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SOUTH EAST EUROPEAN UNIVERSITY

Business Informatics

POSTGRADUATE STUDIES-SECOND CYCLE

THESIS:

The application of NFC technology for navigation in complex system buildings, case study SEEU campus

CANDIDATE:

Djellza Nushi

MENTOR:

Assoc.Prof.Dr Xhemajl Zenuni

Tetovo, 2021

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Declaration of original work

I certify that I am the original author of this thesis:

"THE APPLICATION OF NFC TECHNOLOGY FOR NAVIGATION IN COMPLEX SYSTEM BUILDINGS, CASE STUDY SEEU CAMPUS", and I hereby declare that this master thesis is my own original work, and I have not copied from other's works or from any other sources except due reference to literature, where I have faithfully acknowledged all sources used and have cited them in the reference section.

The research was done under the guidance of Assoc. Prof. Dr.Xhemal Zenuni, and the thesis is submitted in accordance of the requirements of South East European University.

Djellza Nushi

2021

Universitety "Fehmi Agani" in Gjakova
Rectorate, St. Ismail Qemali,nn.
50000 Gjakova, Republic of Kosovo
https://uni-gjk.org/en
Office number: 03820020321

To Whom It May Concern

Re: Djellza Nushi Thesis "The application of NCF technology for navigation in complex system buildings, case study SEEU campus"

This is to confirm that I, Laura Naka, have proofread Djellza Nushi's master thesis "The application of NCF technology for navigation in complex system buildings, case study SEEU campus" in English Language.

Prof.ass.Dr. Laura Naka
Vice Rector for Academic Development and Quality Enhancement
University "Fehmi Agani" in Gjakova
Tel: +38344484600
laura.naka@uni-gjk.org
p.s. For any additional information you can contact me via my official email.

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FAKULTETI I GJUHËVE, KULTURAVE DHE KOMUNIKIMIT

Diplomë

për kryerjen e ciklit të tretë të studimeve

Laura Naka

e lindur më 24.09.1970, me numër identifikimi 119236,

i përfundoi provimet e parapara të studimeve të doktoraturës në programin studimor Gjuhë dhe letërsi angleze, 180 kredi ECTS, me notë mesatare 9.20 dhe mbrojti disertacionin me temë:

"Sfidat e udhëzimeve të diferencuara/ndryshuara në procesin e të mësuarit të Gjuhës Angleze si gjuhë e huaj (Rast studimi me studentët e klasave të përziera të Fakultetit të Filologjisë dhe Fakultetit të Edukimit në Universitetin e Gjakovës "Fehmi Agani")"

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Факултет за јазици, култури и комуникација

South East European University - Tetovo

Faculty of Languages, Cultures and Communication

ДИПЛОМА

за завршен трет циклус на студии

DIPLOMA

on completion of the third cycle of studies

Лаура Нака

родена на 24.09.1970,

со идентификациски број 119236,

Laura Naka

born on 24.09.1970,

with student ID number 119236,

ги положи сите предвидени испити на докторските студии на студиска програма Англиски јазик и литература, 180 ЕКТС кредити, со просек на оценки 9.20, и ја одбрани докторската дисертација под наслов:

"Предизвици на промените упатства во процесот на учење на Англискиот јазик како странски јазик (Студија на случај со ученици од мешани паралелки на Филолошкиот факултет и Образовниот факултет на Универзитетот во Гаковица "Фехми Агани")"

и се здоби со научен степен

ДОКТОР ПО ФИЛОЛОШКИ НАУКИ - Англиски јазик и литература

has passed the required exams of postgraduate studies according to the English Language and Literature, 180 ECTS credits, with grade point average 9.20, and defended the doctoral dissertation, entitled:

"The challenges of differentiated instructions in EFL learning process (Case study with mixed ability students of the Faculty of Philology and the Faculty of Education at the University of Gjakova "Fehmi Agani")"

and gained the qualification of

DOCTOR OF PHILOLOGY - English Language and Literature

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17.12.2018

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Abstract

The navigation system is quickly changing. For outdoor navigation are used more frequently mobile devices and have opened possibilities for indoor navigation. In this thesis, I propose a Near Field Communication (NFC)-based outdoor navigation system, which enables users to navigate through a building or a complex by enabling a location update, simply by touching NFC tags that are spread across SEEU campus and orient users to the destination location.

Evaluate the performance of the system and compare it with other navigation systems. NFC has many advantages compared with other navigation system in term of cost, maintain, complexity and security.

1. Introduction

Technology nowadays is used from youngsters, adolescents to grown-ups and seniors. Technology has influenced people and their daily live. As new technologies devices are developed, new interaction techniques appear and affect how we interact with them. Near field communication (NFC) is wireless technology for transferring data in short range distance, based on RFID technology.

NFC is made to interchange different kinds of data, such as phone numbers, images, and different MP3 files between two devices which has NFC in their phone, or between NFC phone and a perfect RFID chip card that are held near each other.

Navigation is system that helps to control the movement of an item from an origin to a destination along a path. Navigation systems are based on Global Positioning System (GPS), which provides reliable location information also control and update the movements.

In this thesis, I will be able to use NFC tags, which will contain information about objects locations in campus, which can be accessed via a mobile application where users have limited knowledge of the area. Every location in map will have its own tag, the users or students should have the Android or IOS smartphone to have the access on this technology, first they have to activate the NFC, then to hold near the tag. The application will detect the current location of user, then you must bring the smartphone near the NFC and smartphone will show you the way to the location you are looking for.

Sometimes maps give minimal data and are difficult to peruse, near field communication (NFC) improve usability and increase the data contained in the map without clouding the data.

NFC has very fast setup time, high protection and improved performance compared with other wireless technologies. NFC tags are small and passive devices, which means that they operate without a power supply of their own, data which are written in the tag can be read by any NFC device.

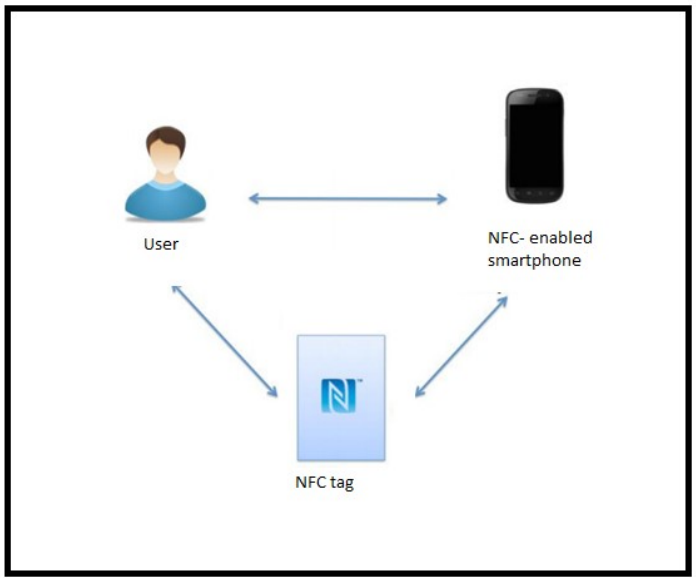


Figure 1 NFC interaction

In this picture you can see the different actors of the NFC-interaction in our case. Relationships between all actors influence both the perception of NFC and the engagement with technology.

Important actors from this interaction are NFC enabled smartphone and NFC tag, without them the communication will not function. Users can use their smartphone to scan a tag and get the required information from it.

The smartphone device can act as a tag and as a reader. NFC interaction from some scenarios can be simple by touching and get the destination they want and some scenarios which are more complex example buying ticket for movie. When an item is scanned by a mobile phone, the device adopts the properties and background of the scanned item. We call this method a transformation process. Each mobile device interaction is intuitive because the mobile device acts just like the scanned item.

The main components of our system and how they work together to enable and evaluate the mode will be discussed in another chapter.

1.1 Problem Statement

New technologies always bring opportunities to solve navigation problems, such as the defining accuracy position of the user, finding the shortest route to the destination and creating innovative map application with minimal cost.

The possibility of using other technology exists but we must bear in mind some challenges like cost, privacy, usability, and accuracy. Implement a campus navigation system that has the focus the user, limiting and solving problems in a considerably way. All this issue will be solved by using Near Field Communication (NFC) technology.

NFC navigation system help users to navigate the complex building, by simply touching NFC tags those are extend around the map and direct users to the destination. The aim is to reduce time and facilitation for finding the right location or object within the school environment. From experience we know that it is often difficult to find locations on our campus, so I developed an easier innovative method.

1.2 Importance of the thesis

NFC technology is marvelous in the sense that almost everybody can understand. The objective of this work is to able to navigate outdoors using NFC mobile phone and system, which is made in security way since technology has short range operation and the opportunity to eavesdrop is rare. I will evaluate the performance of the system and compare with other navigation.

The thesis shows the cost-effective method of navigating campus. Using a smartphone, users do not need to ask others about any objects in campus because they can check the information directly in their phone. I will use mobile device to read and write in NFC tag. NFC tag can be worked without battery. NFC tag can be read in distance less than 10cm. The system will be used.

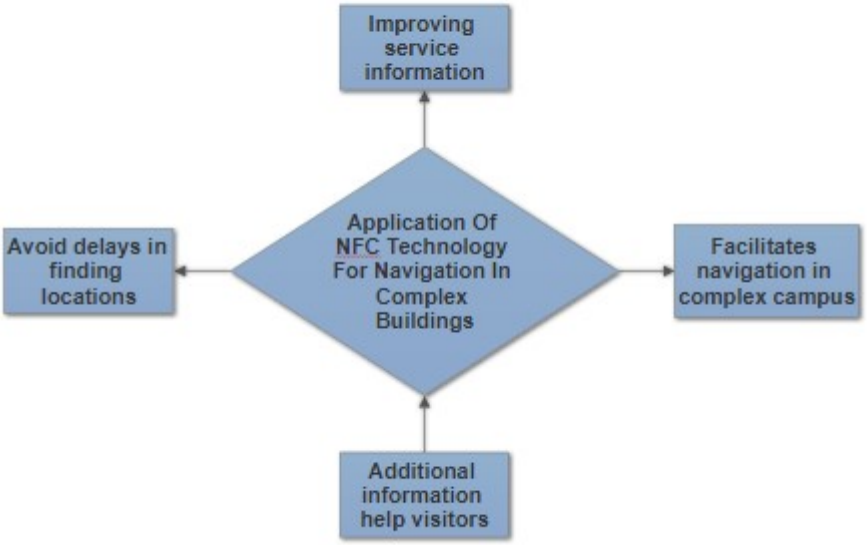
This navigation system will be very useful to users, for example a person must go in conference, but does not have much time, and would like to find the conference room as fast as possible, without much effort.

People will appreciate a solution which in such situations helps them save time and effort.

The benefit of the system is the users can use the device without the need to know about the technology, which positively affects people who are older and have a problem with new technology.

1.3 Hypotheses

The hypotheses in this thesis will be verified during the work.



Development of the hypothesis

- H1: The application of NFC technology will positively affect for improving the service information, with specific focus on campus navigation.
- H2: Users will avoid delays in finding location.
- H3. NFC tag facilitates navigation in complex campus.
- H4: Trusted location data has positive impact on users, to assure their current location.

1.4 Research Methodology

Research methodology is the method that helps us to describe our thought process and reasoning behind the decisions I faced around our study.

Literature review: The aim of this study is to understand NFC research as a science research area, by exploring the current literature in order to provide awareness for NFC. This study is based on articles in journals, books, and mostly conference proceeding papers.

Quantitative analysis: To measure my research model, I used a questionnaire for data collection. The wording of the questions was adjusted to fit our topic. Questions in questionnaire helps to provide additional information about user groups on top of their perception about NFC application. It allows for a deeper and more meaningful discussion and analysis.

1.5 Thesis Structure

The organization of the thesis will be divided into 5 chapters and associated with references. The thesis is collocating as follow:

Chapter 1 start with introduction that notify reader about the NFC technology and navigation. Which include the problem statement, importance of the thesis, hypothesis, and research methodology.

Chapter 2 discuss near field communication in general, how NFC works, how NFC operates, where we can use NFC and about the security of NFC. In this chapter also is included the navigation system, type of navigation and other NFC navigation system.

Chapter 3 discuss the design and implementation of NFC in campus, the creation of map in Open Street Map and connection with application. Also contain the compression with other technology, advantages, and limitations.

Chapter 4 presents the evaluation and discussion of application. And the fulfillment or non-fulfillment of the hypotheses.

Chapter 5 present the conclusion and recommendation of future work.

2. Near Field Communication (NFC)

Just like Bluetooth and Wi-Fi also NFC works to send information over radio wave. NFC is based on the ideas of RFID (Radio Frequency Identification) to transmit data through electromagnetic induction. NFC can be used to induce electrics inside passive components just to send information. Therefore, passive devices do not need their own power supply, but they can be powered by electromagnetic which is produced by an active NFC component.

A passive device is an NFC tag which contains information and other devices can read it. This device can only transmit information nothing else. Active devices are smartphone which is used to gather information from NFC tags and can share information between compatible devices. According to (Vijay Laxmi Kalyani, Neha Sharma , 2017)frequency for transmission data is 13.56 megahertz, and data can be send 06, 212 or 424 kilobits per second.

