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D2D Coupon Dissemination

Bachelor's Thesis (9 ECTS)

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D2D Coupon Dissemination

Abstract:

With the growing popularity of smartphones, companies are seeking for new ways of marketing. One way has been promoting products by offering discount coupons through applications specifically designed for that. Applications offering coupons have reached millions of downloads. Yet, no application has been created, which gives discount codes only when sharing the offer from device to device (D2D) or when getting shared from device to device. This kind of application would rely on a peer-to-peer (P2P) data sharing. Therefore a prototype application will be developed, implementing Bluetooth, Wi-Fi Direct and Near Field Communication (NFC) to test the usabilty and performance of these methods by conducting experiments. According to the results, NFC was the quickest and easiest for sharing coupons, but only 7% of experiment participants had used it before and only 17% had it enabled as it is a relatively new technology. At the same time, Wi-Fi Direct and Bluetooth were no match to NFC regarding the total sharing time of one coupon. These results show that no single technology should be favoured and the most reasonable approach would be not to remove any of the three sharing methods from the application, but let the user decide which on to use.

Keywords:

Mobile, Android, P2P, D2D

P170: Computer science, numerical analysis, systems, control

Seadmelt seadmele kupongide levitamine

Lühikokkuvõte:

Nutitelefonide järjest kasvava populaarsuse tõttu otsivad ettevõtted üha uusi võimalusi, kuidas seda turundamiseks ära kasutada. Üheks populaarsemaks viisiks on osutnud allahindluskupongide pakkumine toodetele selleks spetsiaalselt loodud rakenduste kaudu. Seda tüüpi rakendused on kogunud miljoneid allalaadimisi. Sellegipoolest, pole seni loodud rakendust, mis toimib põhimõttel, et allahindluskoodi saab ainult juhul, kui kasutaja jagab pakkumist seadmelt seadmele või jagatakse pakkumist temaga. Sellist tüüpi rakendus põhineks partnervõrgus (P2P) andmete edasmisel. Seetõttu arendatakse prototüüp, kuhu implementeeritakse Wi-Fi Direct, Bluetooth ja NFC, et testida nende jõudlust ja kasutmise lihtsust katsetega. Selgus, et kupongide jagamiseks oli kõige lihtsam ja kiirem tehnoloogia NFC, aga ainult ainult 7% katsealustest olid seda varem kasutanud ja vaid 17% olid selle oma telefonis aktiveerinud. Samal ajal kulus Wi-Fi Directi ja Bluetoothiga jagamisega tunduvalt rohkem aega kui NFCga. Need tulemused näitavad, et ükski P2P andmejagamise tehnoloogiatest ei ole universaalselt parim ning kõige mõistlikum oleks lasta kasutajal valida, millist meetodit kasutades ta kuponge jagada soovib.

Võtmesõnad:

Mobiilne, Android, P2P, D2D

P170: Arvutiteadus, arvutusmeetodid, süsteemid, juhtimine

Table of Contents

1 Introduction

Device-to-device (D2D) communication has become an inseparable part of data sharing with the rise of mobile phone usage [1]. 15 years ago people were sharing ringtones by connecting their phones and waiting many minutes for infrared to complete the data transfer. Nowadays we have many different technologies to complete these data transfers in few seconds or even less. But as the number of options grows, it becomes more difficult to choose between them.

1.1 Motivation

In the past decade mobile phones have become the seventh mass media channel [2]. It is estimated that 70% of world's population will be using smartphones by 2020 [1]. This vastly growing market has encouraged thousands of developers to create new applications every day and upload them to Google Play or Apple Store for users to test them out. In 2015 Android was in the lead, having over 80% share of unit shipments, followed by iOS with only under 15% as seen on Figure 2.1 [2].

Of course there are businesses interested in using smartphones for marketing. Mobile applications have been created specifically for that purpose and some have had remarkable success, including applications dedicated to coupons. Unfortunately, most of coupon applications have been targeted to the US market and there are no applications for Estonian market. Therefore, the author decided to create such application for Estonian market to give local businesses the opportunity to offer coupons through an application specifically created for that purpose.

Furthermore, the goal is to create an application which is ultimately based on coupon sharing, so that the users get coupon codes only if they share the coupon or receive the coupon from another user. The key aspect is to make the sharing process as easy and quick as possible.

1.2 Contributions

When developing any application or software in general, developer has to have the knowledge about which technologies to use. The goal of this thesis is to research different P2P data sharing technologies and analyse the performance and usability of these methods by implementing them in a prototype application which will be designed and created as a part of this thesis.

