU2.

	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
IU1	0	0	0	0	0	0	2	4.8	4	9.8	22	53.7	13	31.7
IU2	0	0	0	0	1	2.4	2	4.8	11	26.8	17	41.6	10	24.4

Table 7.19: Frequency Table Showing Intention to Use

Item	N	Min	Max	Mean	Mode	Std. Dev.
IU1	41	4	7	6.12	6	0.771
IU2	41	3	7	5.80	6	0.943

Table 7.20: Statistical Summary of Responses to Items Measuring Intention to Use

7.3.2 Comments from Respondents

This section lists some of the comments made by the respondents at the end of the MSAM questionnaire. The comments are translated from Norwegian to English. Original comments can be found in digital attachments.

- Good idea!
- Easy to find new reading rooms I did not know of before. Especially useful in the exam period.

- Will definitely use during the exam period, maybe not so much the rest of the semester.
- The MazeMap logo was a bit difficult to see or understand for users unfamiliar to MazeMap.
- A graph of the history data would have been nice.
- I liked the ability to make favorite rooms
- I believe choosing reading rooms has a lot to do with old habits, but it is nice to be able to find new places during the exam period.
- Map and favorite icon could have been a bit larger.
- It would be nice to also be able to find nearest available "group rooms".
- Application showed one more person than actually in the room.
- Cool application, but it showed 2 persons less than actual when I went to Lise.
- Nice and clear application. Good use of colours and nice design. Number of people in the room was correct!

7.3.3 Statistical Results and Analysis

This section presents an assessment of the reliability and validity (Section 3.9) of the results obtained from the MSAM questionaire, and tests the hypotheses (Section 3.3) in the structural model.

7.3.3.1 Internal Consistency of Reliability

Table 7.21 demonstrates the reliability measures calculated with data from the MSAM constructs. One construct stands out, namely context which has a Cronbach's alpha value of 0.421. The rest of the constructs are above 0.6 with a range between 0.666-0.780. As discussed in Section 3.9.2.1, the Cronbach's alpha value should not be lesser than 0.6, as this is the lowest acceptable limit for exploratory research. This signifies that context is the only construct that is not acceptable, meaning there are two hypotheses involving context that can not be confirmed in this research.

	AVE	Cronbach's alpha
CT	0.294505	0.421
IU	0.784555	0.726
PEOU	0.569269	0.753
PIC	0.535656	0.694
PU	0.420502	0.666
TU	0.610120	0.780

TABLE 7.21: Reliability Measures Calculated with Data from MSAM questionnaire

Also, AVE value (Explained in 3.9.2.1) was below acceptable for context, with a score of 0.295. Another construct, perceived usefulness with a score of 0.421, scored slightly below the recommended level of 0.5. This indicates that 42 % of the variance in the PIC's answers is explained by a single underlying latent construct.

7.3.3.2 Convergent Validity

Table 7.22 shows the outer model loadings and their t-statistics. As mentioned in Section 3.9.2.1, convergent validity is shown when the t-values are above 1.96. As expected several of the items in context where below the minimum accepted value. CT1, CT3 and CT5 had loadings below 0.2. Also PIC1 loads poorly, with a value of 0.286. The rest of the items have a valid score ranging from 0.519 to 0.902, all being significant at the $p < 0.001$ level.

	Loading	T Statistic
CT1 ← CT	0.159112	0.789970
CT2 ← CT	0.813013	14.485224
CT3 ← CT	0.108849	0.497441
CT4 ← CT	0.863315	21.341206
CT5 ← CT	0.170469	0.905518
IU1 ← IU	0.878035	23.139516
IU2 ← IU	0.893401	24.366958
PEO1 ← PEOU	0.744129	9.393506
PEO2 ← PEOU	0.654271	9.110253
PEO3 ← PEOU	0.795981	17.031853
PEO4 ← PEOU	0.813445	21.470097
PIC1 ← PIC	0.286455	1.917378
PIC2 ← PIC	0.838570	20.217084
PIC3 ← PIC	0.854458	18.566128
PIC4 ← PIC	0.792003	12.721165
PU1 ← PU	0.790060	17.179068
PU2 ← PU	0.710868	10.777689
PU3 ← PU	0.556609	5.444879
PU4 ← PU	0.627373	5.303013
PU5 ← PU	0.519201	3.909927
TU1 ← TU	0.833543	28.372023
TU2 ← TU	0.750946	7.904011
TU3 ← TU	0.901786	31.665610
TU4 ← TU	0.607082	5.206000

TABLE 7.22: Outer Loadings Calculated with Data from MSAM questionnaire

7.3.3.3 Discriminant Validity

Table 7.23 shows the cross loadings between items and constructs. As mentioned in Section 3.9.2.1 the items should load strongly against their own respective construct, and weakly against the rest. As one can see from Table 7.23 the values in bold are mostly above the 0.5 limit and considerably larger than the rest. Except, again, for CT1, CT3, CT5 and PIC1, which loads poorly onto their respective construct, with values ranging from 0.109 - 0.286.

Table 7.24 shows the inter-construct correlations. The bold values are the square roots of AVE, and should be above 0.5 as described in Section 3.9.2.1. If context is omitted, the smallest difference between the square root of the AVE and the other correlations happens between PEOU and PU and is 0.11.

If one omit context, both the inter-construct correlation and inter-item correlations satisfies the limits stated by Gefen[62], thus the scales show good discriminant validity.

	CT	IU	PEOU	PIC	PU	TU
CT1	**0.159112**	0.222789	0.076827	0.116250	0.080104	−0.147759
CT2	**0.813013**	0.465235	0.470463	0.362775	0.447015	0.463251
CT3	**0.108849**	0.180644	−0.017638	0.094276	0.052555	0.050922
CT4	**0.863315**	0.221154	0.515625	0.575192	0.491699	0.452433
CT5	**0.170469**	0.047567	−0.006548	0.005434	−0.085287	0.193106
IU1	0.435057	**0.878035**	0.300721	0.405659	0.463490	0.516603
IU2	0.315371	**0.893401**	0.311805	0.539307	0.548472	0.293796
PEO1	0.305841	0.328417	**0.744129**	0.352849	0.550031	0.149826
PEO2	0.409465	0.097800	**0.654271**	0.175048	0.256552	−0.124122
PEO3	0.439233	0.173395	**0.795981**	0.248642	0.465414	0.120794
PEO4	0.593571	0.367374	**0.813445**	0.483451	0.588954	0.173068
PIC1	0.316125	0.091558	0.430051	**0.286455**	0.334158	0.365073
PIC2	0.439298	0.542971	0.469488	**0.838570**	0.478453	0.410432
PIC3	0.371098	0.364594	0.164690	**0.854458**	0.415905	0.433549
PIC4	0.584126	0.395733	0.351150	**0.792003**	0.432461	0.276547
PU1	0.420211	0.373597	0.588512	0.307577	**0.790060**	0.425182
PU2	0.361330	0.352024	0.621908	0.214986	**0.710868**	0.080178
PU3	0.148519	0.197451	0.042615	0.266556	**0.556609**	0.276126
PU4	0.339898	0.421605	0.180677	0.581790	**0.627373**	0.290747
PU5	0.446019	0.438277	0.340102	0.463524	**0.519201**	0.246305
TU1	0.427277	0.398416	0.053257	0.386546	0.278450	**0.833543**
TU2	0.413952	0.298929	0.065284	0.277278	0.227294	**0.750946**
TU3	0.423939	0.424824	0.164269	0.517685	0.374417	**0.901786**
TU4	0.357527	0.265685	0.145107	0.242205	0.363554	**0.607082**

TABLE 7.23: Cross Loadings

	CT	IU	PEOU	PIC	PU	TU
CT	**0.54268**	0.000000	0.000000	0.000000	0.000000	0.000000
IU	0.421375	**0.88575**	0.000000	0.000000	0.000000	0.000000
PEOU	0.591297	0.345883	**0.75449**	0.000000	0.000000	0.000000
PIC	0.572913	0.535685	0.445820	**0.73188**	0.000000	0.000000
PU	0.569420	0.572627	0.643899	0.554141	**0.64846**	0.000000
TU	0.516877	0.453381	0.135401	0.473371	0.394685	**0.78110**

TABLE 7.24: Latent Variable Correlations (Inter-Construct Correlations)

7.3.3.4 Test of Hypotheses

Figure 7.1 illustrates the structural model. The numbers inside the circles indicate the coefficient of determination denoted as R^2 (R-squared). They indicate how well data points fit to a statistical model, i.e. how well future outcomes are likely to be predicated by the model. The values by the paths are the path coefficients that describe the effect one construct has on another.