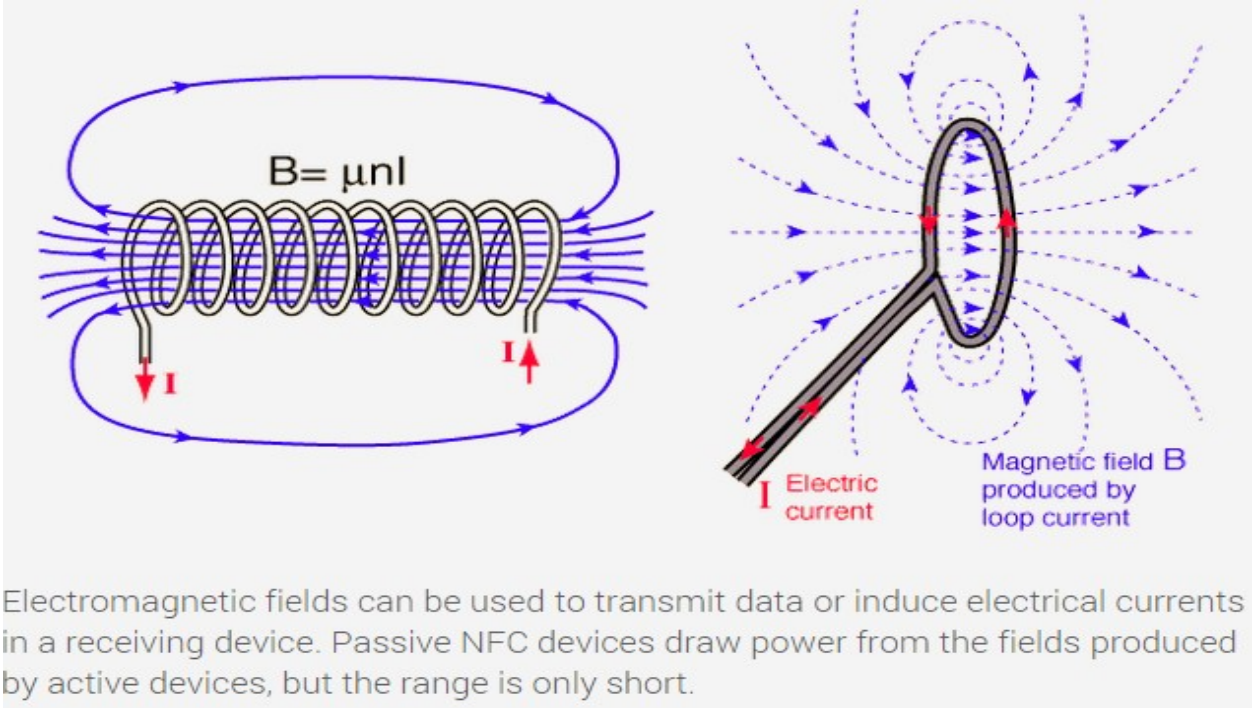


Figure 2 Electromagnetic Field

2.1.1 NFC communication modes

According to (Burkard, 2014), NFC is built upon a subset of existing ISO standards, including the ISO/IEC 14443 Standard that is being used by the RFID technology. NFC therefore operates with amplitude shift-keying modulation on the unlicensed 13.56 MHz radio frequency band, enabling data transmission speeds of up to 424 Kbits per second. (Arjun, 2013)

NFCIP-1 and NFCIP-2 are two standards of NFC. The first standard NFCIP-1 is construing ECMA-340 standard. This mode is destined for peer-to-peer communication between devices which is separated into two variations: active and passive mode. ECMA-352 specifies NFCIP-2, which defines how to automatically choose the correct mode of operation when communications are initiated.

Active Mode

In active mode generates its own carrier frequency its own RF field for transmission purpose. It is outfitted with a power supply for operation. According to (Trivedi, 2015), active NFC device act as an initiator in communication. Alternatively, two active NFC devices can generate RF fields to form a two-way communication connection to transfer data. A passive mode NFC system will not be able to produce its own carrier frequency.

Passive Mode

Passive device acts as a target. The initiator system creates communication RF fields, and the target device uses inductive coupling to react back to them. Target device modulates to initiator's RF field, for replying to initiator. The target device uses power from the electromagnetic RF field produced by the initiator and saves energy. Resultant, Passive device can be provided a small battery for its operation to restrict energy sources consumption (Trivedi, 2015)

2.1.2 NFC operation modes

To share information between devices NFC has three mode operations. One of the most used mode is peer to peer which enable devices to exchange information between devices. Device state active when it sends it data, and passive when its receive. Another mode is read/write and card emulation.

Peer to peer mode

According to (Burkard, 2014)**,** this mode is simple of NFC operation, it is not supported by the Contactless Communication API. Enables to transfer data at a rate of up to 424Kbps.It works on NFCIP-1 protocol, whose protocol's detail and electromagnetic properties are standardized in ISO 18092 and ECMA 320/340.

Figure 3 Peer to peer mod

Read/writer mode.

The NFC device can operate as reader or as writer. As soon as it is close enough to a passive RFID transponder tag or passive smart card, energy is transferred through magnetic inductive coupling to the passive tags. A contactless connection can be set after the tag is powered. The NFC cannot just read the data on tag but also can write data to the memory of tag. (Burkard, 2014)

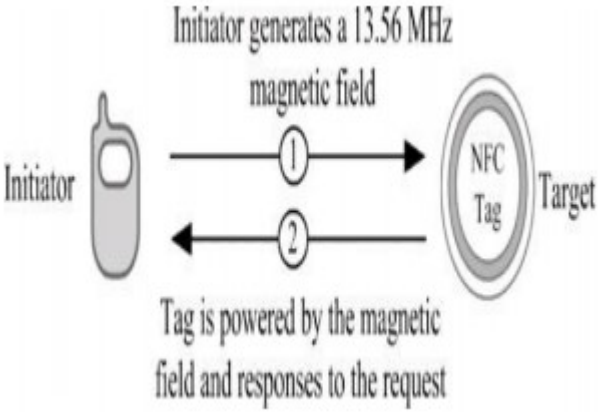


Figure 4 Read/writer mode

Card emulation

NFC device act as a smart cart and other NFC device can read data from it. This mode is used for payment or ticketing application or to give access control. In this mode the NFC emulates ISO 14443 smart card chip. Emulation mode is supported by Contactless Communication API and is secure. (Forum, 2011)

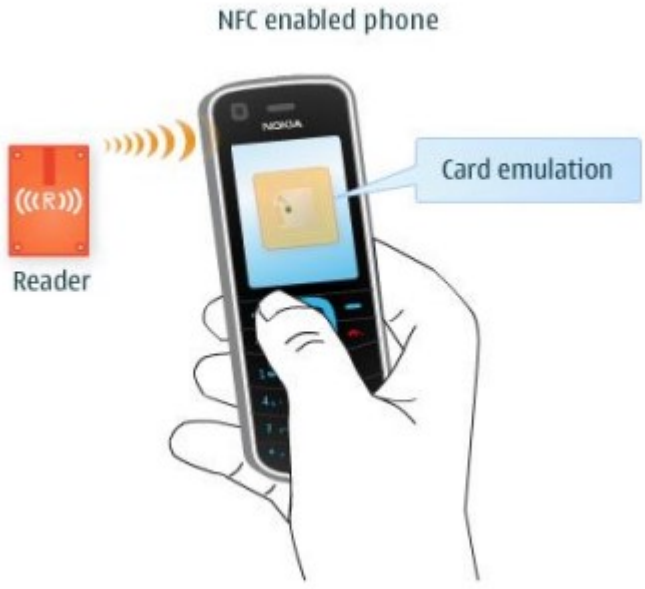


Figure 5 Card emulation mode

2.1.3 NFC Architecture

Keeping in mind the goal to comprehend NFC inside and out, we need to know the architecture of NFC. According to (Tom Igo, Don Coleman & Brian Jepson, 2014), there are several layers to consider, lowest layer is the physical, namely your CPU and the radios that are doing the communication. In the middle, there are data packetization and transport layers, then data format layers, and finally, your application code. (Tom Igo, Don Coleman & Brian Jepson, 2014)

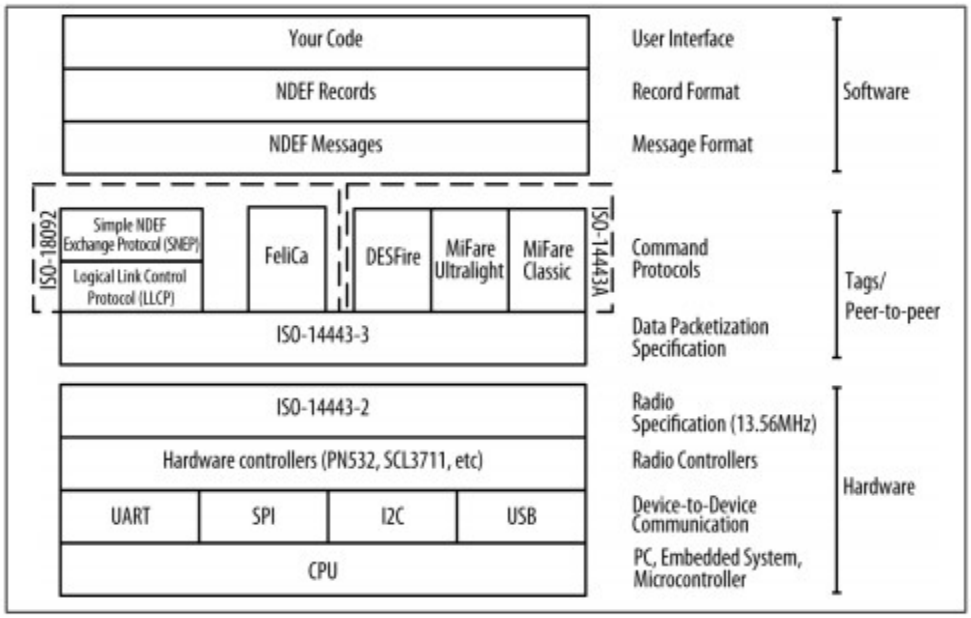


Figure 6 NFC architecture

In physical layer the NFC works on RFID radio specification. ISO-14443-2 explain the low-power radios working at 13. 56MHz.Next layer depict the framing of data bytes sent over the radio, ISO-14443-3. Any of the radios you may utilize are partitioned hardware components. They communicate with the main processor of your device using one or more standard inter-device serial protocols: universal asynchronous receive transmit (UART), serial peripheral interface (SPI), inter-integrated circuit communication (I2C), or universal serial bus (USB). (Tom Igo, Don Coleman & Brian Jepson, 2014)

Over that are a few RFID commands protocol, in view of two particulars. As (Tom Igo, Don Coleman & Brian Jepson, 2014) said the original RFID control specification, NFC tag reading, and writing is built on is ISO-14443A. ISO-14443A is compatible with the Philips/NXP Semiconductors Mifare Classic and Mifare Ultralight and NXP DESFire Protocols. The peer-to-peer NFC exchange is based on the control protocol of ISO-18092.

The main difference between NFC and RFID is peer to peer mode communication which use ISO-18092 standard. Protocols that manage peer to peer communication to exchange data logical link control protocol (LLCP) and a simple NDEF exchange protocol (SNEP).

The second difference between NFC and RFID, NFC data exchange format lies on top of these protocols. NDEF shows a data exchange in messages, which are collected of NDEF records.

2.1.4 NFC Tags

NFC tags can save limited information and transmit to active NFC device. Information stored in tags can be URL, phone number, calendar information etc.

According to (Forum, 2011), there are 5 types of tags.

Tag 1 type: the cost for this type of tag is effective and is suitable for many application

- *Established on ISO-14443A standard.*
- *Read and re-write capable, also users can configure the tag to be read-only.*
- *96 bytes of memory, expandable up to 2KB.*
- *Communication speed 106 Kbits/s.*
- *No data collision protection.*

Tag 2 type: are very much alike types 1 but is separated from NXP/Philips MIFARE Ultralight tag.

- *Established on ISO-14443A standard.*
- *Read and re-write capable, also users can configure the tag to be read-only.*
- *96 bytes of memory, expandable up to 2KB.*
- *Communication speed 106 Kbits/s.*
- *Anti-collision support (Forum, 2011)*

Tag 3 type: this tag is more expensive than type 1 and type2. Is separated from the no secure parts of Sony FeliCa tags

- *Established in the Japanese Industrial Standard (JIS) X 6319-4.*
- *Pre-configured at manufacture to be either read and re-writable, or read-only.*
- *Variable memory, up to 1 MB per service.*
- *Supports two communication speeds, 212 or 424 Kbits/s.*
- *Anti-collision support. (Forum, 2011)*

Tag 4 type: is separated from NXP DesFire tag and is related to type 1.

- *Established on ISO-14443A standard.*
- *Pre-configured at manufacture to be either read and re-writable, or read-only.*
- *Variable memory, up to 32 KB per service.*
- *Supports three different communication speeds 106 or 212 or 424 Kbits/s.*
- *Anti-collision support. (Forum, 2011)*

Tag 5 type: this type is created by NXP Semiconductors.

- *Based on ISO-14443A standard.*
- *Read and re-write capable, also users can configure the tag to be read-only.*
- *Variable memory 192/768/3584 Bytes.*
- *Communication speed 106 Kbits/s.*
- *Anti-collision support (Forum, 2011)*

2.1.5 Ways to use NFC

Most of the mobile phone support NFC, but most of the people are not aware about it. Something the NFC can use only for data transfer and for mobile payment.

At home: You can put NFC tag near the entrance door and then it can do lot of things such as turning on the Wi-Fi, increasing volume and also you can program them to make the opposite.