The prototype will be used for testing data sharing process speed. Also, based on the prototype an experiment will be conducted, where participants have to choose between different data sharing technologies and later rate their experience. Results of these experiments will gathered and analysed for future references.

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[1] http://hugin.info/1061/R/1925907/691079.pdf, 12.05.2016

[2] http://www.idc.com/prodserv/smartphone-os-market-share.jsp, 12.05.2016

[3] http://developer.android.com/sdk/index.html, 12.05.2016

1.3 Outline

Chapter 2: describes similar application which are publicly available at Google Play Store and the platforms that will be used for developing the prototype. It also takes a closer look at data sharing technologies that will be used in application to share coupons.

Chapter 3: describes the research question that this thesis focuses on.

Chapter 4: describes in detail the structure of the prototype as well as how different P2P technologies were implemented in the application

Chapter 5: presents the data gathered by executing the experiments and analyses the feedback gathered from participants

Chapter 6: concludes the thesis with a summary and mentions some possible future directions

2 State of the Art

2.1 Choice of platforms

The prototype application will be developed for Android platform as Android has been the most popular operational system for smartphones for many years now which can be seen on Figure 2.1. The application will be developed using Android SDK (Software Development Kit) which gives all the tools required for developing coupon sharing application in Java programming language. Android Studio is going to be used for this project as it is the official IDE (integrated development environment) for Android and is developed by Google [3].

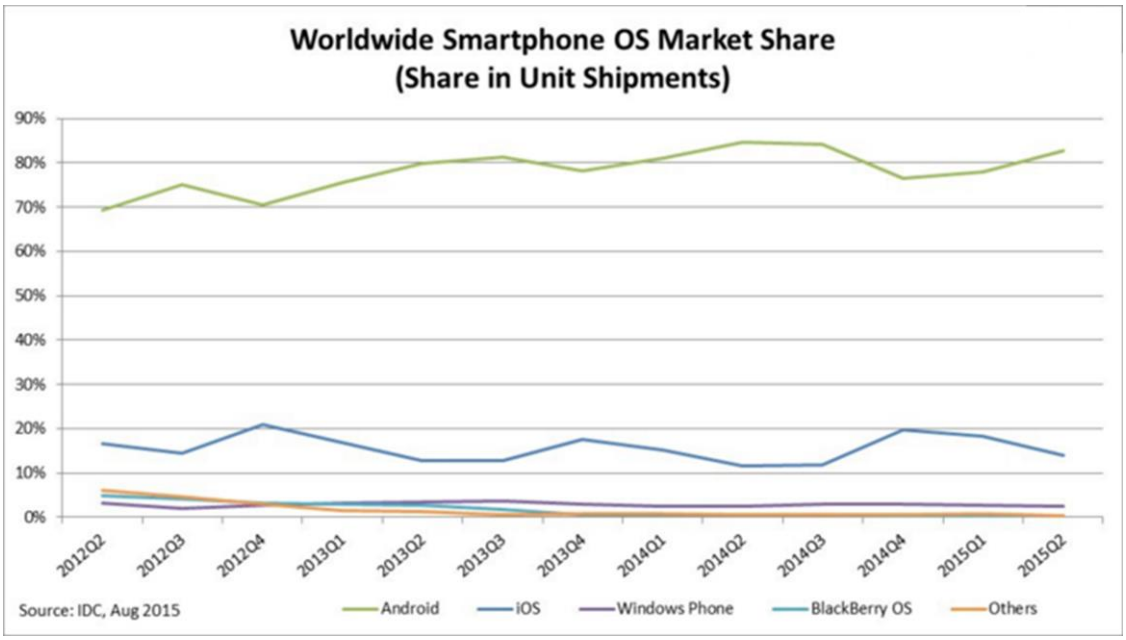

Figure 2.1. Worldwide Smartphone OS Market Share [source[2]]

2.2 Related Works

Many applications in Google Play Store are dedicated to coupons. One of the most popular, with over 10 million installs is The Coupons App. Screenshot of the application can be seen on Figure 2.2 . It has gained such popularity due to its simplicity – no registration is required, user can start scrolling through coupon offers right away [3]. Unfortunately it has no offers targeted to Estonian customers and coupons cannot be shared [4].

Another rather popular coupon application is Anycodes with over 100 000 downloads. Screenshot of the application can be seen on Figure 2.3. Unlike The Coupons App, Anycodes users can also share coupon offers. Coupon offers can be shared using a wide

[3] http://developer.android.com/sdk/index.html, 12.05.2016
[4] https://play.google.com/store/apps/details?id=thecouponsapp.coupon&hl=et, 12.05.2016

variety of methods including peer-to-peer (P2P) technologies like Bluetooth, Wi-Fi Direct and Near Field Communication (NFC). However, only html link of the coupon is being shared and the user, who shares the coupon, gains no benefit from that [5].