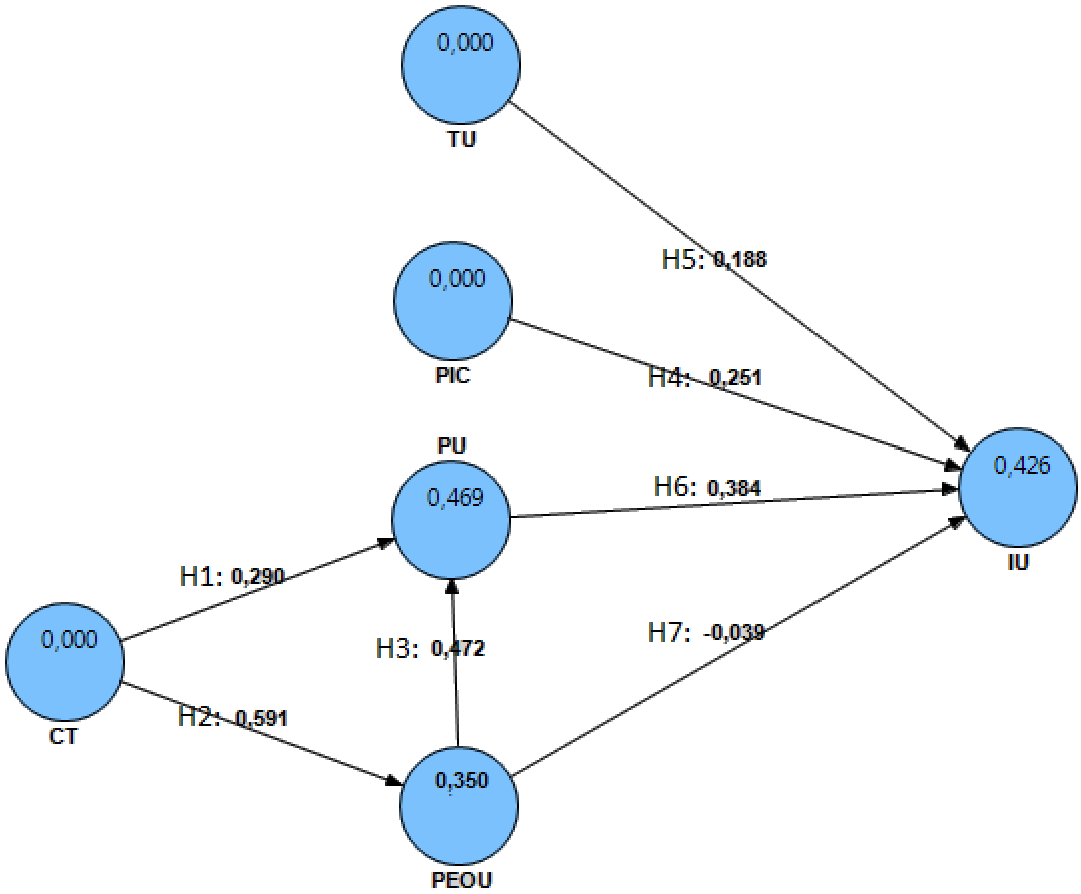


FIGURE 7.1: Structural Model with Data from MSAM questionnaire

The hypotheses, path coefficient and significance of the paths(t-values) are summarized in Table 7.25. As seen in the "Hypotheses Result" column, only three of the seven hypotheses were significantly supported as hypothesis H1 and H2 are not valid due to low internal consistency (Section 7.3.3.1). It can be pointed out that if the Cronbach's alpha for context was valid, their hypothesis would have been supported.

The t-value for the paths TU→IU and PEOU→IU demonstrates that these are not significant at a $p < 0.05$ level, therefore hypotheses H5 and H7 can not be confirmed. The paths PEOU→PU, PIC→IU and PU→IU are significant, meaning the hypotheses H3, H4 and H6 are supported in this Thesis, and provide a direct positive effect.

Hypothesis	Path Coefficient	T value	Hypothesis Result
H1. Context to perceived usefulness	0.290**	2.827	Not valid ICR
H2. Context to perceived ease of use	0.591***	8.460	Not valid ICR
H3. Perceived ease of use to perceived usefulness	0.472***	6.281	Supported
H4. Personal initiatives and characteristics to intention to use	0.251*	2.110	Supported
H5. Trust to intention to use	0.188	1.566	Not significant result
H6. Perceived usefulness to intention to use	0.384***	3.351	Supported
H7. Perceived ease of use to intention to use	−0.039	0.374	Not significant result
	$^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p < 0.001$		

TABLE 7.25: Test of Hypothesis based on Path Coefficient

Chapter 8

Discussion

This chapter provides a discussion of each research question with respect to the results obtained from the analysis, to propose answers to the research questions. One survey and five questionnaires in total were conducted to substantiate and strengthen the results of:

RQ1: *Is there an interest for an application utilizing anonymous indoor user position data among the NTNU students?*

RQ2: *Is it possible to use anonymous user position data from indoor positioning systems with location-based services to solve an "everyday" problem for students at universities?*

RQ2.1: *If yes on RQ2. How can one achieve the students' acceptance to use that kind of application?*

RQ3: *How can one display these data on a mobile device so one can achieve high usability of such applications?*

8.1 Interest in Applications with Anonymous Location-Based Data at University

The research indicates a strong interest in using a mobile application based on anonymous location-based data to offer a mobile service in form of an application for smart phones among NTNU students.

The results from web survey revealed 85.6 % would be interested in using an application with these data *if the application existed.* Figure 8.1 shows respondents characteristic on the X-axis, the blue columns shows the number of people that were interested in using an application with anonymous data, and the red columns are the ones that are not interested. The rightmost column shows the user group that is most relevant; students who own a smart phone, does not have a personal office or reading desk, and who sometimes or frequently uses reading rooms. 93.9% of this group was positively interested in an application that uses anonymous location-based data for displaying room population and availability.

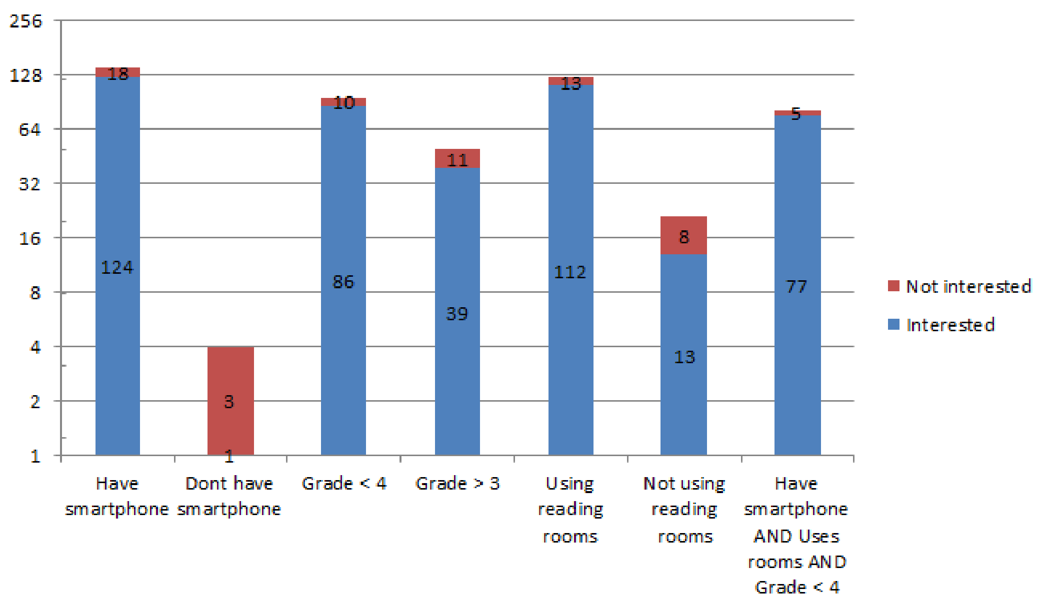


Figure 8.1: Respondents interest in applications with anonymous location data

This high interest may correlate with the mobile service evolution mentioned in section 2.3.1. Applications, smart phones and mobile services popularity have increased the last decade which leads to more experienced users and smart phone owners. The introduction of application stores such as Apple App store and Google Play Store has made the process to install a new mobile service very easy. It takes only a few clicks and less than a minute before an end-user has the new service in his or her pocket, and is ready to use it. If the application does not provide entertainment or solve a problem for the end-users, the chance of the application not being used or uninstalled is likely high.

In item IU1 (“If I have access to the application, I want to use it”) in the application acceptance test, 85.4 % of the respondents ticked either a 6 or 7, while item IU2 (“If I have access to the application, I intend to use it”) got 66 % on 6 or 7.