In the car: To use NFC in the car makes your life easier. If you have Bluetooth radio, you turn on so your phone can connect to the radio and let music play, also you can use for navigate using NFC tag to enable Google Maps.

Gym: You can put NFC tag in your bag which turns on flight mode and let you to make exercises .You can use toggle option when you finished work out by just tapping the tag.

Sleep and wake up: You don't need to make your phone mute or to make flight mood when you sleep, now you can do it by tag with just a tap and you can stop the alarm with that.

Turn on the pc: When put NFC tag in entrance you can program it to start the computer remotely .For this you need applications like Tasker, Trigger Wol Wake on Lan Wan.

Create a hotspot for your tablet: If you are traveling somewhere and you need internet connection quickly to look for something, this you can do it by putting NFC tag on your tablet and let it turn on phones portable Wi-Fi hotspot**.**

At the office: While you are working in your office, you can place a tag in your desk a program to turn on Wi-Fi and make it silent. You can also use the second tag for sending emails to your boss that you are leaving.

Lock and unlock your door: Technology has created a smart home, but some functions need complex installation. NFC tag enables users to unlock and lock the door wherever they are. Smart home has Lockton door, Lockton it will connect with your Wi-Fi home and can give you notification if family member are come in your house.

2.1.6 NFC security and privacy

Security is the level of protection of the data from intentional or accidental misuse. The malicious activity can be caused by an adversary, which wants to earn some benefits, to inhibit any system, and to gain some information.

To have a security system you have to apply basic processes of authentication, authorization, and non-repudiation.

Authentication is the process that guarantees that a person is who he declared to be.

Authorization is the function of specifying access rights to be carried by the authenticated user. So an authenticated user can do the actions that he is permitted to do, but not the actions that he is not allowed.

Nonrepudiation is a version of authentication which ensures that a message has been sent and received by persons pretending to have sent and received the adequate message.

Security primarily deals with considerations, integrity, and availability.

With considerations, it deals to protect data by unauthorized users and usage, with integrity to protect data from modification of the unauthorized users, and with availability to allow authorized users to access any time and in any condition.

Privacy and secrecy are subcategories of confidentiality. The role of secrecy is to keep away private information from unauthorized use. And the role of privacy is to assure that the data aren't used for an unintended purpose by the owner.

Integrity ensures that data aren't modified by an unauthorized user. So, integrity deals with the cases such as malicious activity in the communication between two persons on the Internet, because the message may not arrive at the receiver.

So, security is essential for NFC because it usually used for payment and ticketing. (Kerem Ok, Vedat Coskun, Busra Ozdeninci, 2012)

2.1.7 Importance of security

All want to keep their services secure from attackers, by using an information management tool.

There are many reasons that security is an important issue:

- From the hacker's point of view:
    - A hacker has now more financial opportunities from malicious activities. So he can earn more money than ever.

- From the technical point of view:
    - Due a large number of Internet users, a hacker can hack many victims with just one method. So, for them now it is more convenient to hack.
    - The high development cost in the IT area makes it harder to embed security measures in the new applications then designing the rest of the application.
- From the developer's point of view:
    - Potential buyers tend to appreciate functionality much more than security. Although noticing security features requires expertise, users easily notice other functionalities such as a user interface. (Kerem Ok, Vedat Coskun, Busra Ozdeninci, 2012)

According to (Kerem Ok, Vedat Coskun, Busra Ozdeninci, 2012), the main reasons that security is important issue in the NFC are:

- Everybody has a cell phone and people are worried with things that matter to it.
- NFC is facing heavy pressure from service providers.
- NFC potentially has a big financial market, which is a demanding reason for the hackers

2.1.8 Primary Goals of Security Measures

All systems have different security requirements. Some put limits that only one or more have access to that information while others require the content to be unchanged by illegal parties. Some systems require authentication, some integrity.

Secrecy/Confidentiality: *I*nformation here can be accessed only by authorized person or devices. This requires hiding the content of information by encryption with a secret key.

Authentication*:* means to confirm the identity of a person or device. Methods that are used for authentication are requesting a password, RFID identifies card, pressing fingers into a scanner. Various mechanisms exist for the protection of security, signing digital is one of the strongest mechanisms but banks thought that the one-time password is better and support more.

Some options for authentication in the bank are

- ***One-time password via SMS***
- ***One-time password generator token***
- ***One-time password generator software***
- ***Mobile signature***

Biometric authentication: Biometric is a system used to authenticate person based on physical features. According to *(Kerem Ok, Vedat Coskun, Busra Ozdeninci, 2012)*, metric involves features like fingerprint, retina or voice pattern which provide a higher level of security compared to a password. Biometric methods cost too much for that reason they are not mature enough.

- "It is hard to trust the user because the user may insert some relevant data during the creation of the password by only making some modification to, say, a birth date.

- It is hard to trust to the user even her password is complex because the probability that the user writes the password somewhere is very high.

- As the computing capability increases, hackers will be able to crack complex passwords in just a few seconds that a user can handle in her brain. So, it is good to have a replacement for that future time.

Biometric systems contain static and dynamic properties. Part of statics are fingerprint, DNA, hand geometry, while the dynamic part is voice, signature etc.

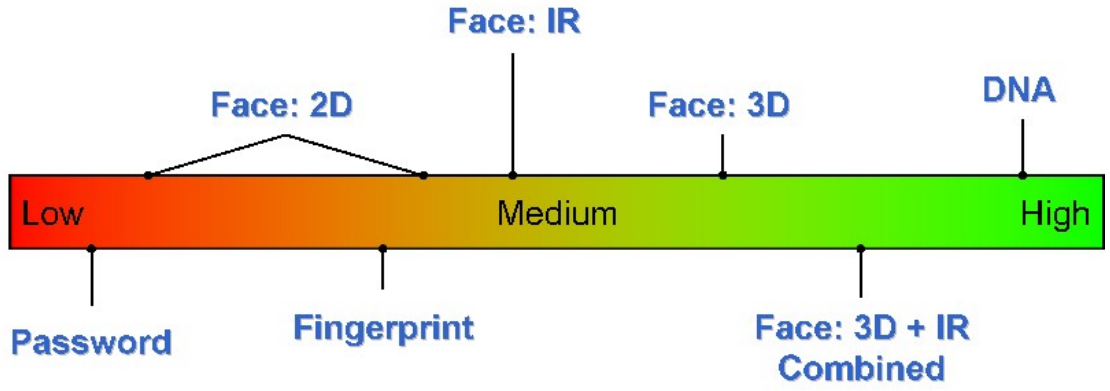


Figure 7 Biometric System

Biometric systems stored data in the enrollment phase which contain information about hand geometry or fingerprint on the database. Then the digital representation (or enrollment phase) of current users compares the data stored on the verification phase. In password based authentication there is no difference between real password and representation password because in the two cases a password is written by symbols, but in biometric are different recordings of the same information

Data integrity: means if the information received are the same as information sent. The information can be accessed or change only by authorized people. Integrity involves controlling network terminal and servers, restricting access to data and maintenance etc. (Kerem Ok, Vedat Coskun, Busra Ozdeninci, 2012)

2.1.9 Attacks on the tag

Attacks which can happen on the tag are:

Destroy

This attack is considered as the simplest, with this attack tag cannot communicate with any NFC devices. A tag can be destroyed by catting the connection to its antenna when electrical components have overload also when tag place into a microwave oven.

Remove

This happens when the thief smuggles the carrier object via security. This attack removes a tag from the carrier objects.

Shield

This kind of attack happened by putting tag inside a metal box. This attack is temporary and is used to pass automated toll checkpoints without recognition.

Clone

This attack read the tag and at the same time creates a copy of it. The tag which can be cloned very easy is read-only tag which include just numeric ID, this tag does not know which is original and cloned.

Falsify / Replace:
This attack enables to overwrite data on original tag without any security measures. The purpose of this is to falsify the original tag.

Tracking

Using the same unique ID enables attacker easy to track tag. So, for attacker is easy to track the movement of user. (Kerschberger, 2011)

2.1.10 Attacks over the Air Interface

Since the Air Interface is contactless technology the attacks can be done without physical attack.

High distance read.
This attack shows how the attacker change the NFC devices to read the tag on great distance, this can be done by increasing the energy of High-Frequency field, increasing the noise of communication and optimizing antenna.

Jamming

Is a great problem that happened in the wireless environment. According to (Lows, 2015), it works by denying service to authorized users as legitimate traffic is jammed by the overwhelming frequencies of illegitimate traffic. The attacker must have the right tool to jam the frequency when the wireless networks do not function. The sender can lock the NFC system by sending a disorder signal on its frequency.

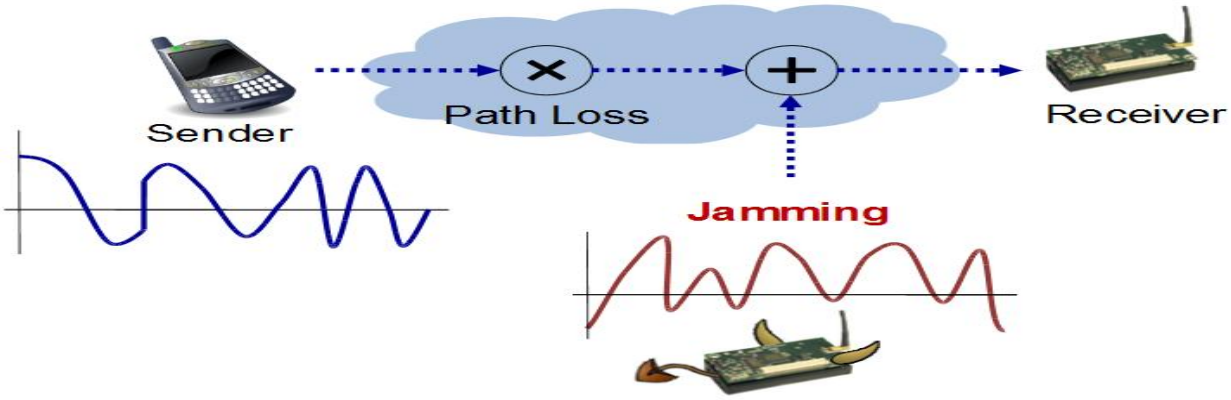


Figure 8 Jamming.

Denial of Service

Another name of this is distributed denial of services, enable network unavailable to users. To protect from it most administrators install the software which limits the damages. There are many tags on the range, the anti-collision algorithm run and choose some individual device to communicate. The attacker here generates the collisions for each device. The reader cannot get the simulated device so the communication that readers want is blocked. (Kerschberger, 2011)

Man in the Middle

According to (Ernst Haselsteiner and Klemens Breitfuß, 2015), Man-in -the-Middle Attack refers to a communication between two parties called Alice and Bob, which are tricked into a three-party conversation by an attacker, which is called Eve. He reads and records the data before

reaching their receiving device. This attacker has harder to act in cases of active-active communication, because of short range proximity.
This middle attacker can establish two keys, one for Alice and one for Bob to eavesdrop on their communication when they use these keys to secure data.

For example, Alice uses active mode and generates the RF field to sends data to Bob which uses passive mode, and the attacker (Eve) which is close enough, pretends to eavesdrop data. To do this, Eve must disturb the transmission of Alice to make sure that Bob doesn't receive the data, but Alice can detect this by checking active disturbance and can stop the key agreement protocol. Otherwise, the protocol can continue, and Eve needs to send data to Bob. Alice is still there, so Eve needs to generate another RF field. So, Bob does not understand data sent by Eve.

Another case is when both (Alice and Bob) use active mode. Even now Alice can detect the disturbance done by Eve and stop protocol. If she does not detect that, the protocol can continue. But the problem now is that while Eve turns on the RF field, Alice can listen and stop the protocol.
So is very hard to start a Man-in-the-Middle attack in e real-world scenario.

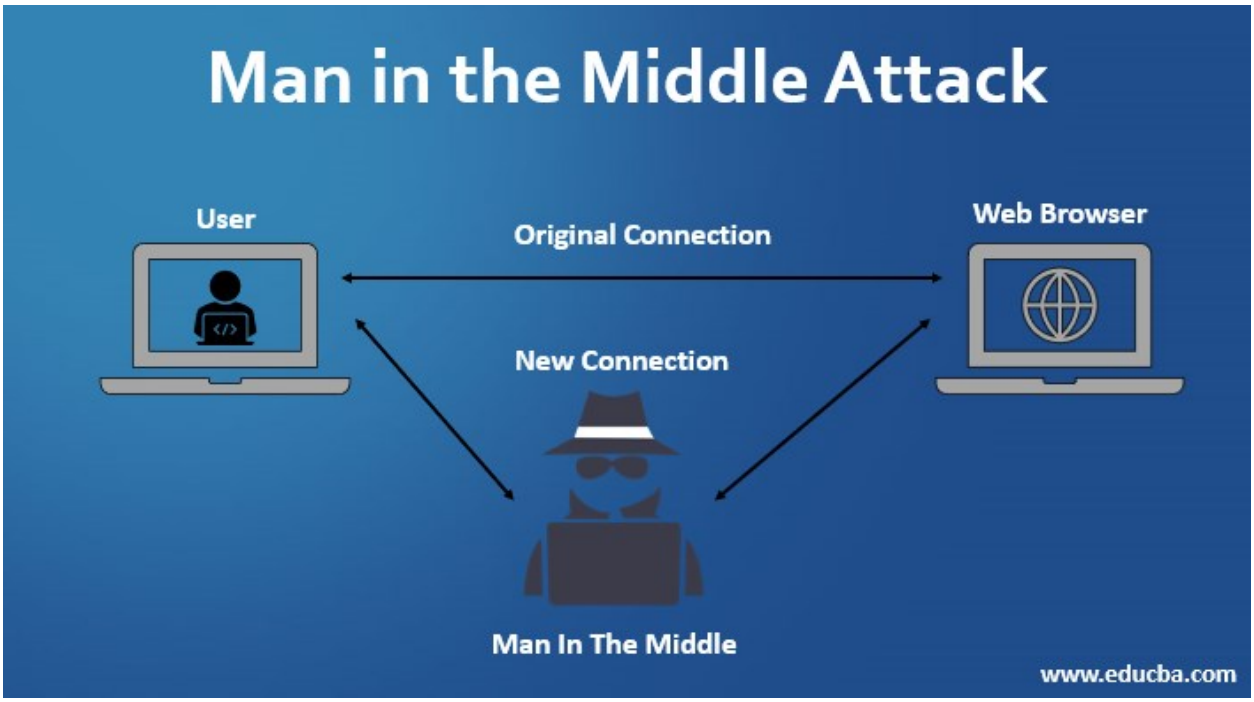


Figure 9 Man in the middle attack

Eavesdrop

This attack can happen during communication over a medium. Attackers use antenna to take the transmitted signal. Communication is only between two devices how attackers can infiltrate to get the information. According to (Ernst Haselsteiner and Klemens Breitfuß, 2015), will explain the question by telling some parameters.