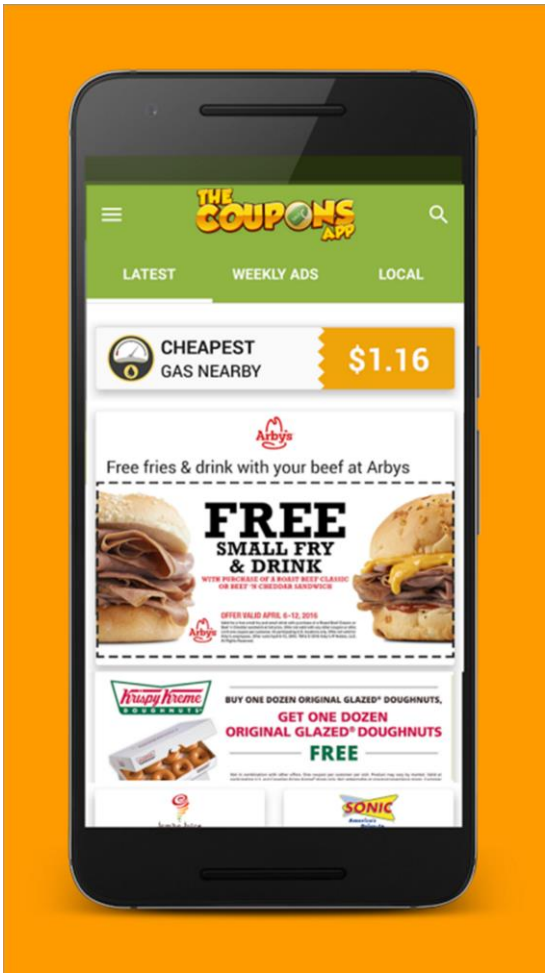

Figure 2.2. The Coupons App [source[4]]

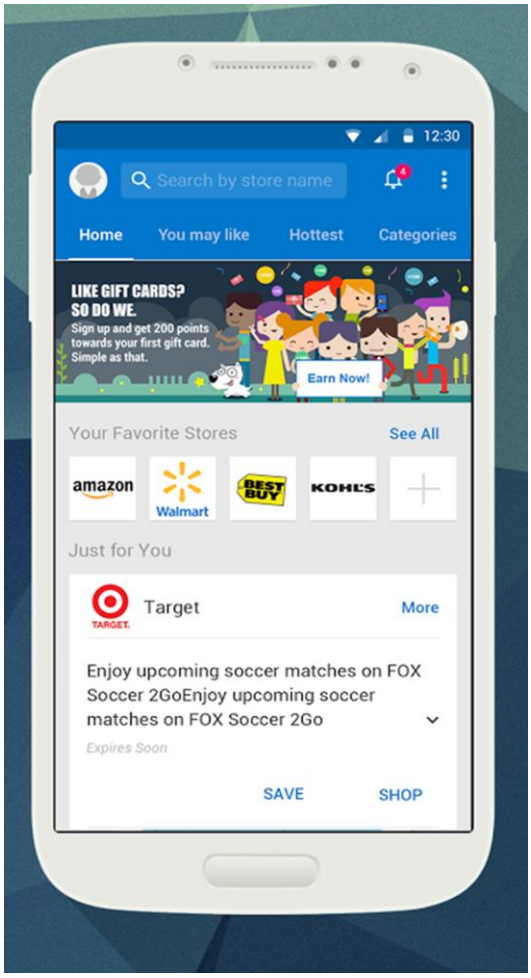

Figure 2.3. Anycodes [source[5]]

2.3 Peer-to-Peer

In P2P network, workload is equally distributed between peers. Opposing to server-client network model, where communication goes through a centralized. Peer-to-peer network's each node can act as a client or server. This kind of decentralization benefits the most in situations where resources are limited as such network consumes less power due to its workload distribution [6].

The nature of P2P makes it ideal to be used by mobile phones. In this document we take a closer look of common wireless peer-to-peer technologies used in smartphones – Bluetooth, Wi-Fi Direct and NFC.