39.1 % of the respondents rated item CT1 (“I would use this app before going to campus”) as a 6 or 7, while 87.8 % replied to item CT2 (“I would use the application while I am on campus”). Item CT4 (“I would use the application if it is available on mobile devices”) received 92.7 % positive score, while item CT5 (“I would like to use the application if it is available on a PC") received 26.8 % from the responders.

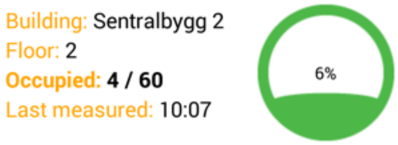
The results from the acceptance test demonstrates that the students have an interest in using *this application*, but it must be available on mobile devices that they own. The most interesting here is the distinction in the answers between question CT1 and CT2. One good reason may be that the population data in the application is up to 25 minutes old thus not completely real-time, as explained in Section 6.2.3.2. This may possibly affect the *users' experience*, which is one of Constantine & Lockwoods' two factors (Section 3.4) for the success of applications. One may assume that since the data are not real-time, students may feel the application is unreliable to deal with when planning where to study before they reach campus. Misinformation of key data can ruin the application's usefulness for end-users in several constructs, but especially their trust in the application. Previous MSAM studies performed on students illustrated that "trust" is the most important determinant for intention to use[9][41]. According to Kaasinen (Section 3.3.1), the users should be able to rely on the data and these data must have good enough accuracy for the adoption of the mobile service.

8.2 Anonymous Data and Location-Based Services in University Context

The research indicates that the combination of anonymous user position data and location-based services can be useful for students at universities as it can solve previously impractical or unsolvable problems. In this Thesis, it was found that the underrated problem of finding available reading rooms is a need, seen by the students at Gløshaugen campus.

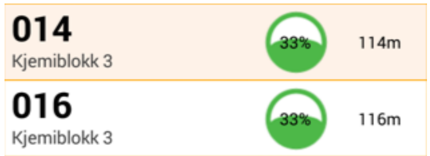
Item PU1 ("Using the application, I can quickly and easily find an available reading room") received 73.2 % on a 6 or 7 from the respondents, demonstrates the Thesis' application with distance measure, navigation (location-based service), and room population and availability (anonymous data) can help students with this issue.

The presented artifact in Chapter 6 is an example of an application that can solve the revealed need. Based on the implemented features in the same chapter, one can see the relation between the Thesis' application and applications mentioned in Section 2.3.3. All of them uses the same basic technologies in the background as LLsP to find user's indoor position, but these are mainly focused on navigation, while LLsP is focused towards showing the anonymous data in the users' language shown in Figure 8.2.



(A) Immediate anonymous data in "Information" screen

(B) Scheduling anonymous data in "Information" screen



(C) Immediate anonymous data in "Main" screen

FIGURE 8.2: Ledig Lesesal Plass presenting anonymous data

The key information illustrated in this application; *occupied*, *number of people* and *filling ratio icon* provides information based on population and availability (if number of desks is known) of a specific area at different times of the day. Other well-known companies using anonymous location data from positioning services such as TomTom (Section 2.4.3), uses them to find which routes that are most effective, and estimate the time it takes between the device's location and the user input destination, based on previous users travel time and current traffic. Google also collects anonymous data from devices running the Google Maps application[75], to show (close to) real-time traffic information. The common denominator for existing applications using anonymous location data is that it is only utilized for outdoor environments.

Personas and scenarios in Chapter 5 elaborated why it is important to combine navigation functionalities and the anonymous data (population and availability) from Wireless Trondheim together, so that users unfamiliar with the buildings and rooms at Gløshaugen campus can find their way to the correct room. This leads to an effortless process where selecting a room nearby and finding the way becomes a seamless process, without the disruption and annoyance of arriving late to a full reading room.

Below, some of the responses from user interface and acceptance testing, showing their opinions of a solution that combines LBS technologies and anonymous location data are listed:

- "Very good application and idea!"
- "Good idea!"
- "Will definitely use during the exam period.."

- “Cool application....”
- “Nice and clear application. Good use of colours and nice design...”

8.3 Mobile Services Acceptance Model for Location-Based Services Application with Anonymous Data

The Mobile Services Acceptance Model and its hypotheses were tested with the results gained from the hallway testing questionnaire, and accounted for 42.6% of the total variance in “intention to use”, and 46.9% of the total variance in “perceived usefulness”. The first empirical study where MSAM was used, Gao et al.[41] accounted for 56.7% of the variance in IU, and 53.8% of the variance in PU. A later study using MSAM, Gao[40] accounted for 66.3% and 32.5% of the variance, respectively.

The results from following this model show a positive relationship between “perceived ease of use” and “perceived usefulness” (H3), “personal initiatives and characteristics” and “intention to use” (H4), and “perceived usefulness” and “intention to use” (H6). In contrast, the relationship between “trust” and “intention to use” (H5), and “perceived ease of use” and “intention to use” (H7) were weak and not statistically significant. Surprisingly PEOU $\rightarrow$ IU was found to have a very slight negative path coefficient of -0.039[1], but PEOU had a strong effect on PU with a weight of 0.484, which could mean PEOU is a transitive determinant of IU.

The first empirical study using MSAM[41] indicated that hypothesis H6 “perceived usefulness” on “intention to use” was rejected, which is contradicting to most of the findings of the original model, TAM in other studies. [41] explained in their research that it may have to do with the participants; Many of them were senior students with much knowledge of mobile- devices and services, who thought the tested system was not equally useful for them in the present but maybe when they were junior students. Another theory that was pointed out that could affect the constructs is that experienced users (Section 5.3) have different requirements. In the same research, it was found that the construct “personal initiatives and characteristics” have a direct effect on “intention to use” due to their experiences with mobile devices. On the basis of this, it is easier for them to be willing to adopt new mobile services. In this Thesis, the test participants were primarily first to third graders, which means they most likely do not have a personal reading room, thus making the perceived usefulness higher for this user group.

According to [9], students felt that it would be more natural not to carry an

[1]Insignificant t-value, so the result cannot be trusted.

extra device when using a system or a mobile service. Five of the participants said that they would use it as long it was free of charge. This may symbolize an influence of "perceived ease of use" as they expect new technologies and mobile services to be available to their devices without the need to buy new devices or carry additional devices.

The results found in this Thesis' research demonstrates that the intention to use applications with anonymous indoor location-based data from indoor positioning systems that offers mobile services for students at universities are threefold. First, students believe that mobile services utilizing these data are useful only if they are free of effort to use (PIC) and are available to the devices they own (PEOU). Second, they want to use the application as long it helps them to achieve their goals (PU). And third, as mentioned in Section 3.3.1, students as the Thesis' target group also have a greater interest in trying new technologies and are willing to learn and adapt new technologies in their daily lives (PIC). As seen in Section 7.4, 100 % of the students who performed the MSAM questionnaire were experienced with smart phones, and 90 % had 2 or more years of experience with mobile applications.

8.4 Achieving High Usability

The whole process from finding a user need, preparing requirements, to a finished developed product could be used as directions to find an approach to similar problems and create similar applications in the future.

The results from SUS testing shows that all 10 questions scored above the mean average score which is 2. Q1 ("I think that I would like to use this system frequently") scored a mean score of 2.5 but the rest were between 3 and 4. The reason for the lower score on Q1 may be because of the nature of the study room problem, where many rooms are not much utilized during the parts of the year with lots of lectures and projects, but during the exam period the reading rooms are mostly full. This can be seen by the participants' comments in Section 7.3.2. The application also received an average participant SUS score of 86 from the maximum of 100, meaning the students found it easy to use an application based on anonymous data and location-based services. However, the SUS test was executed in an early stage of development, with dummy data and less functionality than the finished version. As stated by Gould & Lewis (Section 3.4), it is important to let the users test a prototype at an early stage. The finished prototype has more features based on the participants' suggestions from the user interface test. This is also one of the key elements from Gould & Lewis, about iteratively improving the artifact from user testing.

All of the user interface participants owns a smart phone and assesses themselves to have slightly above average skills in smart phone usage. 80 % of the 10 testers said they would use the prototype when it is finished, 90 % stated that the prototype satisfied their requirements of finding an available reading room.

The research followed Nielsen's 10 heuristics principles (Section 3.4.1) for the usability. The main challenges of achieving high usability of the application were Nielsen's "visibility of system status" and "match between system and the real world". These are further elaborated below.