- *RF filed characteristic of the given sender device*
- *Characteristic of the attacker's antenna*
- *Quality of the attacker's receiver*
- *Quality of the attacker's RF signal decoder*
- *Setup of the spot where the attack is carried out*
- *Power sent out by the NFC device*.

But the reader can be based on some thoughts, in order to get a rough idea. Active devices can eavesdrop up to a distance of about 10m, whereas for passive devices this distance is to about 1 m.

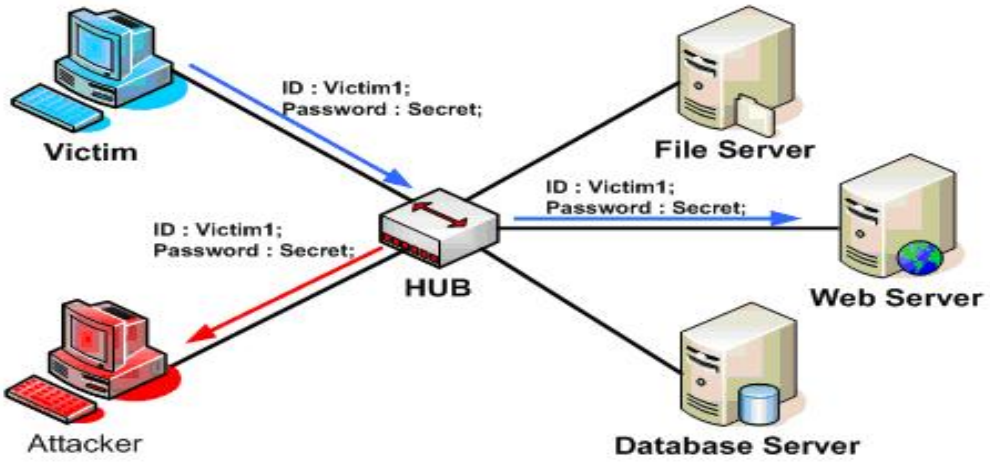


Figure 10 Eavesdrop.

Relay Attack

Attackers use another channel for communication and is an intermediary that tries to increase range. This attacker just needs an antenna to read the range, it does not need any physical access. (Kerschberger, 2011)

Data modification
When your data go to attacker his work is to alter it. The attacker can modify data without knowing the sender or receiver. The complexity of this attack depends on the coding mechanism. (Kerschberger, 2011)

Data Insertion
If you wait long to get the answer from your device at that time attacker can insert messages within the communication. This attack can be successful only if the transmission is finished. (Kerschberger, 2011)

2.2 Navigation System

A navigation system is electronic system that guides in route. Navigation system can be everywhere and communicate via radio or other signals.

According to (Emil Dziadczyk Wojciech Zabierowski,Andrezej Napieralski, 2014) Year 1957 is considered as beginning existences this system. In this year the employees of John Hopkins University in Baltimore (USA) proved that determining of satellites' orbits by their own signals is possible. Opposite task was solved. To take advantage of radio signals transmitted by Soviet satellite Sputnik I proved that Earth's artificial satellites can help in navigations. (Emil Dziadczyk Wojciech Zabierowski,Andrezej Napieralski, 2014)

In 1958-1962 in Applied Physics Laboratory of John Hopkins University it was created the first navigation system called NNSS (Navy Navigation Satellite System). The system comprised of six satellites encompassing the Earth on orbits which are on 1100 km high. This system used two frequencies to transmit signal 150MHz and 400MHz.

Defense Navigation Satellite System (DNSS) supervised by Joint Program Office created by Defense Department of USA. According to (Emil Dziadczyk Wojciech Zabierowski,Andrezej Napieralski, 2014) JPO was formed from all forms of US armies: military, air force, navy, DMA (Defense Mapping Agency) and USNO (United States Naval Observatory). From all this came a combined system called Navstar (for Navigation System with Timing and Ranging) Global Positioning System, or simply GPS. This event began with four phases of GPS system development.

2.2.1 Outdoor navigation system

Before the navigation was used to specify the movement of ships in the sea. But nowadays it is also used for cars, robots, and airplanes. The main goal of navigation is to move from the current location through a route to the destination. Early people utilize natural landmarks and other elements like wind, mountains, moon, and sun to lead while navigation on land or sea. These components helped them to ascertain and decide their development eastwards, westwards, southwards or northwards.

According to (Wilson Sakperea ,Michael Adeyeye-Oshinb,Nhlanhla B.W. Mlitwac, 2017), in the 15th century, Christopher Columbus did his explorations by travelling mainly on sea using celestial elements, and navigation maps and tools. The utilization of maps and graphs which advanced helped people to draw a landmark and to keep the detail record direction. After some time, devices that helped in accomplishing a precise navigation timing were created. According to (Wilson Sakperea ,Michael Adeyeye-Oshinb,Nhlanhla B.W. Mlitwac, 2017) include the hourglass, cross-staff, astrolabe, sextant, quadrant and compass among others.

The most difficult part was the creation of air navigation which brought different challenges. Innovator created apparatuses that made position and navigation faster and secure. Also, these apparatuses include their difficulties. For navigation was incorporate many guesswork which sometimes failure and lost the way. According to (Wilson Sakperea ,Michael Adeyeye-Oshinb,Nhlanhla B.W. Mlitwac, 2017) Christopher Columbus made an error during one of his explorations when he got to the Americas; he thought he had arrived in Asia and named the place the Indies.

Different challenges were for navigation in space, many inventers used orbits satellite to determine the position and navigation. The development of Global Position System (GPS) utilized in many applications involving outdoor position and navigation. According to (Wilson Sakperea ,Michael Adeyeye-Oshinb,Nhlanhla B.W. Mlitwac, 2017) traffic road signs and billboards as conventional means of navigating outdoors, locating a destination, and helping a user understand current position on the route of orientation, the advent of the GPS has transformed navigation into a simplified activity.

GPS is essentially utilized for timing and position of which navigation is a section. Navigation application contains location based services, mobile mapping, mobile robotics, pedestrian navigation and indoor navigation (Wilson Sakperea ,Michael Adeyeye-Oshinb,Nhlanhla B.W. Mlitwac, 2017)

Since the biggest problem in navigation applications was the position determination, the GPS has fulfilled this criterion and is used outdoor due to its accuracy and precision.

2.2.2 GPS system

A satellite navigation system with worldwide inclusion might be named a global navigation satellite system (GNSS). According to (Tiwari, 2015), United States Global Positioning System (GPS) and the Russian GLONASS system are the only operational satellite navigation systems. Europe has started the improvement of a third independent global system, known as 'Galileo.

GPS is a satellite navigation system equipped for giving an exceptionally exact, constant, worldwide navigation service independent of other positioning aids.

The Global Positioning System or GPS has been produced to enable exact situating and route anyplace on or close to the surface of the earth. The US system GPS-NAVSTAR, the Russian GLONASS system is likewise set up and operational. The key estimation included is the season of movement of signals from a specific GPS spacecraft to the navigation receiver. Route correctness of the request of tenth of meters are achievable, and exactness at the centimeter level can likewise be acquired with extraordinary upgrade procedures.

According to (M. Hasan, Khairulmizam Samsudin, Abd Rahman Ramli, Raja Syamsul Azm ir,and Salam A. Ismaeel Department , 2009), structure of GPS system can be part into three sections, Space, Segment - comprised of twenty-four satellites encompassing the Earth on six orbits which are on 20162,61 km high over the equator.

The Global Positioning System Control Section consists of one Master Control Station (MCS) located at Falcon Air Force Base in Colorado Springs, and five other monitors are located worldwide.

User Segment all users are separated to two fundamental gatherings: military users who can utilize two frequencies L1 and L2, and non- military personnel users who can utilize just L1 frequencies. (M. Hasan, Khairulmizam Samsudin, Abd Rahman Ramli, Raja Syamsul Azm ir,and Salam A. Ismaeel Department , 2009)

It was contended that the GPS positioning model is better planned as a linear equation with errors in both the information and estimation factors. There are two new GPS fault detection metrics. The first integrity evaluation statistic is the residual vector norm in the calculation of the total least squares.

According to (Emil Dziadczyk Wojciech Zabierowski,Andrezej Napieralski, 2014) the second metric is a two-dimensional vector that characterizes the norm of the residual vector and mismatch matrix, both of which are the products of the system of total least squares or the optimization method.

In 2006 it was developed a simple model of positioning error estimation and applied on data obtained by measurements; this method only needs position information without satellite constellation.

2.2.3 GPS/INS Integration

Integration of GPS with an inertial Navigation System enhances the quality and integrity of every route, INS can be utilized to enhance the tracking and re-acquisition execution of the GPS recipient. Exist two technique that can be used in GPS/INS system: the feedforward and feedback method

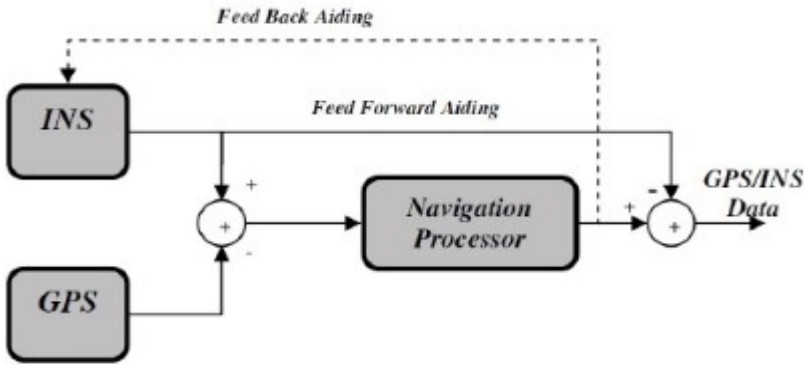


Figure 11 GPS and INS

Likewise, there are two techniques for integration of GPS and INS information in a system, the first is loosely coupled and second tightly coupled. A navigation processor within the GPS receiver calculates location and velocity loosely coupled using only GPS observables.
According to (M. Hasan, Khairulmizam Samsudin, Abd Rahman Ramli, Raja Syamsul Azm ir,and Salam A. Ismaeel Department , 2009), the main specific of this technique is the GPS receiver can be considered as “black box”.

In tightly coupled technique the external navigation filter receives raw GPS measurements of pseudo-range and Doppler or delta-range. According to (Ahmed Hasan,Abd Rahman bin Ramli, Khairulmizam Samsudin,raja syamsul azmir raja abdullah, 2009), the tightly coupled GPS/INS filter benefits from GPS measurement updates even if there are less than four satellites available for a complete GPS navigation solution.

The first GPS was very big and cost a thousand dollars, it also was used only to display the position of receiver in the WGS-84 system. Advancement of microelectronics caused improvement of GPS receiver which has LCD displayers and digital road maps. The most GPS used is car navigation, is built of the GPS system and digital map. Enable to show car position and history of car road. GPS system is everywhere in the land, air and on the sea, it gives an accurate position even if the weather condition is not good. (M. Hasan, Khairulmizam Samsudin, Abd Rahman Ramli, Raja Syamsul Azm ir,and Salam A. Ismaeel Department , 2009)

The system of satellite navigation is advancing all the time and has new uses. The satellite navigation system is integrated into other systems to improve performance.

Many planes use GNSS (Global Navigation Satellite System) which is comprised of all three satellite navigation systems – GPS, GLONASS, and GALILEO. The state of using this system to charge is that all cars will be prepared with the GPS receiver.

GPS is winding up more famous in any branch of our life, it can be very helpful and can easily be integrated into other systems.

GOLONASS System: Network of Golonass gives real time positions and speed information for surface, ocean and airborne articles with a precision of one meter. A group of 28 GLONASS satellites was in orbit as of April 2014, with 24 in operation, three spares, and one in the test-flight phase. According to (Security, 2008) GLONASS satellites has been accomplished primarily by the Polet PO. Conceived and promoted in the early 1970's by the former Soviet Ministry of Defense, and in particular by the Soviet Navy, GLONASS is now the centerpiece of the CIS' Intergovernmental Radio navigation Program, which has close ties with the International Civil Aviation Organization (ICAO) and the International Maritime Organization. (Security, 2008)

According to ((ROB), 2016), the GLONASS constellation was finished in 1995. The system debased with the fall of the Russian economy. Starting 2001, Russia committed to reestablish the system. The finished GLONASS system will require 24 practical satellites. In 2009, 17 satellites are operational and 10 extra satellites ought to be propelled in the period 2009-2010.