[5] https://play.google.com/store/apps/details?id=com.anycodes&hl=et, 12.05.2016
[6] http://academic.eb.com.ezproxy.utlib.ut.ee/EBchecked/topic/1055404/P2P, 12.05.2016

Bluetooth

Bluetooth was first introduced in 1994 by Swedish mobile manufacturer Ericsson [7]. It provides a way to create wireless networks between devices physically close to each other. Like many other wireless technologies, Bluetooth uses an unlicensed 2.4 gigahertz (GHz) to 2.4835 GHz frequency band [4]. Data transmission is established by using frequency hopping spread spectrum (FHSS). It means that every channel is being used for a short time (usually less than a millisecond) after "hopping" to another channel. This kind of hopping is predetermined by a pseudo-random sequence. FHSS ensures connection stability by reducing transmission errors and interference [5].

Since its launch, Bluetooth has gone through a lot of improvements, latest version being Bluetooth v4.2 which was presented in 2014 [8]. Bluetooth 4.0+, often called Bluetooth low energy (LE), aim is to consume less energy as its name suggests. Therefore it is an ideal form of communication for small monitoring devices [9]. However, as Bluetooth LE is a relatively new technology, many of the older Android devices do not support it.

Wi-Fi Direct

Wi-Fi Direct, also called Wi-Fi peer-to-peer is a Wi-Fi standard which allows devices to directly connect to each other without the need of wireless access point or internet connection [6]. It supports regular Wi-Fi speeds, which could be up to 250 Mbps [10]. One of the advantages of Wi-Fi direct is the fact that the connection can be established over much longer distances compared to Bluetooth [11].

Near Field Communication

First Android NFC device was Samsung Nexus S, released in 2010 [12]. Since then, more and more NFC-enabled handsets have been released, reaching 444 million devices in 2014, it is expected to more than double by the year of 2016 as seen on Figure 2.4 [13].

NFC itself is a set of communication protocols which allow small chunks of data to be shared between two devices, one of which is usually a mobile phone [7]. NFC device, also called as a reader, interrogator or active device works by creating a radio frequency which are picked up by another NFC-enabled device [14]. It is typically required to have a distance of 4 cm or less between devices for initiating NFC connection [15].

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[7] http://www.oxfordreference.com.ezproxy.utlib.ut.ee/view/10.1093/acref/9780199651467.001.0001/acref-9780199651467-e-0034, 12.05.2016

[8] https://www.bluetooth.com/news/pressreleases/2014/12/03/new-bluetoothspecifications-enable-ip-connectivity-deliver-industry-leading-privacy-increased-speed, 12.05.2016

[9] https://www.bluetooth.com/what-is-bluetooth-technology/bluetooth-technology-basics/low-energy, 12.05.2016

[10] http://www.wi-fi.org/knowledge-center/faq/how-fast-is-wi-fi-direct, 12.05.2016

[11] http://developer.android.com/guide/topics/connectivity/wifip2p.html, 12.05.2016

[12] http://www.androidcentral.com/gingerbread-feature-near-field-communication, 12.05.2016

[13] https://technology.ihs.com/533599/nfc-enabled-handset-shipments-to-reach-three-quarters-of-a-billion-in-2015, 12.05.2016

[14] http://www.nearfieldcommunication.org/about-nfc.html, 12.05.2016

[15] http://developer.android.com/guide/topics/connectivity/nfc/index.html, 12.05.2016

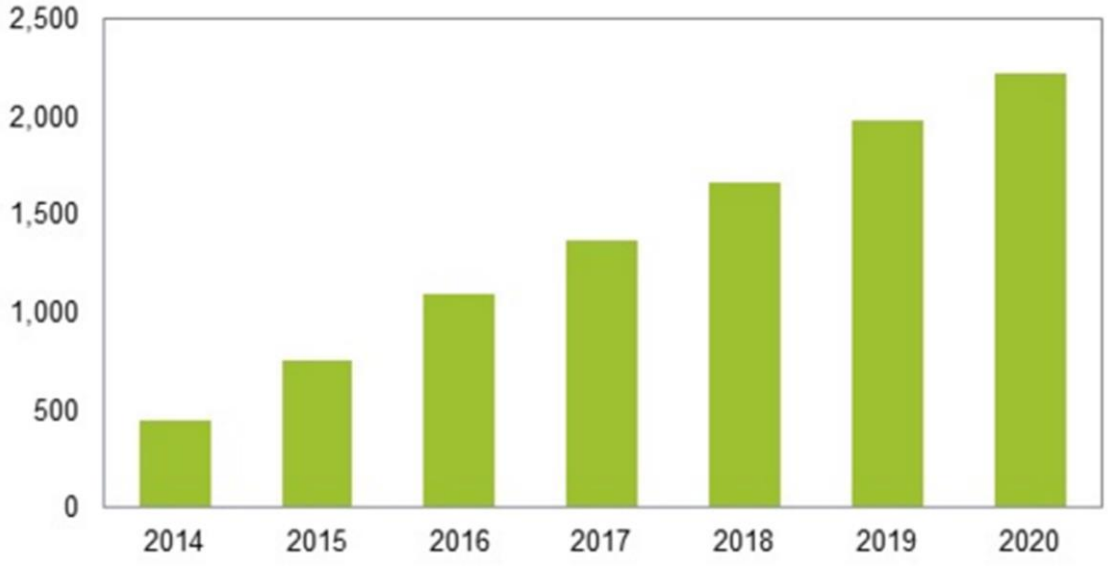

Figure 2.4. World shipment of NFC-enabled cellular handsets (in millions) [source[13]]