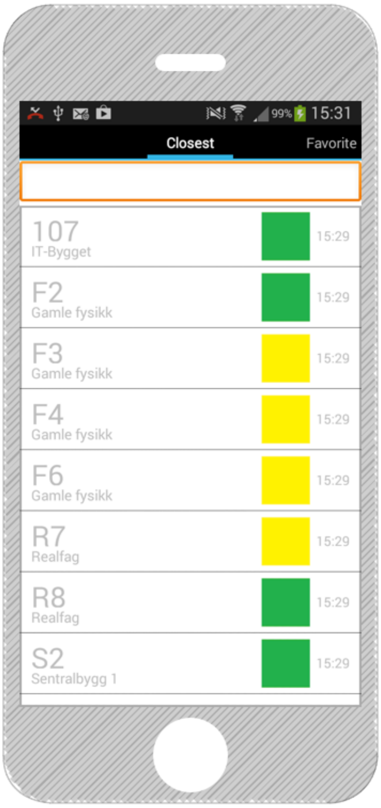
8.4.1 Feedback within Reasonable Time

This first principle from Nielsen may be the biggest challenge in this Thesis' development. As mentioned in Section 5.4.2.2, the application could not store the anonymous data on the device. This requirement from Wireless Trondheim could have an impact on the usability of the final prototype. Retrieving data from Cisco Analytics server every time the application needed, has made the response time a bit slower. The Thesis' solution to Nielsen's first heuristic was to induce thread programming[2], where most of the information is retrieved in the background while the application is starting up. Overall, the application used four thread processes to make the response time faster and in reasonable time for the end-users.

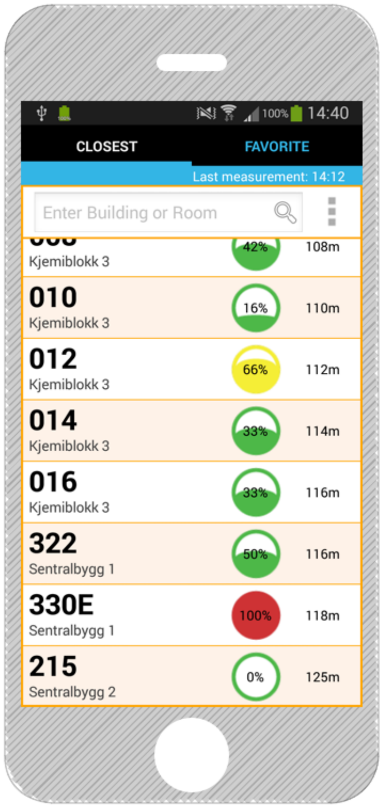
8.4.2 Users' Language

Nielsen's second principle was a big focus during the user interface testing. A few indicators in the earlier versions of the UI made the test participants insecure. Insecure situations can create a lot of misunderstandings as they confuse the users of the application. In the user interface test, some were not sure if there were 2 of 16 desks that were occupied or available. The most insecure elements during user interface test are shown in Figures 8.3a and 8.3c. In Figure 8.3a, the "occupied" symbol were square-shaped and had no filling ratio or percentage based on how many people were in a room. Figure 8.3c shows the "Occupied" indicator was named "Capacity" earlier. "Last updated" is changed to "Last measured", and "Timestamp" replaced with "Time". Also there was added a distance measure between user and each reading room. Figures 8.3b and 8.3d illustrates the latest and improved version of the screens.

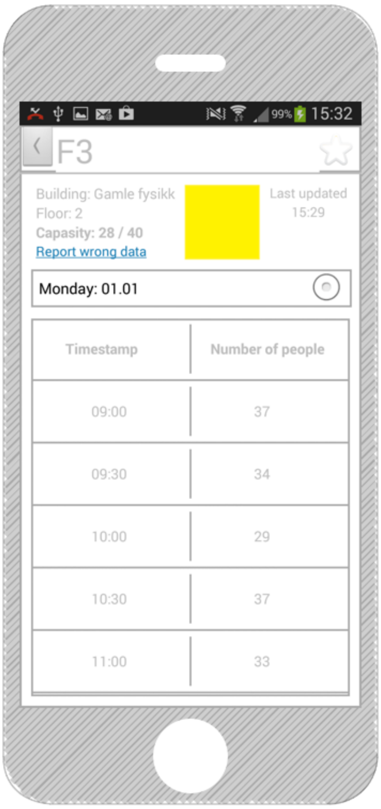
[2]Thread class, AsyncTask in Android (`http://developer.android.com/reference/android/os/AsyncTask.html`)



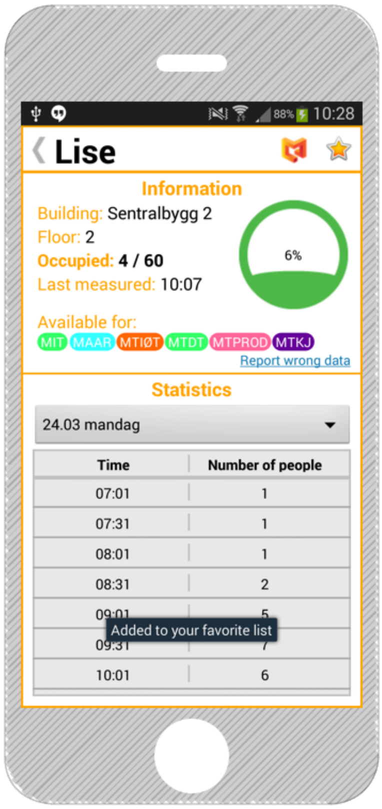
(A) Old "Closest" screen



(B) New "Closest" screen



(C) Old "Information" screen



(D) New "Information" screen

Figure 8.3: Before and after User Interface Test

8.5 Implications

This section discusses the implications for students and business based on the results found in the research.

8.5.1 Implications for Students

Ledig Lesesal Plass contributes features (Chapter 6) to find immediate and scheduling information about the population in reading rooms at Gløshaugen campus in an easy and effortless way, using anonymous location-based data displayed on student's handheld devices. Using the factors that have an influence of the students' intention to use a mobile service from the Mobile Services Acceptance Model, one can concentrate on developing a mobile service that has a higher chance of acceptance from students. The results from the "intention to use" construct and students' feedback demonstrates there are different points one has to take into consideration; application's usefulness, students' personal background, the right platform, users' context, better interoperability, clear and accurate key information.

8.5.1.1 Increasing Application's Usefulness

The result confirms that "perceived usefulness" is one of two constructs that has a strong positive effect on students' intention to use the application. Increasing the factor of application's usefulness is therefor important, and topics such as further development of the mobile service will be meaningful. Four subjects are elaborated based on the comments and results; selecting the *right platform*, *interoperability*, *key information* and *stability of the system.*

8.5.1.2 Selecting the Right Platform

The result suggests that the created service is more suitable for handheld devices than computers, based on the responses to items CT4 and CT5. As mentioned in Section 8.1, 92.7 % were positive to using the application on a mobile device, while 26.8 % were positive to using it on a PC. This can also be seen in CT1 vs CT2 where more people were positive to using the application while on campus than at home. This may be because the service is most relevant close to the time one wants to use a reading room, thus one checks the availability while on the way to campus, on an available device (e.g. a smart phone). Other devices that could feature the proposed service is interactive information screens, which is already installed in some buildings on campus.

8.5.1.3 Boosting Interoperability

The results from surveys and questionaire confirms that boosting the application's ability to inter-operate with other systems for students will increase the application's usefulness. The reasoning behind this is to have *all* frequently used features and services from NTNU systems, collected in one application.

In the web survey, some participants suggested that it should communicate with NTNU's room reservation service for group rooms. Others suggested to display who has access to the reading rooms. To implement this feature LLsP would have to interact with the building access service, which does not have any access points for external applications. Another creative proposal (that is against the privacy law explained in Section 2.4.4) is to implement an online social networking service where people can track the whereabouts of friends, teaching- or student assistants, to see where one can get help with e.g. assignments.

8.5.1.4 Improving Key Information

The result provides an assumption that the population data in the application should be more accurate to gain and keep students' trust in the application. Trust has no direct positive effect on students' intention to use in this study, but from their comments on MSAM questionnaire, this is somewhat contradictory. An assumption can be that the questions for "trust" in MSAM questionnaire are formulated "wrong". Based on previous MSAM studies, trust was an important factor and should have a direct positive effect on "intention to use". The anonymous location data is the key information in this service, and should therefore be correct if the users are to frequently use the application.

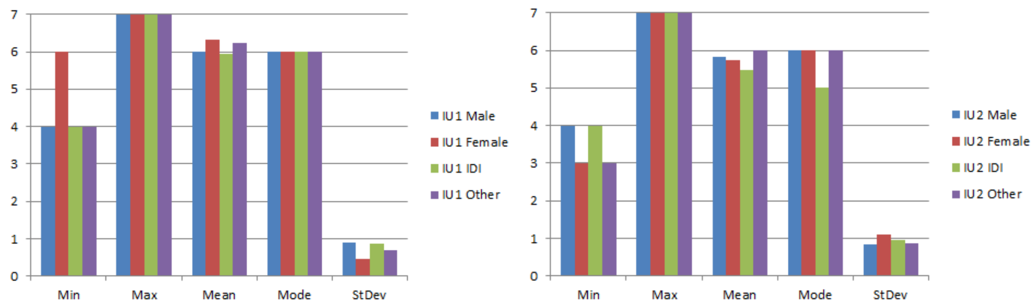
8.5.1.5 Improving Stability of Location Server

In the period this application was developed and tested, the location determining server has been somewhat unstable, which has caused problems with acquiring anonymous location data in the application. This is understandable as the service is still in a beta phase[3], but improving the stability will greatly improve application's key information and its usefulness.