GLONASS satellite transmits two codes (C/An and P-code) on two frequencies (L1 and L2 recurrence) permitting again to expel the principal arrange ionospheric mistake from the signs. In GPS each satellite transmits same code, this is not same in Golonass. GLONASS satellites discharge their signal each at various frequencies. The mean frequency for L1 is 1602MHz (between 1597 and 1617MHz) and 1246 MHz for L2 (between 1240 and 1260MHz).These doled out frequencies ought to be changed over the span of the following years. ((ROB), 2016)

To increase the performance of the positioning with Golonass new satellite and signal will be conveyed inside the following couple of years. Specifically, a third carrier frequency, G3 at 1024.704 Mhz with at least two signal modulations, will be given by the GLONASS-K satellite.

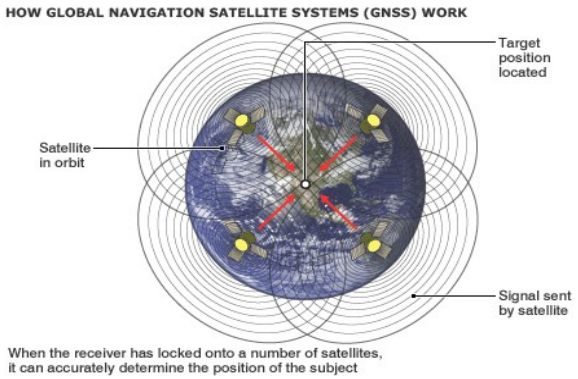


Figure 12 Global Navigation satellite

The Galileo system is a global navigation system known as GNSS in Europe, offering better positioning and timing data with major positive effects for many European services and users. Galileo is interoperable with GPS and Golonass, US and Russian global navigation system. Galileo is set to deliver real-time positioning accuracy down to the meter range and offer dual frequencies as standard.

According to ((ESA), 2017), Galileo system will consist of 24 operational satellites plus six in-orbit spares, positioned in three circular Medium Earth Orbit (MEO) planes at 23 222 km altitude above the Earth, and at an inclination of the orbital planes of 56 degrees to the equator.

Two Galileo Control Centers (GCCs) have been set up on European ground to ensure the control of satellites and the management of navigation missions. The data provided by a global network of Galileo Sensor Stations (GSSs) are sent to the Galileo Control Centers through a redundant communications network. To compute the integrity information and synchronize the time signal of all satellites with the ground station clocks, the GCCs use the data from the Sensor Stations ((ESA), 2017)

The Galileo frequencies will correspond to the GPS/GOLONASS frequencies. E1 (1575.42 Mhz), E5a (1176.45 Mhz) and E5b (1207.14 Mhz); additionally, Galileo will use E6 (1278.75 Mhz) for special services. E1 (1575.42 Mhz), E5a (1176.45 Mhz) and E5b (1207.14 Mhz); additionally, Galileo will use E6 (1278.75 Mhz) for special services. ((ESA), 2017)

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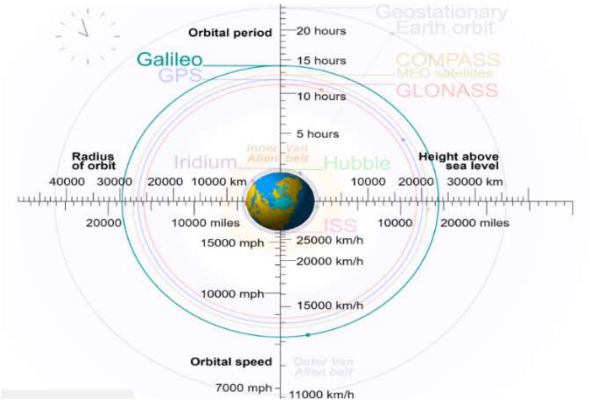


Figure 13 Galileo system

2.2.4 Indoor navigation system

GPS provided accurate service for outdoor navigation system, but more difficult challenge is for indoor navigation. Are created many applications to help the indoor services. According to (Wilson Sakperea ,Michael Adeyeye-Oshinb,Nhlanhla B.W. Mlitwac, 2017) said the ability to locate objects and people indoors remains a substantial challenge, forming the major bottleneck preventing seamless positioning in all environments.

Indoor navigation has been studied for many years using different types of techniques and tools. Indoor navigation system includes a lot of devices which help to provide object location or people inside. Old indoor navigation system contained sensors, which comprise the transmitter and receiver for position and routing. Late navigation system utilizes mobile phone for position and routing.

When we want to move the first need is accelerate, we can track our acceleration over time, at that point we can decide the amount we move (Use accelerometers to measure acceleration). Also keeping track of the direction in which, we accelerate, then we can decide how much we moved in the given direction (Use gyroscopes to measure changes in direction over time). When we know where we started and in what direction we were, then we can set our position, speed and orientation (Use initial conditions) (Frank, 2013)

Robotic mapping: robotic- a device that move through the environment, mapping- modeling the movement. The robot has two source information, the first is the idiothetic and the second is allothetic sources. The idiothetic source can give the absolute position of the robot, in any case, it is liable to total mistake which can develop rapidly. The allothetic source has to do with sensor of robot like a camera, a microphone, laser and lidar. The problem here is the two different places can perceive at the same time. (Robotic mapping, n.d.)

It is simple to localize the robot given a precise model of the environment or to create an exact model if the correct area is known for each perceived sensor estimation, but the problem is very hard because errors in the model and the localization do affect each other.

According to (Wolfram Burgard, Cyrill Stachniss,Kai Arras, Maren Bennewitz , n.d.) The robot mapping problem is called simultaneous localization and mapping (SLAM) problem. SLAM is estimating the robot's pose and the map of the environment at the same time.

SLAM is elementary for many navigation systems. SLAM is hard problem because mapping between observations and landmarks is unknown and picking wrong data associations can have catastrophic consequences. According to (Mapping, n.d.) SLAM problem has mainly been reduced to finding algorithms that compute the most likely model from a sequence of actions and direct sensor observations for an arbitrarily predetermined representation approach.

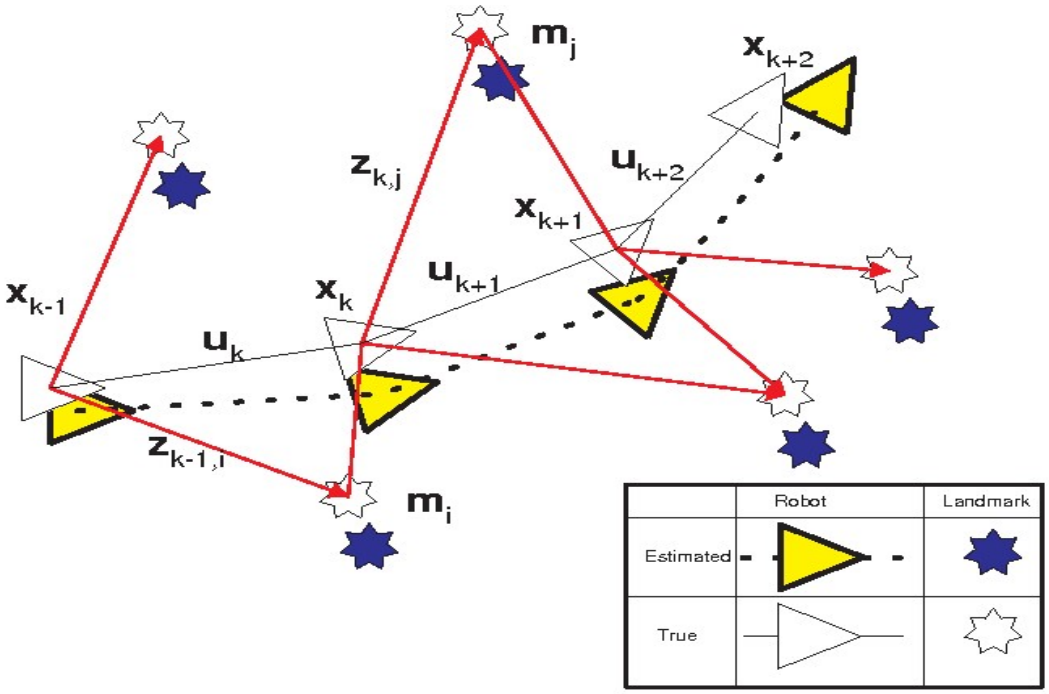


Figure 14 SLAM Problem

Deciding the current location of a client is the most significant and also challenging in indoor environment. If we fail to determine the current location and routing to the destination, then navigating with any equipment will become more difficult. Other technologies which help to classify position in indoor environment are: Radio Frequency, Magnetic Optical, and Audible Sound etc.

2.2.5 Related work

Exist many navigation applications like Google map, Map and Yahoo map which help user to go from one location to another. These applications are not ready to ensure precise routes on Campus. Campus are based on Global Positioning System (GPS). According to (Nikoohemat, 2013) GPS tracking devices are capable of telling the user his/her approximate latitude, longitude, altitude, time and number of satellites seen.

Navigation system helps user to arrive quickly to the destination when in a new territory without any difficulty. There are maps at some points on the campus but the lack of instruction they can't get to the desired destination. They will try to get to the destination using a static map or ask anyone along the way.

According to (Shayan Nikoohemat, 2013) has used GPS device, a keypad and LCD are interfaced to a micro controller, as a micro controller is chosen Arduino Atmega 328P. To show

the current position and destination position they used LCD display. According to (Nikoohemat, 2013)This LCD has two registers, namely, Command and Data. There is register stored command instruction given by LCD. The command given to the LCD to perform an operation can be, initializing, clearing the screen and setting the location. etc. Micro controller is connected with LCD display and GPS.

The map of Velammal Engineering College is drawn as program in micro controller memory and location tracking algorithm, the algorithm should adjust according to different routes. The tracking is done by compression two sources which are current location and destination (user input), the difference between them are known to the controller and help to fine the optimal paths in the campus.

Putting many GPS coordinate will confuse the microcontroller or can lead microcontroller to transpose the place and confuse the user. With our technology we can avoid this problem, because every building in campus will have its own tag contain longitude and latitude coordinates.

User doesn't need to write the destination where to want to go, it can just put the phone near the tag and routing will be shown. NFC technology contain short range operation it difficult to eavesdrop. NFC all the time is increasing the integration on the mobile phone.

Chloe University used Wifi, RFID and CoO for position and created virtual simulation guide. The client utilizes voice command to give direction and through 3D show will be lead to the destination. The accuracy of the localization is restricted to least 5 meters and has consistency for finding the user location. There are many systems in the area of indoor routing and is created from University of Seoul. According to (Shayan Nikoohemat, 2013) discuss 2D-3D hybrid model for indoor routing using a spatial data base management system (SDBMS). Shayan said that using this kind of hybrid model in SDBMS it increases the data flexibility and minimize the computing cost.

Norwegian University of Science and Technology used indoor routing for campus called Campus Guide. User with this application can lead inside and outside the building with the accuracy 5 till 10 meters for indoor navigation this is not good.

Another project is form Steuer which describe 3D indoor routing on reduced visibility graph. Using the visibility graph for routing indoor environment decrease the computational cost using (A*-3D_Buliding) algorithm for optimal path routing.

For indoor routing Goetz and Zipf created a web platform with volunteered geographic information(VGI) and Open Street Map(OSM).According to (Shayan Nikoohemat, 2013) said the system has two parts, on server side it uses PostgreSQL8 database with PostGIS9 extension and on the client side the WMS10 data can be rendered and visualized by any GIS application. Web platform shows floor plans user can select start (level, room) and target (level, room) from

drop down box and compute the route. The point of this system is to use VGI from OSM for indoor routing.

Students from Oregon University developed mapping application. The main goal of this application is browsing map and routing on campus. According to (Lautenschläger, 2012) application is connected to ArcGis server, after defining two place on campus, a route which guides to the destination point. The application only support for outdoor route, so cannot use to go to specific room.