2.4 Summary

The prototype will be developed for Android and it will implement 3 major P2P technologies: Wi-Fi, Bluetooth and NFC. In peer-to-peer network, communication does not go through a centralized server like in a regular client-server model. Data is sent directly from peer to peer.

3 Problem Statement

There are currently no coupon applications for Estonian market which are specifically created for distributing coupons. Moreover, there are no applications at all which are entirely built around sharing coupons D2D and giving discount codes to users only when they share or get shared. Creating such application requires implementation of P2P data sharing technology. If some years ago Bluetooth would have been basically the only viable option, then today we have more possibilities [8]. As D2D coupon sharing will be the only way receiving discount codes, choosing one or the other P2P sharing technology will probably be one the most crucial factors which determines whether the application will be successful or not.

3.1 Research question

In order to make the right choice, possible coupon sharing methods must be considered, researched and tested. There are currently three main P2P data sharing technologies – Bluetooth, Wi-Fi Direct and NFC as mentioned before. Choosing one of them without testing all of them first is the easy way, but could be a big mistake if it turns out to be a wrong choice later. This thesis tries to avoid this mistake by creating a prototype beforehand to test out all of the 3 technologies. The aim is to find the most suitable technology for an application which depends on P2P sharing.

3.2 Summary

It is always useful to research and test different technologies which could be used in the project before developing any application. Creating a prototype for testing those methods out is always a good idea. This thesis attempts to find the best P2P technology for a coupon sharing application. A prototype application as well as experiments will be created to accomplish that goal.

4 Implementation

In order to carry out P2P experiments and to demonstrate P2P capabilities, a prototype coupon sharing application is designed and developed. It involves implementing Bluetooth, Wi-Fi Direct and NFC technologies to share coupons from device to device. The application is stored in a GitHub repository [16].

4.1 Application structure

The structure of the application is described by a sequence diagram as seen on Figure 4.1. As the application is prototype for a coupon sharing application, Google Maps application programming interface (API) was also implemented to add map to the coupon details page with the location of the coupon. Furthermore, Google API was also used to add geofences to coupon locations. This means that the user will get a notification by the application every time they get close to a place which offers coupons.

Coupon objects are converted into JavaScript Object Notation (JSON) and then stored to a SQLite database as JSON objects. When receiving JSON objects from database, they are converted back to coupon objects. The database used by the application is local, but can easily be connected to an online database [9].