[3]The anonymous data were made available in the beginning of February.

8.5.1.6 Focusing on Students' Background

The results confirmed that "personal initiatives and characteristics" is another construct which has a direct positive effect on students' intention to use the application. Based on the findings in Figure 8.4, there are minimal differences between the genders or which departments students belong to.



(A) IU1: Want to use it (B) IU2: Intend to use it

FIGURE 8.4: Students' Background

One reason for this may be that most of the students tested on Gløshaugen campus are technical as most technical study programs have lessons here. Their background reflects their willingness to try new technologies. Another assumption is that the results would show a lower intention to use if it were tested on persons with non-technical background and low smart phone experience.

8.5.1.7 Thinking on Students' Context

The result provides a strong assumption that students would prefer to use the application when they are on the campus and to retrieve immediate data. This instead of when they are at home or when they are planning where to study. From the MSAM hypotheses, context do not have an implicit direct effect on intention to use, but it can have a transitive effect on IU, as it has an effect on PEOU and PU which directly affects IU.

8.5.2 Implications for Business

The results implies that there are other applications (new mobile services) where these data also are useful. There are big potentials for other scenarios such as shopping malls, hospitals and emergency departments. Tailor-made, location-specific advertising may be the opportunities through the anonymous data that is based on location popularity. Mall managers can exploit these to optimize the shopping experience for customers, by getting information about the customers' shopping patterns. The same situation will also be for employees in hospitals as keeping track of their equipments or where patients and staff move in the building, increasing the efficiency when an unexpected event occur. Response teams can be sent to exact locations where mobile devices are moving inside a building in cases of emergencies[76].

8.6 Limitations

This section provides some potential areas where this Thesis may fall short based on its research and results.

8.6.1 Reliability of Context

There are several limitations of this research. The biggest limitation of the MSAM acceptance test is that the construct Context did not pass the Cronbach's Internal Consistency of Reliability (ICR) test. This is because the questions in this construct tried to measure all the types of contexts mentioned in Section 3.3.2, thus it did not measure the same kind of context which led to the answers given by users were not consistent throughout the scale. This resulted in two hypotheses with a high significance and good path coefficients, but that still could not be used to support the hypotheses.

One advice to fellow researchers using the MSAM is to split the context construct into several categories if one wants to attain results for different kinds of contexts.

8.6.2 Varying Accuracy

One limitation it was not possible to influence in this Thesis is the restricted Wi-Fi accuracy in some parts of Gløshaugen campus. Based on the technologies described in Section 2.2, the accuracy can be between $5 - 10$ meters using the 1800 Wi-Fi access points around NTNU[24]. In some small reading rooms, it was noticed that the device's location was reported to be outside the room, even if it was placed right in the centre of the room. This affects to a large degree the quality of the data used in this Thesis's application, and results in the application showing 0 people in a room that may have several people in it.

A solution for better accuracy is to install more Wi-Fi access points, better calibration of the existing infrastructure or reallocate their positions better. Both options would require investments in resources such as time and money.

8.6.3 Distribution of Application Impact

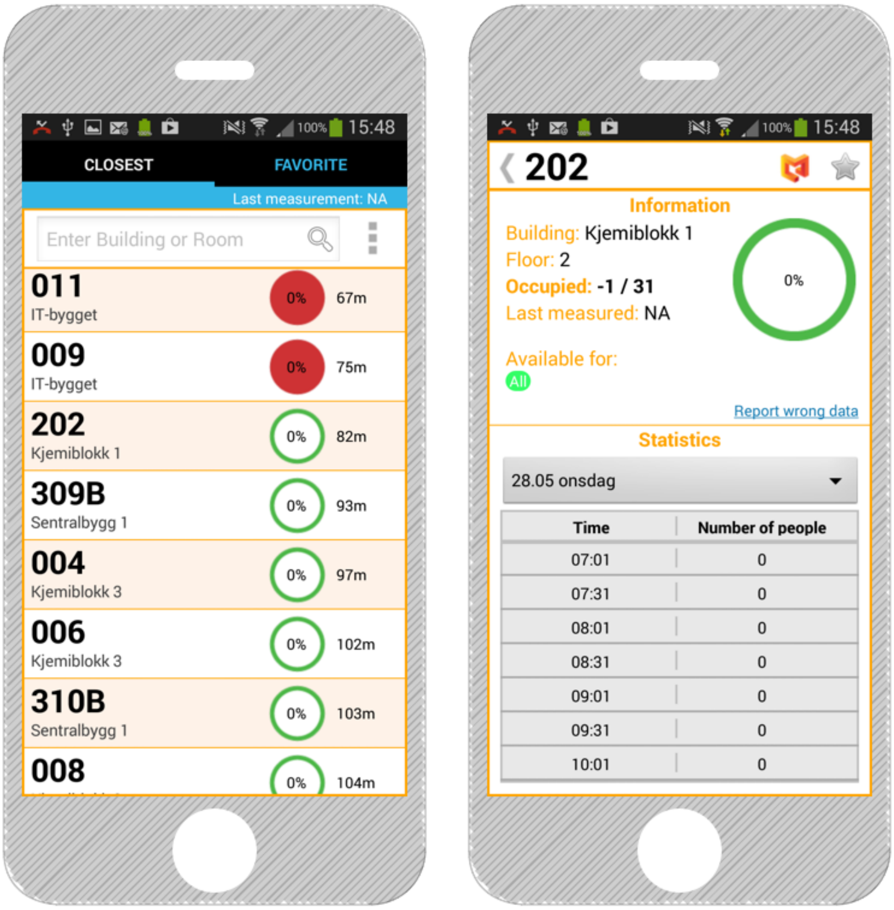
One requirement from Wireless Trondheim was that the application should not be distributed to Google Play Store or otherwise released to the public. The number of participants in the acceptance test could have been much higher and it could have been tested over some time, if it was allowed to distribute the application. According to [62], the required minimal sample size is at least 10 times the number of items in the most complex construct, something this Thesis' MSAM test were unable to attain as the context and perceived usefulness constructs have 5 items each.

This may have an effect as the "missing" data could have been the turning point to get the context's reliability to be valid and two more hypotheses being significant.

8.6.4 No Data Stored in Application

Another requirement from Wireless Trondheim, was not to store the anonymous data in the LLsP application.

An assumption is that the architecture of the application could have been developed differently, making the whole application's response time faster when the data is stored locally. This could also enable the application to show better and old statistics if the positioning server is offline (Figure 8.5). This could possibly have increased users' experience, and the end results would have been even more positive.



(A) "Closest" screen without anonymous data (B) "Information" screen without anonymous data

FIGURE 8.5: No Anonymous Data Available because the Server is Down

8.6.5 Interviewer Bias

The user interface test was executed in a room with only the test participant, observer and test leader. Also during the MSAM test, the applications developers were present when the questionnaires were filled out by the testers. An assumption is that this can lead to interviewer bias effect, which makes users respond more positively to the questions. This phenomenon is explained more in Section 3.6.2.

8.6.6 Server Downtime

Cisco Analytics server has been offline several times during this research. Uncertainty from the server has caused problems with the application's presentation of anonymous data. The data shows 0 *number of people* in statistics screen, Not available (NA) on *last measured* and -1 on *occupied* shown in Figure 8.5, the times the servers are down. In these incidents when the application can not retrieve the anonymous data the key information is incorrect, and the application only functions as a reading room wayfinding application.

8.6.7 Testing Devices

The results of acceptance testing may have been affected by the test participants using older and smaller devices than what is standard as of 2014. Smaller screens means smaller on-screen buttons. Some of the respondents complained about this during the test (See Section 7.3.2), indicating that it can reduce their experience. Also the map feature used JavaScript, which is tough on older devices and does not run as smoothly as native applications.

Another issue was that the devices lost Wi-Fi connection under testing (and had no SIM-card for mobile Internet connection) so the navigation and data stream stopped. These reasons may affect the acceptance result.

8.6.8 Reality versus Application's Data

One limitation that can affect the acceptance result as well is the reality versus the data shown in the application. Because of the time scope and mentioned server downtime, there was not time to do a thorough check of the quality of the data received from the Analytics API. The data shown to users in the application is not 100 % reliable since a person can either have multiple or no Wi-Fi enabled devices. An assumption is that the data is +\- 2 persons off in most rooms with several Wi-Fi AP's nearby, based on the comments received from the acceptance test (Section 7.3.2), and random checks that was performed during this research.