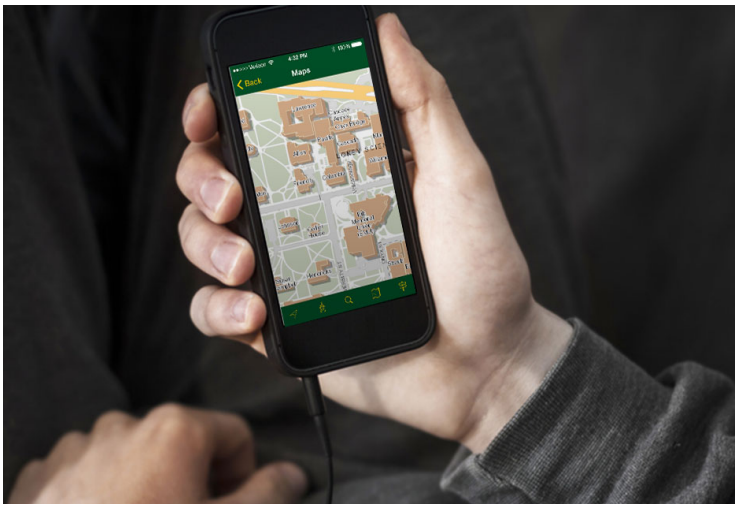


Figure 15 Map in Oregon University

Project glass is Google application. This application allows users to make things which can only be done with a smartphone. The user is enabled to see the context-based information, make video, take picture and get direction to the store or to other locations. The information is shown on a heads-up display. This project is based around a head mounted display in the form of glasses (Lautenschläger, 2012)

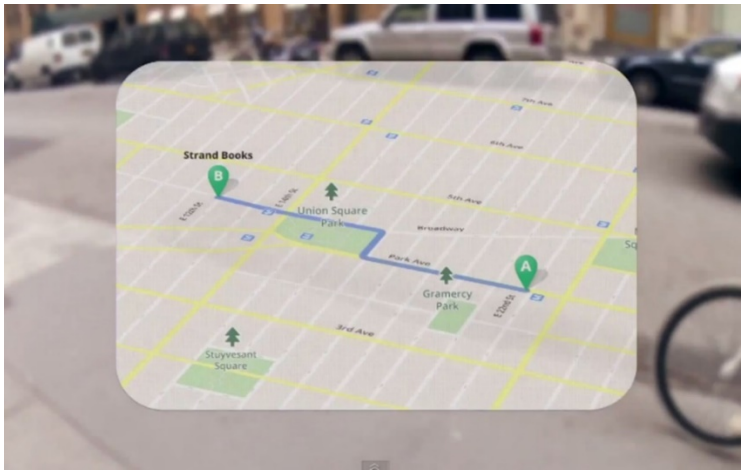


Figure 16 Project Glass map

Another application which is created from Google is Google Maps Indoor android application. Rather than simply demonstrating only outdoor map details, google saw the need to create a floor mapping app as well. This application enables users to pass different floor. Indoor maps application is accessible for probably the greatest retailers in the United States (shopping mall), airport and train stations. Google used radio frequency fingerprint for positioning the accuracy is between 5 to 10 meters.

3. Design and implementation of NFC outdoor system

NFC campus navigation system enable to read data from NFC tag using smartphone and transfer them to the customized application to process in order to guide users in campus environment. Each tag stores the information of its destination. The application displays the route with direction to the desired destination. The number of NFC tags depend on the numbers of building in campus. The application is developed for SEEU campus which can be used only in online mood.

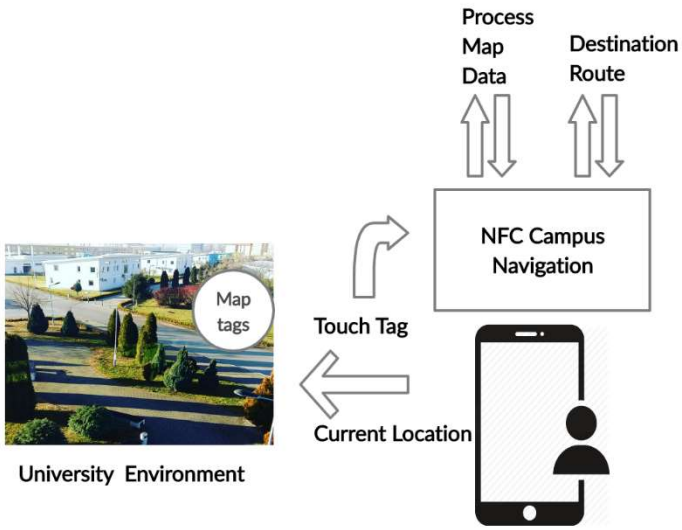


Figure 17 Design of NFC system

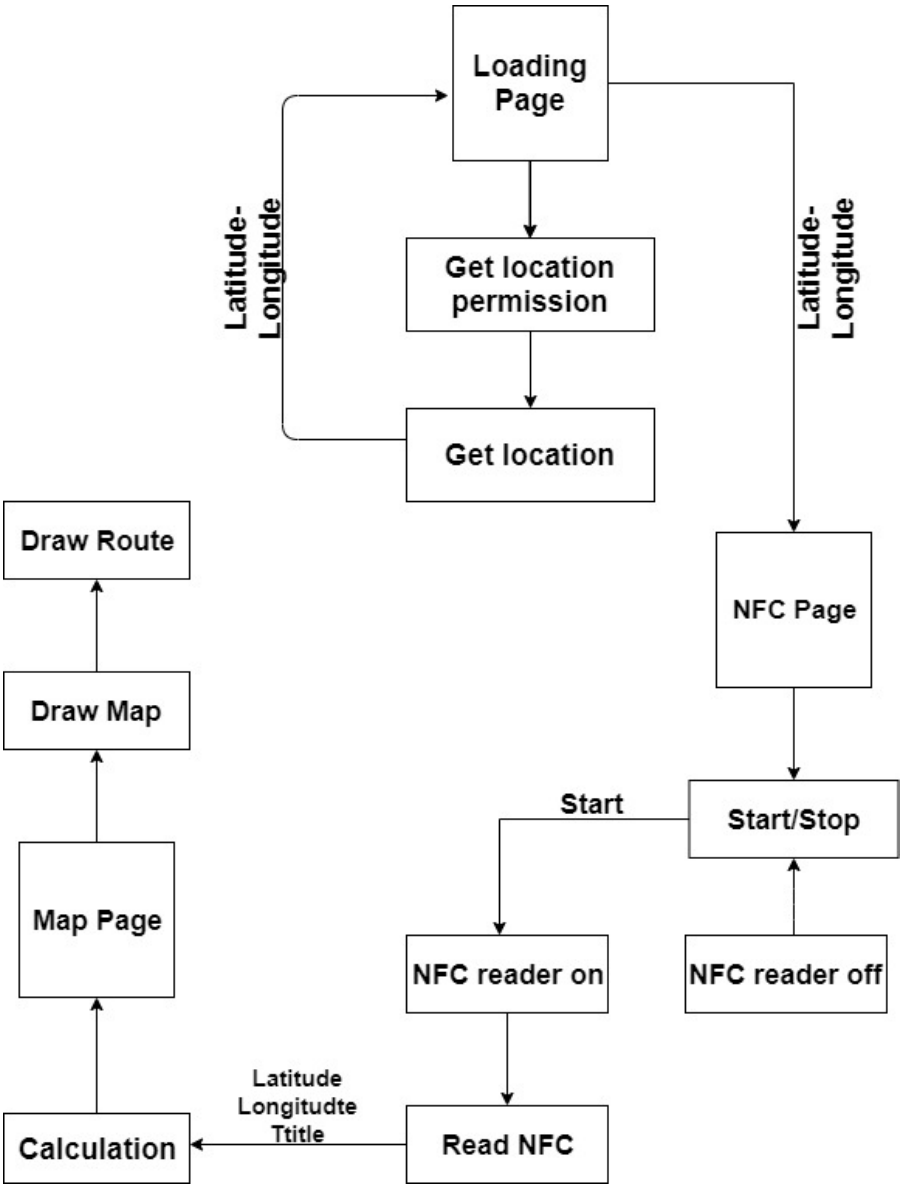


Figure 18 System architecture of Campus Navigation

3.1 System Architecture

The system architecture is shown in figures 18. You can see all the components of system and how they interact with each other. Rectangle represents the pages and arrows the communication.

The navigation system is created on three pages: Loading Page, NFC Page and Map page.

The Loading Page: gets location from users. The application is created in Android. The Android device can decide its location with varying degrees of accuracy by using GPS.GPS is more reliable but needs to be outside and uses more battery. It requires the permission for location with the requestPermission() function. In new version of Android, the permission is divided in 2 protection levels: normal and dangerous.

Dangerous permission impact the user's access to private data, such as location or contact, and enable the user to grant them individually while running the application, not when it is installed.

In the application will appear the dialog to allow or to deny the permission for location. Location variable will get all the information needed to determine the latitude and longitude positions: When gets the latitude and longitude it brings to Loading Page, this information will go to the NFC page.

NFC Page: this page will get the current location information and destination information. It contains options Start/Read for tag. When you click start the NFC reader will be on and start to read the information in NFC tag.

In NFC tag we will write data such as longitude, latitude for each object in Campus. So to write this data we have installed the application called TagWritter . In the TagWritter click new dataset and put information for buildings. So, each object in campus has it own latitude and longitude and each NFC Tags sticker. All this tag will be stitched in Campus Map.

NFC reader on: To read NFC tags just need to turn on the NFC in Android and bring the phone 10 cm from the tag it will automatically read and decode the tag. To turn on the NFC in phone you need to go to:

1. Settings
2. Wireless and Network Section
3. Activate the NFC feature.

Map Page: After reading NFC tag will get data as latitude, longitude, and description. With this information will calculate the distance and it will bring to the Map Page. It will draw map and route.

Map is created in Open street map, which I have drawn the road from the entry to each building. First, I have used point options to name all building in Campus. Each building has its own sign,

example parking has car which means you have to park the car there, restaurant has fork and knife, and also dormitory has its own sign. All road is calculated to go on foot except the road for parking.

Figure 19 SEEU map in open street map

3.1.1 NFC tags for each building and road

To navigate the SEEU campus, needs SEEU information to calculate all accessible paths. Tags are placed in SEEU maps which is located at the entrance of campus. A description for each tag is used to allow easy search destination points, and each tag include location information which

is comprised from a building identifier data. After touching the tag, the NFC application runs automatically, retrieves the data from the tag and processes the map afterwards.

3.1.2 NFC application

NFC application is the smartphone application developed specifically to implement the SEEU campus navigation system.

The application has the following functionalities:

- *Get the current location of the users*- obtaining the location data from GPS
- *Reading the NFC destination tags*- using smartphone with NFC to read the destination tag which are spread on the map.
- *Appearing the road on map*- display the road associated with other information like meters and hours.
- *Information* - description of the object which is the destination tag.

The application is created to be used in Android platform and also in IOS. The programming language is DART and the framework is Flutter, which is a new technology for creating cross platform applications. It is developed by Google and is used to build mobile, desktop, backend and web applications.

3.2 System Implementation

Campus have complex structure. The students that may not have much time and do not wish to spend too much time to find the right object. NFC application is definitely a time and effort saver an especially when any visitors come. The university has the guard which can help but sometimes is difficult to understand.

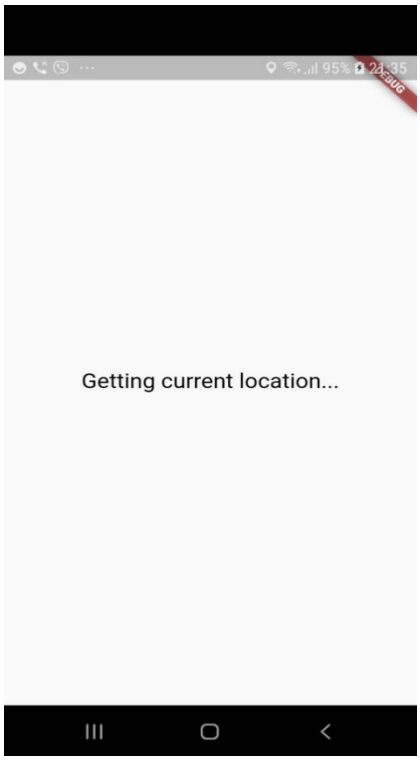
Scenario: The student (users) enters to SEEU and wants to go to Language Center (LH1001)

Figure 20 SEEU map on open street map

The students come from the school entrance stop to the SEEU map and start to activate the NFC on his phone also open the NFC application.

Figure 21 SEEU map on campus

NFC tags sticker will be stick in every building on SEEU campus map. NFC tag will contain information about that object. Campus map needs 42 NFC stickers.



When it opens the NFC application it will appear the text" Getting current location" so application is going to recognize the location where user is. To get the current location users should turn on the location in Smartphone. The application gets the location from GPS.

Figure 22 Reading the Current location of user.

After getting the current location from user. The users should put the phone near the NFC tag sticker. In display it will appear Start reading. The application must read the tag in which we have programed the longitude and latitude for each object in Campus. I have used NFC tool application to write in NFC tag stickers.

Figure 23 Start reading the NFC Tag.