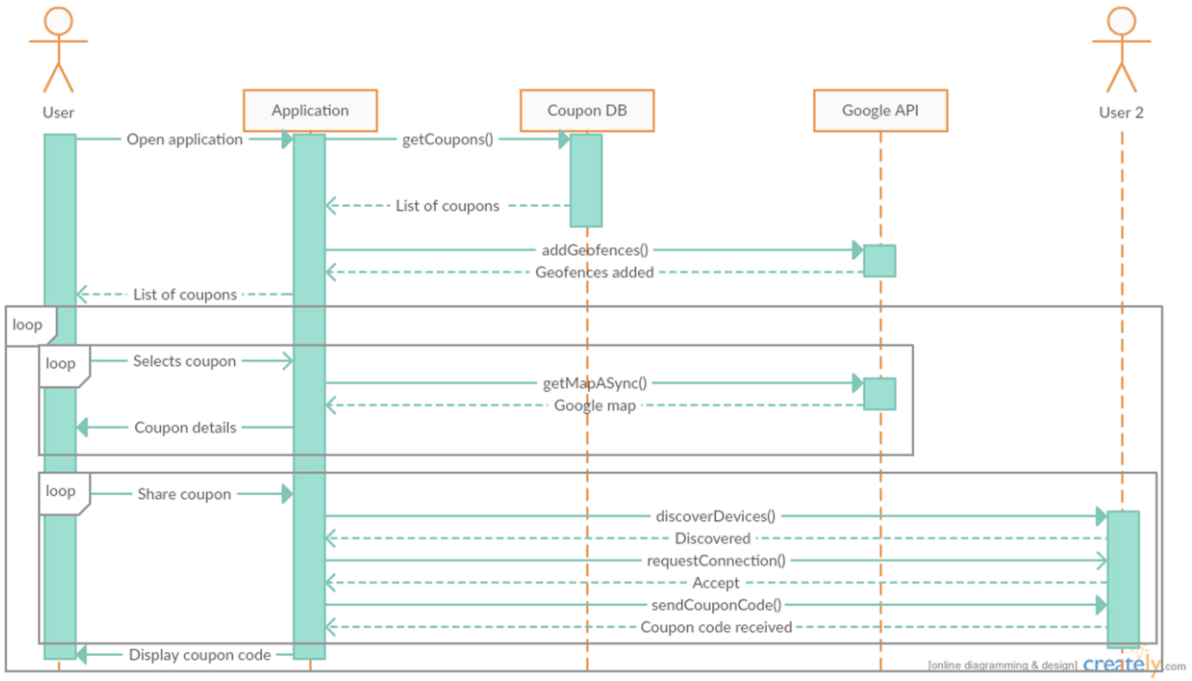

Figure 4.1. Sequence diagram of the application

[16] https://github.com/mobile-cloud-computing/Kupongitasku

4.2 Application flow

Selecting coupons

When the user opens the application, main activity starts and coupons will be loaded from the database as JSON objects and then converted to Coupon objects. A custom adapter is used to inflate a listview of coupons which will be shown in the main activity as seen on Figure 4.2.

After the user chooses any coupon from the list, the coupon will be again converted to JSON, an intent will be created to start coupon details activity and the JSON object will be sent as an extra of the intent which was created. Then coupon details activity will be started as seen on Figure 4.3 and Google Maps will be loaded asynchronously as seen on Figure 4.9. Coupon codes are not shown to users unless they share the coupon or get the coupon shared to them by someone else.