8.6.9 User Misconceptions

Last limitation is that there are many companies that are using the same technology (Cisco MSE) as Wireless Trondheim, but none of them are focusing on presenting anonymous indoor location data as a mobile service to end-users. Since users are not used to such a service, one assumption is that it can confuse the end-users into thinking the data is always correct. The participants tested the application around 20-25 minutes, and maybe did not gain enough insight to conclude. However, if the application was tested for a longer period, the results might have been different.

Chapter 9

Conclusion and Future Work

This chapter provides the research questions that are evaluated against the findings. Foundation for a conclusion will be presented, and the elements identified for future work.

9.1 Conclusion

This research has examined the factors behind the intention to use an application based on anonymous location data and location-based features for students to solve an "everyday" problem at the NTNU university. The usability of the application has also been a big focus as the target audience can be very diverse with different experiences with smart phones and applications.

A prototype was developed and evaluated twice at different completion stages and time periods. Several methods and tools were used to collect the data and analyze the results. Four research questions have been pursued during this process:

RQ1: *Is there an interest for an application utilizing anonymous indoor user position data among the NTNU students?*

RQ2: *Is it possible to use anonymous indoor user position data from indoor positioning systems with location-based services to solve an "everyday" problem for students at universities?*

RQ2.1: *If yes on RQ2. How can one achieve the students' acceptance to use that kind of application?*

RQ3: *How can one display these data on a mobile device so one can achieve high usability of such applications?*

The results concludes that there is an interest for an application utilizing anonymous user position data among students at NTNU university. A prototype that utilizes location-based services and anonymous location data was created to produce the end-users' opinions of the identified problem: "finding an available reading room". Section 8.2 illustrates how anonymous data can be clearly presented. Chapter 6 presents how one can combine these data with other location-based services to solve an "everyday" problem. Section 8.3 summarizes that the students will use an application based on anonymous data if it helps them to achieve their goals, but only with "free of effort" and "no purchasing costs" policies. This means both perceived usefulness and personal initiatives and characteristics constructs are very important factors for their intention to use a location-based services application with anonymous data.

Early involvement with the end-users to analyze their perception of the application's usability, and their viewpoints of the problem and needs has been important for the result. Followed by well-known general usability guidelines to create an intuitive and understandable user interface. The findings demonstrates that the crafting of this kind of applications can solve smaller problems that also has a great importance to a group of people.

9.2 Future Work

This section provides some approaches for subsequent work based on this Thesis' results.

9.2.1 Examine the Usage

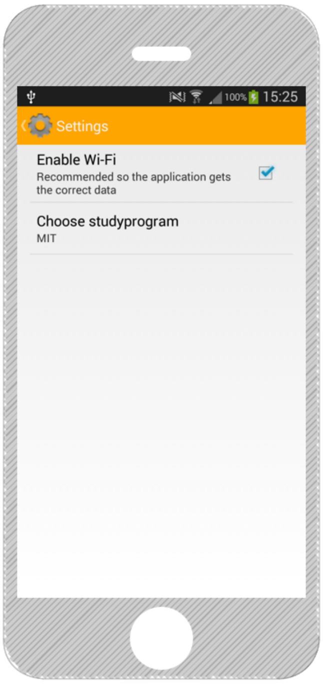
This study shows that some students would use this application only when the examination period begins. According to [24], MazeMap is mostly used at the start of the year (for freshmen) and in the examination periods. It could be useful to examine the usage in the examination period, but also the effect of using the application over a longer period (by releasing it to the end-users) to gain more feedback and possibly generate better data.

9.2.2 Examine Real Data versus Application's Data

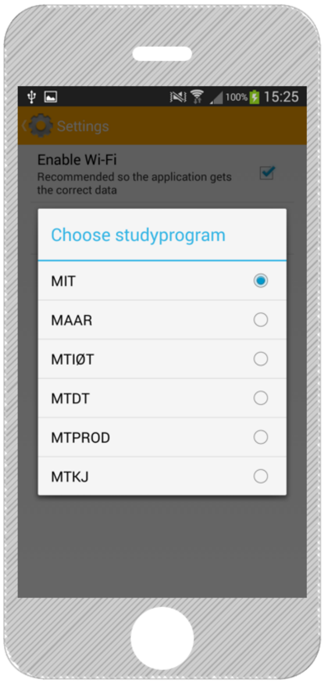
The results from the random checks and comments from the acceptance test demonstrates that the data are not as credible as it probably should be for daily use. An examination to see the possibility to improve the data from the API more to real data, to see the impact on trust construct. Previous MSAM studies shows that trust is the most important factor for intention to use, which was not found in this Thesis' study. Future studies could examine if trust construct is more related to the real data versus application's data.

9.2.3 Extend Functionality

The functionality could be extended to also include which study programs have access to which reading rooms. An option to choose a study program and only reading rooms available for the specific choice appears on the list. This was investigated but it appeared to be impossible to obtain such a list as Byggsikring[1] and all departments in NTNU do not have the lists available for easy consummation by computer programs. In LLsP, implementation was started (Figure 9.1) but since room access policies changes, it was decided not to filter out which rooms students don't have access to. Future studies could extend this functionality in LLsP.



(A) Unfinished Settings screen



(B) Studyprogram selection

Figure 9.1: Ledig Lesesal Plass' Settings

[1]https://innsida.ntnu.no/adgangskort

9.2.4 Extend Target Groups in the University Context

The NTNU administration or employees are an interesting group as they can also use the application to allocate the resources more accurately such as resources to maintain the rooms based on how much a room is being used. According to [76], the data from IPS can provide data on actual user movement, distances to cover in breaks between classes and potential bottleneck staircases and corridors, which can make the outcome of location resource management closer to optimal.

Future studies could examine this topic and find other “un-revealed” needs in university or public building context.

9.2.5 Develop new Mobile Services with Anonymous Data

Section 8.5.2 explains that it is possible to use the anonymous data to gain new benefits and advantages from other fields of applications based on population. By utilizing anonymous population data from Wi-Fi AP’s in applications, will help the user achieve their goals in a more seamless and natural way without intrusive and irritating elements.

Future studies could investigate and create new mobile services based on the same data that is utilized in LLsP.

9.2.6 Incorporate Anonymous Indoor Data in MazeMap

This study illustrates that it is possible to combine anonymous data with LBS applications. MazeMap is an LBS application that has a large user base already and the proposed feature can be implemented in MazeMap to obtain even more users. Future studies could present the anonymous data in MazeMap for higher efficiency to solve many kinds of possible tasks that involves the usage of campus.

Appendix A

Web Survey

This survey is made in Google Form and is distributed through NTNU's Intranet "Innsida", Studentservice NTNU's twitter page and NTNU's area in Itslearning.

App for finding available study rooms
We are two MSc Informatics students currently working on a thesis that deals with the usage of anonymous position data collected from Wi-Fi devices located at NTNU Gløshaugen. The data collected are completely anonymous and approved by the Norwegian Data Inspectorate, and will only be used for R&D purposes. Our goal is to make an app that utilize these data to show which study rooms at Gløshaugen that has available seats, and hope you have a couple of minutes to answer this short questionnaire. * means it is required to answer the question

App for finding available study rooms

We are two MSc Informatics students currently working on a thesis that deals with the usage of anonymous position data collected from WiFi devices located at NTNU Gløshaugen.
The data collected are completely anonymous and approved by the Norwegian Data Inspectorate, and will only be used for R&D purposes.
Our goal is to make an app that utilize these data to show which study rooms at Gløshaugen that has available seats, and hope you have a couple of minutes to answer this short questionnaire.

* Required

Q1: Gender *

- Female
- Male

Q2: Are you currently a student? *

- Yes
- No

Q3: If yes, which grade? *

- 1st grade
- 2nd grade
- 3rd grade
- 4th grade
- 5th grade
- PhD student

Q4: Do you own a smartphone or tablet? *

E.g. iPhone, iPad, Android phone or tab, Windows phone

- Yes
- No

Continue »

50% completed

App for finding available study rooms

* Required

App for finding available study rooms

Q4.1: If yes, how much do you use your phone per day?

- Less than 1 hour
- 1-2 hours
- 3-5 hours
- More than 5 hours

Q5: Do you use study rooms at NTNU Gløshaugen? *

- Yes
- No

Q5.1: If no,
why don't you use study rooms?

Q5.2: If yes, how many hours do you estimate you spend at study rooms per week?