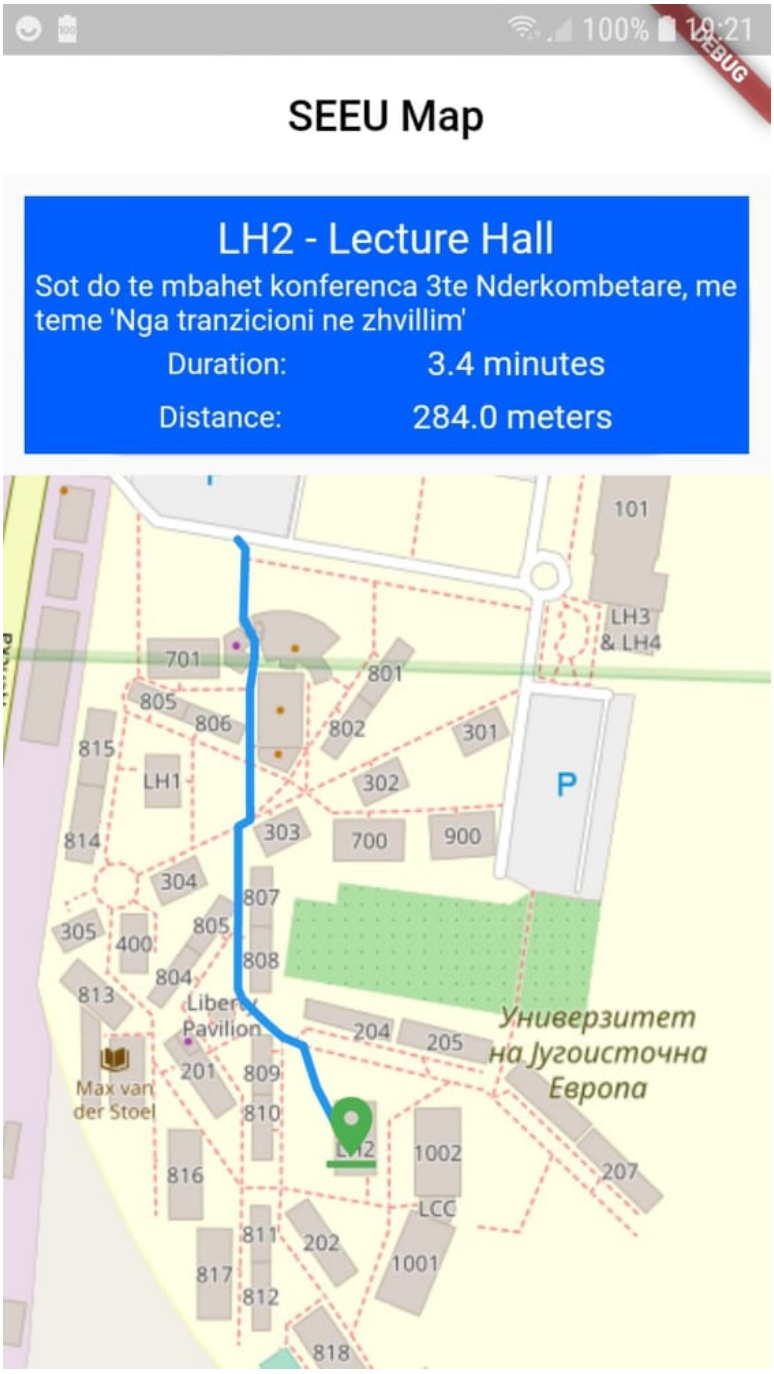


Figure 24 SEEU Map

Then it will open the map page and it will draw the shortest route from current location to destination. The users should follow the blue light to go to the desired destination. Application will appear information for how many minutes you can go, meters and information about the building.

4. Performance Evaluation

This section includes an NFC application performance evaluation and a correlation with other current navigation system. Based on the criteria, we survey the effectiveness of NFC application. Based on the user preferences and experiences, which will give the useful guide to assess the NFC.

Security and Privacy: For users' protection has consistently been a significant concern. The security in navigation system implies keeping the user position private

When a user navigates to a destination, the position of the user is obtained by the passive NFC tags by the Smartphone and processed by the NFC application. Smartphone gives location information to outsider. Nobody can access this personal and sensitive data. When user touches NFC tag on the way, the communication is one way and to the Smartphone only, no data is passed to the tag. The tag does not have any information about the identity of the user.

Cost: Components which need to be prepared for implementation of NFC system are NFC tag, NFC application and smartphone

NFC tag

- **Purchase cost**: One NFC tag costs less than $1. Using 25 tags represents an affordable cost.
- **Installation cost:** Destination tag should be encoded and then placed to the map on campus. The encoding tag is not a time-consuming process, installing all the tags of one NFC system requires only one or two days.
- **Maintenance cost:** Fixing a damaged tag means replacing it, as it is much easier than dealing with troubleshooting problem. NFC tags are passive components don't have batteries so with power supply will not have a problem. Because NFC tags do not wear out as time goes by, they can therefore be used almost indefinitely unless they are harmed or demolished by environmental or human conditions. If mobile cannot read the content NFC tag, e the tag shall be immediately replaced. Destination Tag with an error will cause only a local problem and will not affect the overall system. Maintenance of the NFC system has a small cost.

Smartphone: Users who plan to use NFC system will already have on a mobile phone, with no extra costs as a result.

Compare with other technology: Many navigation systems use different technologies like: RF-based technology and ultrasonic technology. The position of object is determined by calculation of object distance using signal coming from transmitters. According to (Sensors, 2015) signal-based systems invasion of privacy, theft, accessing sensitive information from transmitters, and

corruption of this sensitive information are all challenging issues, when compared with NFC technology.

Each alternative model to NFC Internal involves device ownership and user-friendly maintenance costs. With regard to installation and purchase costs are more expensive, system hardware and installation costs rise when greater performance is anticipated from navigat ion scheme; these systems require additional infrastructure and setup problems to deliver greater performance. In addition, GPS navigation systems are costly and complicated solutions as they also require big infrastructure to support high performance and accuracy for location measurement. The operating cost of UWB-based navigation system is high. Professional engineers, experts are mostly needed to support system operation and provide system maintenance, which implies extra expenses.

According to (Sensors, 2015) WLAN technology can provide navigation services with high accuracy for large environments, however UWB can only provide highly accurate position estimations for small areas. In the case of active RFID for navigation systems, the signal strength sometimes drops between the tag and the antenna, hence the accuracy level depends on the proper placement of readers in the indoor environment. None of the current alternatives deliver 100% location accuracy awareness compared to NFC.

Strength and fault tolerance: NFC system is so vigorous since the perusing lifetime of a passive NFC tag is about boundless, and the likelihood that it'll breakdown amid its lifetime is irrelevant as well. In a tag occurs fault, the in general system keeps up its performance since the fault in one tag does not influence the remaining system in any way. I conclude that the system is tolerant to faults.

Compare with other technology: The strength of navigation is influenced by a few components (metal, florescent lights, sunlight, noise), restricted battery control and reflection of signals from obstacles, which moreover diminish the exactness and execution level of the system. According to (Sensors, 2015) signal strength in WLAN navigation technologies are also highly affected by various elements such as overlapping of access points, movement and orientation of the human body, walls, doors and so on. Inside the instance of NFC innovation, the endless lifetime of the tags and low probability of an issue in a tag augments the quality of the system.

Complicity: Viewpoints of the complexity for navigation system are the human intercession, efforts for the arrangement and upkeep of the navigation system, and specified computing and processing time of the device carried by the client to decide his/her position. For installing the system components like Destination tag, human intercession during the deployment of NFC system is very high, but to maintain the system is very low.

The user will not lose time using the system because the processing time for each action as position and calculating routes is very low and can be measured in milliseconds. Complexity of the NFC system is average.

Compared with other technologies: Other system required more effort to install the system components (sensors, receiver, and reader) and also need better planning, because they need to be placed properly. Particularly for sensors, IR, ultrasound, WLAN, and RFID innovations, as the scope region increments, the complexity gets to be an important concern. According to (Sensors, 2015) in terms of the second aspect, lower computing time and higher processing capability are always desirable for any navigation solution; the limited battery power of positioned devices and their processing capabilities need to be addressed.

Restrictions: NFC system does have a few confinements. To begin with of all, a client who points to utilize the system must have an NFC-equipped. I do not feel this to be a necessity, as the appropriate levels of NFCs in smartphones is very high and is still growing. Real time positioning cannot be given in NFC system. The DR method is utilized by NFC to calculate the location when the client is moving between Destination Tags, and fixed situating will be performed quickly after the client touches to the next tag.

Compared with other technologies: Other indoor navigation system has different restriction in terms of security, performance, cost, complexity and strength. Between a precision and cost systems with high performance also have higher cost. Consequently, a desirable and reliable solution will be highly appreciated.

4.1 Evaluation methodology

Method that I used in my research is questionnaire, the purpose of this questionnaire was the reason to improve the effectiveness of the application. There were 9 questions which was created to fit our topic and were 11 respondents. The data gained from the questionnaire was not for statistical purposes however, for application refinement purposes. Responses were classified agree and disagree. These are student from our campus who answered.
The questionnaire was created by Google forms. The answers of student are below.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Person1	SA	N	N	A	SA	A	A	N	N
Person2	A	SD	N	D	SA	A	SA	SA	A
Person3	N	D	A	N	A	N	SD	A	N
Person4	SA	SD	A	A	SA	N	SA	SA	A

Person5	N	D	A	A	SA	D	SD	A	A
Person6	SA	SD	A	A	SA	N	A	SA	N
Person7	SA	D	D	A	SA	D	SA	A	A
Person8	A	D	N	SA	SA	A	SA	SA	SA
Person9	A	SD	D	A	SA	A	SD	A	A
Person10	SA	D	N	A	A	SD	N	A	A

Table 1 Collected answers from conducted survey.

There were 54.5% who said there is trouble to find building and classroom in campus, for students who goes from the first time in SEEU has very difficult to find classes and for students who are part time, also for visitors. Many of students take some time to explore the campus and find out where each class will be before the semester begins. You will be able to find every class using this application and get to them all on time, without even having to wake up super early.

36.4% were agree that speed of system is enough. Speed is one of the most important factors in system. The percentage 36.4% were satisfied with the speed because the system is simple, if the system will be more complex, they will not be gratified.

81.8% said the application minimized time to go to the destination. This is the main purpose of thesis, to create system for smartphone to help users to find the object in shortest way. Application enables users to easily find location with minimal effort for this reason there is large number of students which are agreed and satisfied with this method.

45.5% said the application do not need to have more buttons. For our users, I simply wanted to solve a problem. Target group to use the application are also the visitor of older generations who have lack information about technology, if I put more buttons or options for them will be complicated.

45.5% response impression of the application prototype is very positive. The application is getting accuracy current locations, is ease of use, the data are protected and contains all necessary details.

Complexity is missing in questionnaire because is directly related to the cost. When complexity of system increases the cost will also increase.
The evaluation metric used include cost, security, awareness, real time and easy to use. The usability of system is determined by privacy and real time.

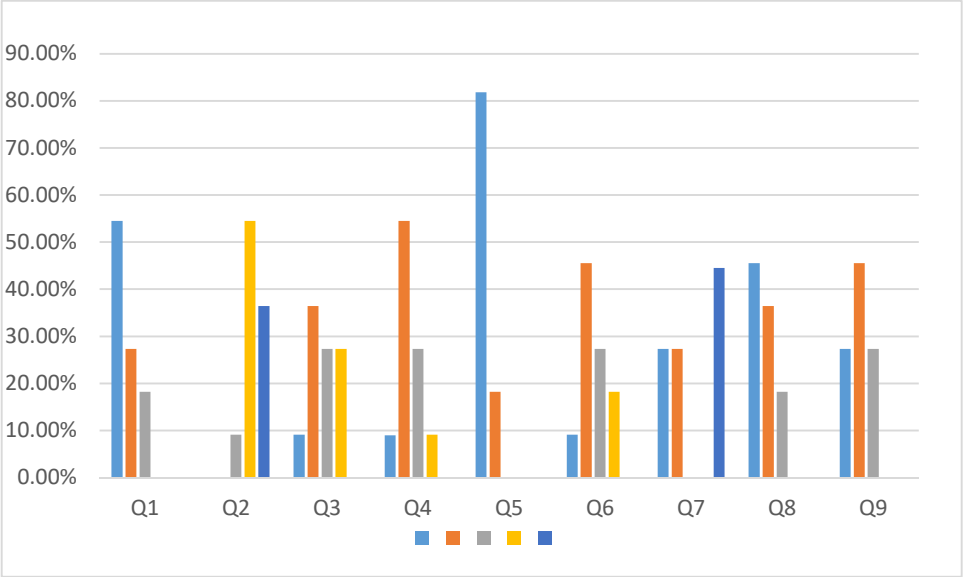


Figure 25 Survey responses charts

4.2 Evaluation Findings

During the implementation of NFC system, we measured the system performance based on the parameters which we talked above.
System evaluation and implementation was based on this metrics accuracy, privacy, cost, and usability is introduced in questionnaire. NFC system is feasible compared with other technologies.
Table below show the findings based on the parameters.

Parameters	Findings
Accuracy	Destination tags are spread around the maps located in campus. When user touches NFC tag can go to the destination without worry. The main parameter in our system is accuracy. The accuracy location is 100%, because when user touches a tag, the exact location is retrieved directly.
Security and privacy	During the tests, user demonstrated that they have a sense of safety while contacting the NFC tags and the protection of their delicate data is exceptionally guaranteed.

Cost	The prototype has just the organization cost. There is no cost for using map in open street map (OSM), location data is encoded in NFC tag, NFC tag price for 20 tags was 15$.
Precision location	The location data are encoded in NFC tags. The correct location is retrieved from NFC application after touching a tag. The exactness of location in our system is 100%.
Strength and fault tolerance	During the test I purposefully harmed the tags just to see the fault tolerance of system. The harmed tag cannot get the location. I touched the nearest tag after the damaged tag, it started to navigate without any problem. The system fault tolerance is 100%.
Complexity	Processing time for deciding the position relies on the time required for getting information from the NFC tag and preparing it on the Smartphone. Testing the prototype, the reading speed from NFC and time that needed to process data in smartphone is less than 0.5s.

Table 2 Findings based on parameters.

4.3 Review Hypothesis

H1: ***The application of NFC technology will positively affect for improving the service information, with specific focus on campus navigation***.

SEEU University campus has complex infrastructure. Particularly new student and individuals who are on it for the first time have difficult to orientate themselves and discover places. The

campus has many buildings some are connected to each other's and some are far. There are some points of static map, but when user start to walk, they don't have help anymore. The navigation system in NFC application help user to know the campus and is easy to use.