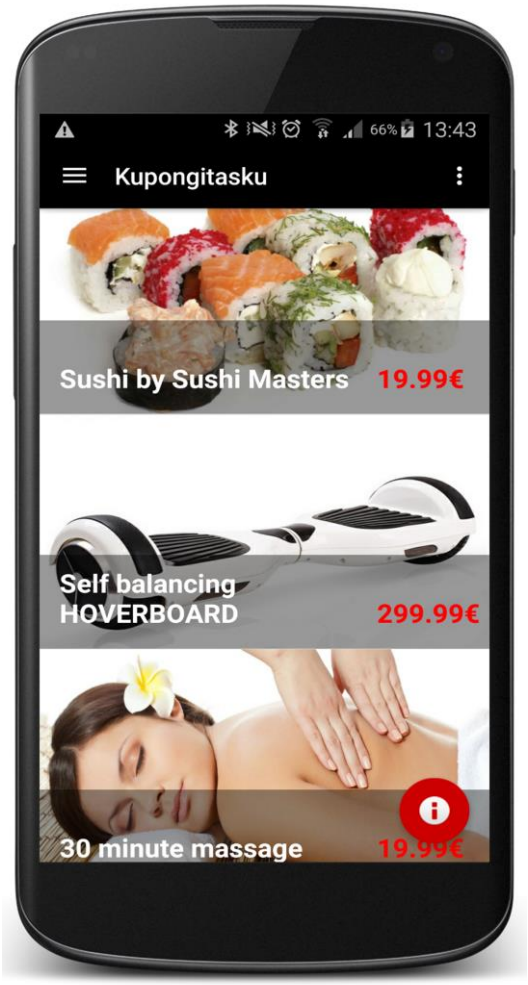

Figure 4.2. Main activity

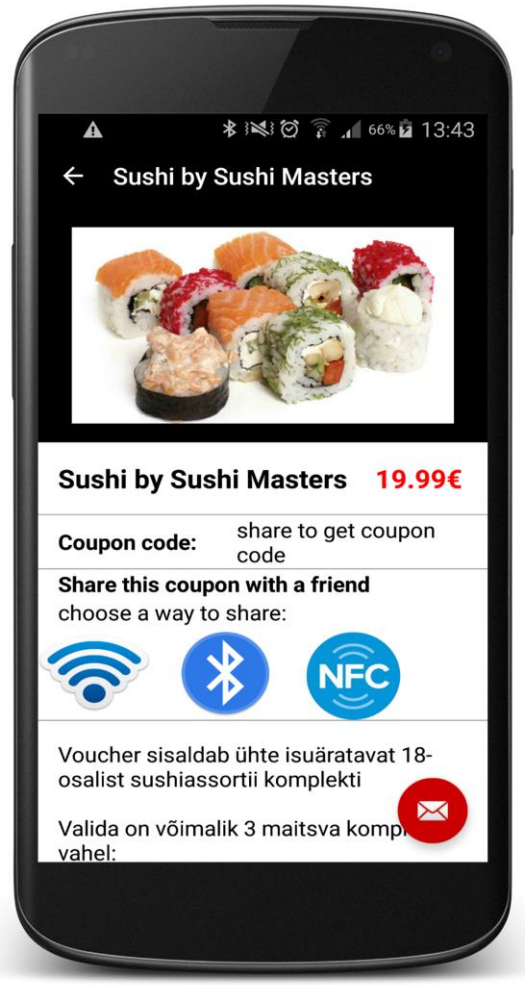

Figure 4.3. Coupon details activity

Sharing coupons

For experimental purposes, three different P2P data sharing methods were implemented to share coupons. Choosing NFC will just create a popup telling the user to connect the back sides of two phones to share with NFC. For NFC to work, receiving user must have its phone screen turned on, but opening the app itself is not required. After connecting the phones, sending user has to simply touch the screen to complete the transfer. Coupon details activity will be opened for the receiving user and coupon code will be available to him as well as for the sending user.

If the user chooses to share the coupon with Bluetooth, a listview of available remote devices with device names and hardware addresses will be shown in a popup window as seen on Figure 4.4. The list will contain all paired devices and all devices which have set themselves discoverable. After choosing unpaired device from the list, a RCOMM socket will be created and a pairing request popup will be shown by Android system for both sending and receiving users as seen on Figure 4.5. If both users choose to accept it, connection will be established and the coupon will be shared, finally showing coupon code for both users.