- 1-5
- 6-10
- 11-20
- 21-30
- 31+

Q6: How useful do you think that an app that displays the nearest study rooms and number of persons in it is? *

- Very much useful
- Somewhat useful
- Not particularly useful
- Completely useless

Q7: What do you think of these proposed features? *

	Completely useless	Not particularly useful	Somewhat useful	Very Useful	Not sure
Show the nearerst study rooms (if you are on campus)	○	○	○	○	○
Step-by-step navigation to chosen study room	○	○	○	○	○
Information about study rooms (e.g. size, accessibility to sinks, toilets, type of chairs and desks)	○	○	○	○	○
Usage statistics (which hours/days are most crowded, etc.)	○	○	○	○	○
Store favorite rooms that show up first in the app	○	○	○	○	○
User reviews of study rooms	○	○	○	○	○

Q8: Would you use an app like this? *

- ○ Yes
- ○ No

Q8.1: Could you elaborate?

Q9: Do you have any suggestions for features you think this app should support?

Or other app-ideas that benefits from collecting anonymous user position data.

Q10: Other comments?

« Back Submit

Never submit passwords through Google Forms.

100%: You made it.

Appendix B

User Interface Questionnaire

The participants who executed the user interface testing, were asked to fill out these questionnaires and to carry out the tasks. SUS questionnaire[1] is in Norwegian.

B.1 User Interface Test Subject Questionnaire - Demographics

The questionnaire to find more about who the participants are.

[1] http://www.brukskvalitet.no/wp-content/uploads/2010/01/SUS-norsk.pdf

Q1. Kjønn
Mann [ ] Dame [ ]

Q2. Hva er din alder?

____

Q3. Hvilket studieprogram tar du?

____

Q4. Hvilket årstrinn?

____

Q5. Eier du en smarttelefon?
Ja [ ] Nei [ ]

Q6. Hvor mange timer om dagen benytter du smarttelefon?
Mindre enn 1 time [ ] 1-2 timer [ ] 3-5 timer [ ] Mer enn 5 timer [ ]

Q7. Hvor mye erfaring har du med å bruke smarttelefoner?
Nybegynner 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] Ekspert

Q8. Benytter du lesesaler på Gløshaugen?
Ja [ ] Nei [ ]

Q9. Har du en egen lesesalplass/kontor reservert til deg?
Ja [ ] Nei [ ]

Q9.1 dersom JA, har du tidligere hatt problemer med å finne ledige lesesalplasser?

____

Q10. Hvor mange timer i uka benytter du lesesal?
1-5 [ ] 6-10 [ ] 11-20 [ ] 21-30 [ ] 31+ [ ]

B.2 User Interface Test Tasks

The tasks that the participants have to execute during the user interface prototype testing. The tasks are in Norwegian.

Introduksjon

Tenk deg at du er en student i andre klasse fra Gløshaugen som ikke har en fast plass på lesesal enda. Under eksamensperioden prøver du å finne en ledig plass og lese på campus. Etter utallige forsøk der alt er opptatt, går du lei og vil gi opp. Du får et tips fra en venn om at det finnes en applikasjon som finner ledige leseplasser for deg.

Oppgave 1: Finn den nærmeste lesesalen som har ledig plass. Hvor mange plasser er **opptatt** og hvor mange er det igjen?

Oppgave 2: Legg denne lesesalen til dine favoritter. Gå tilbake og finn ditt nye rom i favorittlista og informasjon om hvilken **bygning** og **etasje** lesesalen ligger i, samt når **informasjonen sist ble oppdatert.**

Oppgave 3: Du trenger en plass å lese hver **fredag** mellom klokken **10-12**. Finn ut hvor mange folk det var i ditt favoritt-rom fredag den **05.01**, klokken **10:00**.

Anta at du går til rom 151, og ser at antall personer i rommet ikke stemmer overens med hva appen sier. Det er 5 personer mindre i dette rommet enn det appen viser.

Oppgave 4: Send en melding til utviklerne om feil antall mennesker i rommet.

B.3 User Interface Test Subject Questionnaire - Usability

This questionnaire seeks to gather a wider perspective of the SUS respondents opinions and if they noticed any usability problems during the test.

Q1 Savner du noe funksjonalitet?

____

Q2. Synes du appen trenger å vise mer detaljert info om rommene, basert på data om hvor det befinner seg personer på gløshaugen?
Ja [ ] Nei [ ],
forklar:

____

Q3. Savner du noen annen informasjon?
Ja [ ] Nei [ ],
forklar:

____

Q4. Synes du informasjonen presentert om rommene er grei, eller burde noe forandres?
Ja [ ] Nei [ ],
forklar:

____

Q5. Er det noen designendringer du synes burde gjøres?
Ja [ ] Nei [ ],
forklar:

____

Q6. Tilfredstiller appen dine behov for å raskt finne en ledig lesesal?
Ja [ ] Nei [ ],
forklar:

____

Q7. Tror du at du ville brukt appen når den er ferdig?
Ja [ ] Nei [ ], forklar:

____

B.4 System Usability Scale Questionnaire

The participants were also asked to score the following 10 items with one to five responses that range from "*strongly disagree*" (score 1) to "*strongly agree*" (score 5).

Noen spørsmål om systemet du har brukt.

Vennligst sett kryss i kun en rute pr. spørsmål.

	Sterkt uenig				Sterkt enig
1. Jeg kunne tenke meg å bruke dette systemet ofte.	1	2	3	4	5
2. Jeg synes systemet var unødvendig komplisert.	1	2	3	4	5
3. Jeg synes systemet var lett å bruke.	1	2	3	4	5
4. Jeg tror jeg vil måtte trenge hjelp fra en person med teknisk kunnskap for å kunne bruke dette systemet.	1	2	3	4	5
5. Jeg syntes at de forskjellige delene av systemet hang godt sammen.	1	2	3	4	5
6. Jeg syntes det var for mye inkonsistens i systemet. (Det virket "ulogisk")	1	2	3	4	5
7. Jeg vil anta at folk flest kan lære seg dette systemet veldig raskt.	1	2	3	4	5
8. Jeg synes systemet var veldig vanskelig å bruke	1	2	3	4	5
9. Jeg følte meg sikker da jeg brukte systemet.	1	2	3	4	5
10. Jeg trenger å lære meg mye før jeg kan komme i gang med å bruke dette systemet på egen hånd.	1	2	3	4	5

I

SUS
Norsk versjon ved Dag Svanæs
NTNU 2006

Appendix C

Acceptance Questionnaire

The participants who executed the acceptance testing, were asked to carry out these tasks. In the first place, an introduction was given out before they borrowed one of the smart phone with LLsP installed. After they did the tasks, they had to fill out two questionnaires; test subject profile questionnaire and MSAM questionnaire.

C.1 Introduction to Application

The Introduction that was given to the participants. The introduction of Ledig Lesesal Plass is in Norwegian.

Introduksjon

Applikasjonen "Ledig Lesesal Plass" er en applikasjon laget for Android enheter som finner de nærmeste lesesalplassene med ledig kapasitet på NTNU Gløshaugen. Applikasjonen benytter seg av anonyme brukerlokasjonsdata samlet inn fra NTNUs Wi-Fi nettverk. Appen registrerer ikke informasjon om- eller lokasjonen til brukeren, men får data om antall personer som befinner seg på lesesalene fra en server styrt av Trådløse Trondheim (firmaet som har laget MazeMap). Informasjon om antall personer som befinner seg i en lesesal er ikke alltid 100 % nøyaktige, og de kan være opptil 25 minutter gamle. Tidspunkt for siste oppdatering fra server står opplyst i appen.

Appen har også funksjonaliteter som: hvor en lesesal ligger gjennom MazeMap sin karttjeneste (også kjent som CampusGuiden), antall meter du befinner deg unna lesesaler, en favorittliste der man kan legge til eller fjerne sine mest besøkte lesesalplasser og søkefunksjon for å finne en lesesal eller bygning.

C.2 Acceptance Test Tasks

The tasks that the participants have to executed during the acceptance testing. The tasks are in Norwegian.

Oppgaver

Tenk deg at du ikke har en egen fast plass på lesesal. Under eksamensperioden prøver du å finne en ledig lesesalplass på Gløshaugen. Du får tips om å bruke en app som finner lesesaler med ledige plasser i nærheten av deg.

Husk at dette er en prototype, så appen kan være noe ustabil. **Utfør følgende oppgaver ved å bruke appen "Ledig LesesalPlass":**

Oppgave 1: Finn lesesalen med navnet **Lise** og sjekk hva appen sier om ledige plasser der. Hvis du befinner deg langt unna Lise må du bla nedover i listen eller bruke søkefunksjonen).

Oppgave 1.1: Finn veien til lesesalen, og se om det stemmer at det er ledige plasser der. Dersom du ikke vet hvor **Lise** er bruk informasjon om etasje og bygning, eller benytt MazeMap kartløsningen (oransje knapp øverst til venstre). Obs, ikke forstyrr de som sitter der og leser :)

Oppgave 2: Legg **Lise** til dine favoritter, dersom ditt studieprogram har tilgang til denne lesesalen. Sjekk at den nå ligger i favoritt lista di.