- NFC application will help newcomers to colleague, students and faculty it will decrease time to go the destination. It will serve as a useful informative navigate.
- The NFC application contain all necessary details, is easy and accurate navigation, recognizable of different buildings will help users to go to destination without trouble.
- The NFC application make campus to operate in smart way for navigation.
- The NFC application improve the university experience for new students.
- The NFC application reduce the time your staff spends giving directions.

There is also opportunities with NFC technology to give information about any conference, where it will be held and sent to there, this will effect positively to visitors which will not lose time and effort to find the building where the conference will be held.

H2: Users will avoid delays in finding location.

The navigation system gives variety of useful information to the users. Nowadays the most important and most frustrating challenge of technology users are the delays. Performance of a device or application focuses on managing and eliminating delays. With particular emphasis on searching for or finding a specific location should be as quick and easy as possible. NFC as an application constitutes these two key components for users, efficiency and easy way of use.

Using NFC offers some very important facilities for the users. They are speed of use which means sending and receiving information immediately; is versatile - including locating; is a smart application that makes quick reading of requests from users.

The speed of communication plays a very big role. Using NFC ensures that all technical factors are coordinated with one another. Processes related to the NFC location component are well interconnected and usually have no problems during operation, thus saving users' time. It is also worth noting that the accuracy of information transfer is another factor that affects users' time saving. Rapid exchange of information is a successful achievement, for users this is the primary requirement.

H3: NFC tag facilitates navigation in complex campus.

All NFC tag which are spread on static map in campus contain information about the building. The main factor in NFC technology are tags, without NFC tag we could not make anything. The

number of these tags depends on the complexity of the building. Each tag contain data in NDEF message format.

NFC tags are passive component if tag is damaged it will not affect our navigation system. When your mobile read the information from destination tag and perform correctly, so tag is not damaged.
NFC tags are cheap compare with other technologies because they don't contain batteries. Users use mobile phone to read the tags. There is no maintained for the tags. The main factor for developing any solution is cost.
NFC tag are cheap, fast and accurate which enable out system to be accurate and fast on processing data.

H4: Trusted location data has positive impact on users, to assure their current location.

Protection has consistently been a significant worry for the users. NFC technology is collection and usage the sensitive and private data. According to (Vedat Cosgun, Kerem Ok, Busra Ozdenizci, 2015) in way to achieve the trust of user there is a clear need for effective tools that support users to protect their privacy.

According to (James B. D. Joshi,Mohd Anwar,Amirreza Masoumzadeh, 2013) mobile users will be happy to let safety related location-based services know their location details, they might be reluctant to provide personal information to other third-party services. Location data may fall under the control of somebody with noxious aims and spot clients in hazardous circumstances.

Security in navigation system includes keeping the client's position private. User location data is received from mobile phone location and processed by NFC application. Mobile phone gives location data to an outsider no one can have access on this private and sensitive information. When user touches NFC tag the communication is one way to the mobile phone, so no data cross to the tag.

The users are convinced this application will not abuse their personal data and privacy. The position of user is very accurate compare with other technologies because the tags are stationary. The position of user is done on mobile phone not on the server, this enables to grow the speed and improve the performance.

5. Conclusion

In this paper I presented navigation campus based on NFC, which is most reliable and innovative solution. The NFC enable to transfer data through smartphone by touching NFC tags spread on maps in campus. NFC system include Destination tag and NFC application installed on smartphone.
My paper contains the system design, how to use and development of prototype to study the viability of NFC system in SEEU campus, and to conclude based on the performance evaluation. The system is evaluated based on this criteria accuracy, cost, security, awareness and fault tolerance and user preference.

The advantages of NFC technology:

- Provide secure and private navigation (no personal data can be retrieved from the phone)
- NFC system has effective cost, which are explained in evaluation performance.
- Provide the accurate position of users.
- The lifetime of NFC tags is unlimited, even if the tag is harmed it will not affect the whole system.
- Remove the requirement for a server to orient position.
- The time to transfer data from tag to smartphone and to generate in application is minimized.

The proposed model has few constraints. The first and most important is the need to be always connected with Wi-Fi. The second is the phone should contain NFC. But in general, the system is very simple to use, not expensive, secure and has many advantages to use.

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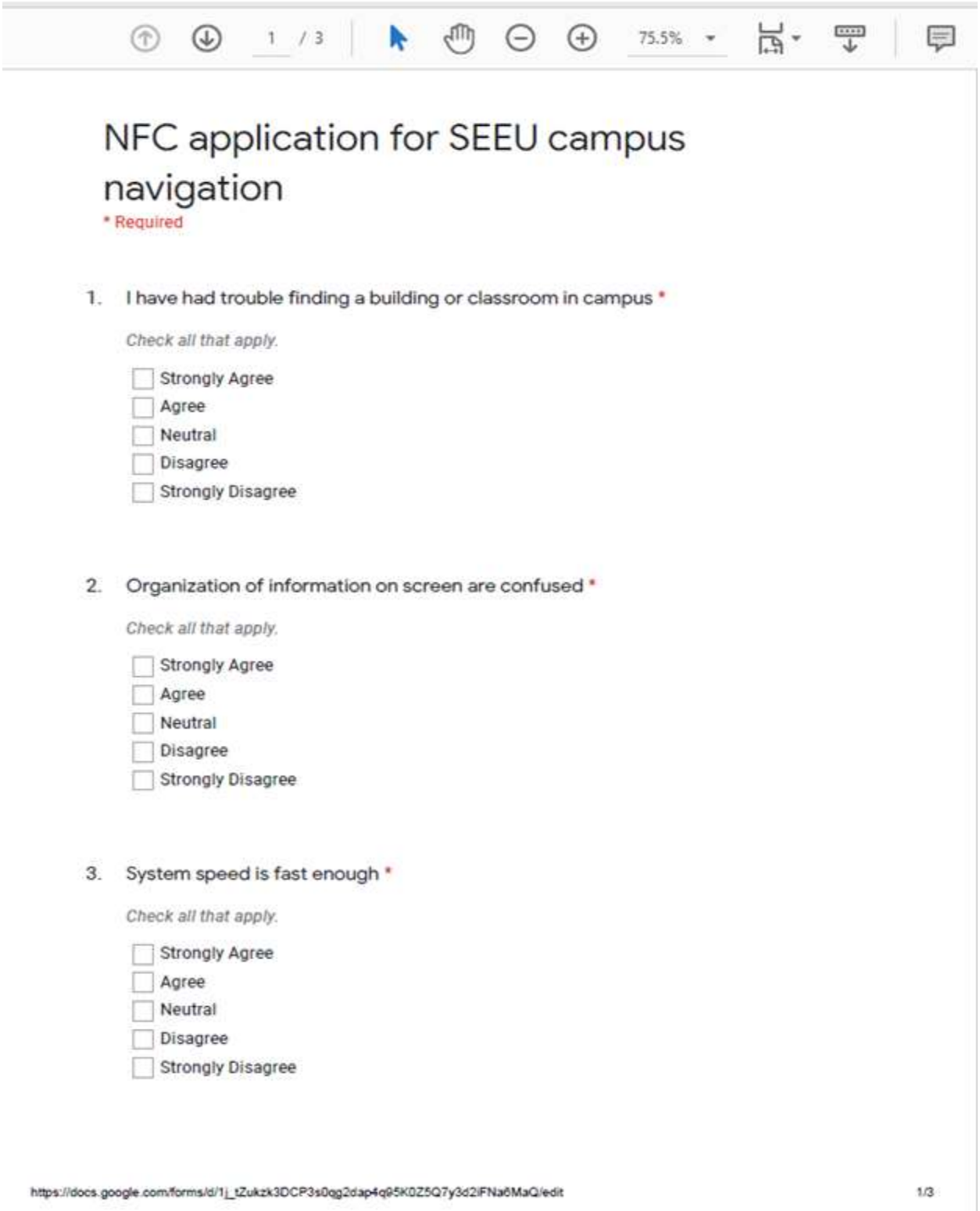
Appendix

Survey



1 / 3 75.5%

NFC application for SEEU campus navigation

* Required

1. I have had trouble finding a building or classroom in campus *

Check all that apply.

- [ ] Strongly Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Strongly Disagree

2. Organization of information on screen are confused *

Check all that apply.

- [ ] Strongly Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Strongly Disagree

3. System speed is fast enough *

Check all that apply.

- [ ] Strongly Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Strongly Disagree

https://docs.google.com/forms/d/1j_tZukzk3DCP3s0qg2dap4q95K0Z5Q7y3d2iFNa6MaQ/edit 1/3

4. The application has a clear interface *

Check all that apply.

- [ ] Strongly Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Strongly Disagree

5. The application minimized time to go the destination *

Check all that apply.

- [ ] Strongly Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Strongly Disagree

6. I found the application prototype to be easy to use. *

Check all that apply.

- [ ] Strongly Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Strongly Disagree

7. The application needs to have more buttons *

Check all that apply.

- [ ] Strongly Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Strongly Disagree

8. The application give an easy-to-follow direction *

Check all that apply.

- [ ] Strongly Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Strongly Disagree

9. My overall impression of the application prototype is very positive *

Check all that apply.

- [ ] Stronlgy Agree
- [ ] Agree
- [ ] Neutral
- [ ] Disagree
- [ ] Strongly Disagree

Implementation Code

Loading Page

```
// Platform messages are asynchronous, so we initialize in an async method.
initPlatformState() async {
  await _locationService.changeSettings(accuracy: LocationAccuracy.HIGH, interval: 1000);

  LocationData location;
  // Platform messages may fail, so we use a try/catch PlatformException.
  try {
    bool serviceStatus = await _locationService.serviceEnabled();
    print("Service status: $serviceStatus");
    if (serviceStatus) {
      _permission = await _locationService.requestPermission();
      print("Permission: $_permission");

      if (_permission) {
        location = await _locationService.getLocation();

        _locationSubscription = _locationService.onLocationChanged().listen((LocationData result) async {

          if(mounted){
            setState(() {
              _currentLocation = result;
            });
            _locationSubscription.cancel();
            Timer.run(
                () => Navigator.push(
              context,
              ScaleRoute(
                widget: NFCPage(
                  position: LatLng(result.latitude, result.longitude),
                ),
              ),
            ),
          ),
        );
```

NFC Page

```
class NFCPage extends StatefulWidget {
  LatLng position;

  NFCPage({this.position});

  @override
  _NFCPageState createState() => _NFCPageState();
}

class _NFCPageState extends State<NFCPage> {
  bool _supportsNFC = true;
  bool _reading = false;
  StreamSubscription<NDEFMessage> _stream;
  LatLng _position;

  @override
  void initState() {
    super.initState();
    // Check if the device supports NFC reading
    _position = widget.position;
  }

  @override
  Widget build(BuildContext context) {
    if (!_supportsNFC) {
      return RaisedButton(
        child: const Text("You device does not support NFC", style: TextStyle(color: Colors.black, fontSize: 20.0)),
        onPressed: null,
      );
    }
```

```
return RaisedButton(
    child: Text(_reading ? "Stop reading" : "Start reading", style: TextStyle(color: Colors.black, fontSize: 20.0)),
    onPressed: () {
      if (_reading) {
        _stream?.cancel();
        setState(() {
          _reading = false;
        });
      } else {
        setState(() {
          _reading = true;

          //Start reading using NFC.readNDEF()
          _stream = NFC.readNDEF(
            once: true,
            throwOnUserCancel: false,
          ).listen((NDEFMessage message) {

            String payload = message.payload;
            final payloadDecoded = JSON.jsonDecode(payload);

            print(payloadDecoded);

            Timer.run(
                () => Navigator.push(
              context,
              ScaleRoute(
                widget: MapPage(
                  currentLocation: _position,
                  destination: LatLng(payloadDecoded['lat'], payloadDecoded['lng']),
                    title: payloadDecoded['title'],
                    description: payloadDecoded['description']
                ),
              ),
            ),
```

Map Page

```
@override
void initState() {
  super.initState();
  _route = [];
  _currentSource = _MapSource.OSM;
  _currentLocation = widget.currentLocation;
  _destination = widget.destination;
  _title = widget.title;
  _description = widget.description;
  setState(() {
    _from =
        buildMarker(_currentLocation, Icons.pin_drop, Colors.purple, 40.0);
    _to = buildMarker(_destination, Icons.pin_drop, Colors.green, 40.0);
  });
  _mapController = new MapController();
//    StreamSubscription<LocationData> sub =
//        Location().onLocationChanged().listen((data) {});
//
//    sub.onData((LocationData pos) {
//      LatLng user = new LatLng(pos.latitude, pos.longitude);
//
//      setState(() {
//        _user = buildMarker(user, Icons.person_pin_circle, Colors.blueAccent);
//        _mapController.move(user, 18.0);
//        sub.cancel();
//      });
//    });
```

```
void loadRoute() {
  if (_to == null || _from == null) {
    return;
  }
  LatLng from = _from.point;
  LatLng to = _to.point;
  String fromStr = '${from.longitude.toString()},${from.latitude.toString()}';
  String toStr = '${to.longitude.toString()},${to.latitude.toString()}';
  String coords = '$fromStr|$toStr';

  print("From: $from");
  print("To: $to");

  _scaffoldKey.currentState.showSnackBar(new SnackBar(
    content: Text('Route calculation, please wait...'),
  ));
  OSMAPIService.getInstance().request('GET', '/directions', params: {
    'profile': 'foot-walking',
    'geometry_format': 'polyline',
    'coordinates': coords,
  }).then((data) {
    if (data != null &&
        !data['routes'].isEmpty &&
        !data['routes'][0]['geometry'].isEmpty) {
      print(data);
```