Oppgave 3: Du finner ut at **Lise** er en god leseplass. Nå vil du sjekke hvor mange som brukte rommet for tre dager siden, samme tidspunkt slik at du har en oversikt over når det bruker å være ledige plasser der.

C.3 Detailed User Guide

The aids against the tasks if the participants are stuck. THe aids are in Norwegian.

Hjelpeguide (Brukes dersom du står fast eller trenger noen hint)

Oppgave 1:

- Finn **Lise** i lista, eller søk på **Lise** med søkefunksjonen.
- Finn informasjon om antall opptatte plasser gjennom "fyllingsgrad" ikonet, eventuelt gå inn **Lise** og les av informasjon.

Oppgave 1.1:

- Les av hvilken bygning og etasje **Lise** ligger i.
- Trykk på det oransje *MazeMap*-ikonet for å bruke kartfunksjonen **OBS**, dette kan ta noen sekunder på gamle telefoner.
- Trykk på det første resultat som dukker opp i søkelisten.
- Hvis din posisjon på kartet ikke synes (en blå blinkende sirkel): trykk på posisjonsikonet nede til venstre(blå pil.
- Zoom inn til det valgte rommet og gå dit.

Oppgave 2:

- I informasjonsvinduet til **Lise** under **"Available for"**, ser du hvilke studieprogram som kan sitte der. Finn ut om du kan sitte her.
- Legg til **Lise** som favoritt ved å trykke på stjerne-ikonet.
- Trykk tilbake-knappen til du kommer til listen med de nærmeste lesesalene.
- Gå til favorittlista enten ved å trykke på FAVORITE eller ved å *"swipe"* til siden.

Oppgave 3:

- Under informasjonsvindu til Lise, finner du noe som heter *"Statistics"*.
- Trykk på den store knapp som indikerer hvilken dag og dato som vises.
- Velg dagen du vil sjekke statistikk for.Bla gjennom lista og finn tidspunktet.

C.4 Acceptance Test Subject Questionnaire - Demographics

The questionnaire to find more about who the participants are. They are in Norwegian.

Spørreundersøkelse om Ledig Lesesal Plass App

Takk for at du bruker noen minutter på å svare på denne undersøkelsen som angår appens brukbarhet, opplevd nytteverdi og generelle holdninger og inntrykk.
Undersøkelsen er anonym.

Del 1

Q1. Kjønn
☐Dame ☐Mann

Q2. Alder
☐Under 20 år ☐ 20-25 år ☐Over 25år

Q3. Hvilken studieavdeling tilhører du?
☐IDI eller IME ☐Annen avdeling

Q4. Utdanningsnivå
☐ 1. klasse ☐ 2. klasse ☐ 3. klasse ☐ 4. klasse ☐5. klasse ☐ Doktorgrad

Q5. Jeg har erfaring med smarttelefoner
☐Ja ☐Nei

Q6. Hvor mye erfaring har du med apper?
☐Ingen ☐0-1år ☐2-5år ☐Mer enn 5 år

Q7. Har du erfaring med liknende apper?
☐Ja ☐Nei

Hvis ja, navn på appen(e): ______________________________

____

____

C.5 Mobile Services Acceptance Model Questionnaire

The participants were also asked to score the following 24 items with one to seven responses that range from "*strongly disagree*" (score 1) to "*strongly agree*" (score 7). They are in Norwegian.

Del 2

1. Opplevd nytteverdi	Sterkt uenig						Sterkt enig
Ved å bruke appen…	1	2	3	4	5	6	7
PU1. finner jeg raskt og enkelt en ledig lesesal…………	☐	☐	☐	☐	☐	☐	☐
PU2. finner jeg raskt en lesesal i nærheten av meg……	☐	☐	☐	☐	☐	☐	☐
PU3. er det større sannsynlighet for at jeg finner en lesesal jeg ikke visste om fra før………	☐	☐	☐	☐	☐	☐	☐
PU4. er det større sannsynlighet for at jeg benytter meg av lesesaler på Gløshaugen………………..	☐	☐	☐	☐	☐	☐	☐
PU5. er det enkelt å planlegge hvilken lesesal jeg skal gå til før jeg drar på skolen………………………..	☐	☐	☐	☐	☐	☐	☐

2. Opplevd brukervennlighet	Sterkt uenig						Sterkt enig
	1	2	3	4	5	6	7
PEOU1. Jeg synes appen er klar og forståelig…………	☐	☐	☐	☐	☐	☐	☐
PEOU2. Å bruke appen krever lite konsentrasjon……..	☐	☐	☐	☐	☐	☐	☐
PEOU3. Jeg synes det er lett å få appen til å gjøre…… det jeg har lyst til…………………………………..	☐	☐	☐	☐	☐	☐	☐
PEOU4. Jeg finner lett den informasjonen jeg leter etter	☐	☐	☐	☐	☐	☐	☐

3. Tillit	Sterkt uenig						Sterkt enig
Jeg vil bruke appen…	1	2	3	4	5	6	7
TU1. hvis jeg har en klar oppfatning av appens funksjonaliteter………………………….	☐	☐	☐	☐	☐	☐	☐
TU2. hvis appen beskytter brukerens personvern……	☐	☐	☐	☐	☐	☐	☐
TU3. hvis jeg føler meg trygg på at jeg kan kontrollere appen……………………………………………..	☐	☐	☐	☐	☐	☐	☐
TU4. hvis jeg føler data fra appen er til å stole på…….	☐	☐	☐	☐	☐	☐	☐

4. Personlig initiativ	Sterkt uenig						Sterkt enig
	1	2	3	4	5	6	7
PIC1. Jeg er i stand til å bruke denne appen	☐	☐	☐	☐	☐	☐	☐
PIC2. Jeg vil gjerne være blant de første til å bruke appen……………………………………………..	☐	☐	☐	☐	☐	☐	☐
PIC3. Å bruke denne appen vil gi meg en fordel over de som ikke bruker appen……………………..	☐	☐	☐	☐	☐	☐	☐
PIC4. Å bruke denne appen er en god idé…………….	☐	☐	☐	☐	☐	☐	☐

5. Kontekst	Sterkt uenig						Sterkt enig
Jeg vil bruke appen…	1	2	3	4	5	6	7
CT1. før jeg skal til campus……………………………	☐	☐	☐	☐	☐	☐	☐
CT2. mens jeg er på campus…………………………	☐	☐	☐	☐	☐	☐	☐
CT3. hvis universitetet anbefaler studentene å bruke appen………………………………………………	☐	☐	☐	☐	☐	☐	☐
CT4. hvis den finnes til mobil eller nettbrett…………..	☐	☐	☐	☐	☐	☐	☐
CT5. hvis den finnes til PC……………………………..	☐	☐	☐	☐	☐	☐	☐

6. Bruksintensjon	Sterkt uenig						Sterkt enig
Gitt at jeg har tilgang til appen…	1	2	3	4	5	6	7
IU1. jeg har lyst til å bruke denne appen………………	☐	☐	☐	☐	☐	☐	☐
IU2. jeg kommer til å bruke denne appen………………	☐	☐	☐	☐	☐	☐	☐

Kommentarer:

Appendix D

Digital Attachments

This Thesis contains 1 zip archive with 2 folders: sourceCode and dataCollection

sourceCode folder:

1. source code
2. application (.apk)
3. readme file

dataCollection folder:

1. raw and calculated data from web survey, SUS questionnaire and MSAM questionnaire and all test subject questionnaires.
2. room data gather from manual check.
3. observation notes.

D.1 Source Code

The source code for the application "Ledig Lesesal Plass" is not open-source as it contains sensitive URL's. The .apk file is also included. The ViewPagerIndicator framework is also included in the LLsP's source code because of the changes that have been made. A readme file is included in the sourceCode folder with a short explanation of the source code.

D.2 Survey and Questionnaire Data

All data from web survey and questionnaires are included in the folder "dataCollection". It contains 11 files:

- Capacity_readingrooms.xlsx
- MSAM_with_demographics.xlsx
- MSAM_pls_project.splsp
- MSAM_with_math_stats.xlsx
- Observation_notes_from_interface_testing.pdf
- SUS_post_test_subject_form_responses.docx
- SUS_pre_test_subject_form_responses.docx
- SUS_scores.xlsx
- Websurvey_responses_english.xlsx
- Websurvey_responses_norwegian.xlsx
- Websurvey_with_diagram.xlsx

Adobe Reader opens .pdf files.
Microsoft Excel opens .xlsx files.
Microsoft Word opens .docx files.
Smart PLS opens .splsp files.

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