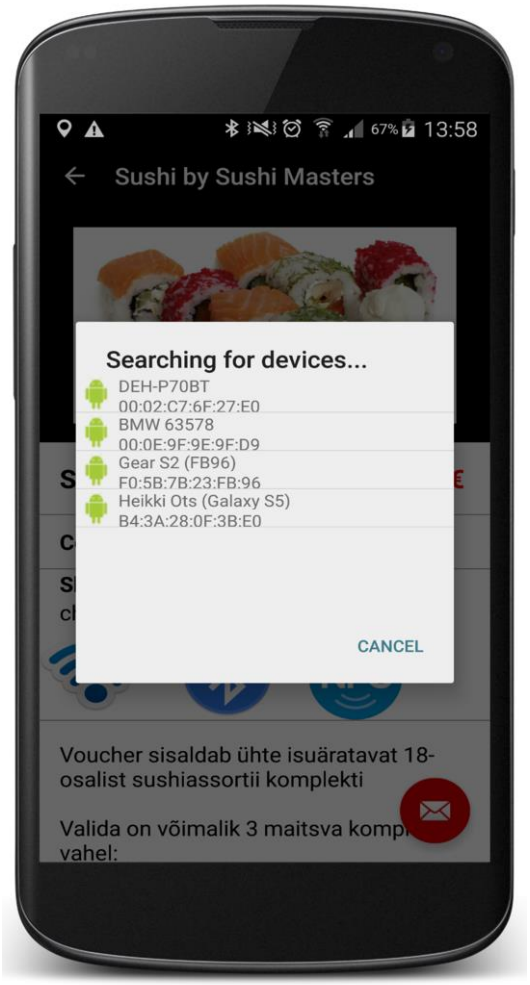

Figure 4.4. Bluetooth discovery

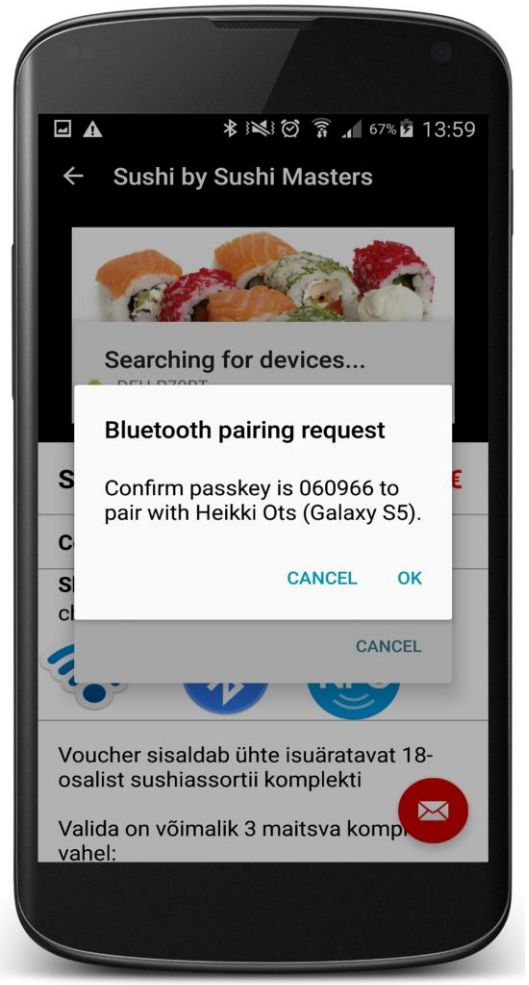

Figure 4.5. Bluetooth pairing request

If the user chooses to share the coupon with Wi-Fi Direct, similar popup window with available devices list will appear as seen on Figure 4.6. All devices in the list have their current status under device name. After choosing an available device from the list, the status changes to “invited” as seen on Figure 4.7 and the receiving user will have to confirm the connection request. If the receiving user chooses to do so, a Wi-Fi Direct connection will be formed, status changes to connected and the coupon will be shared and also coupon code will be available for both participants as seen on Figure 4.8.

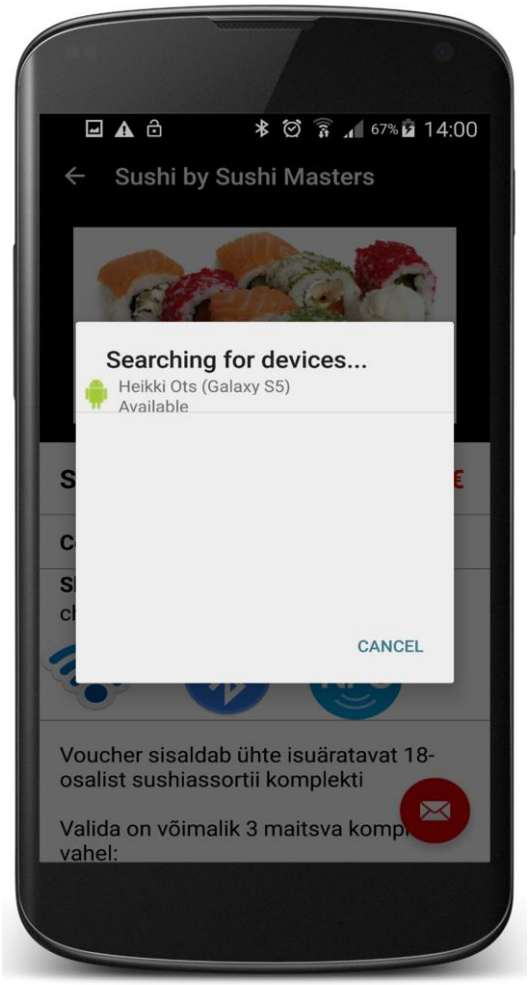

Figure 4.6. Wi-Fi Direct discovery

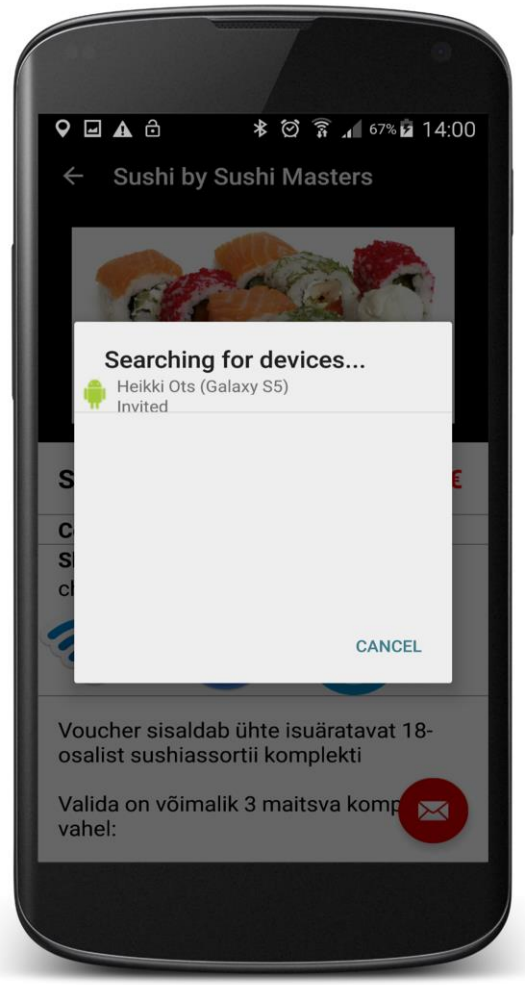

Figure 4.7. Bluetooth connecting

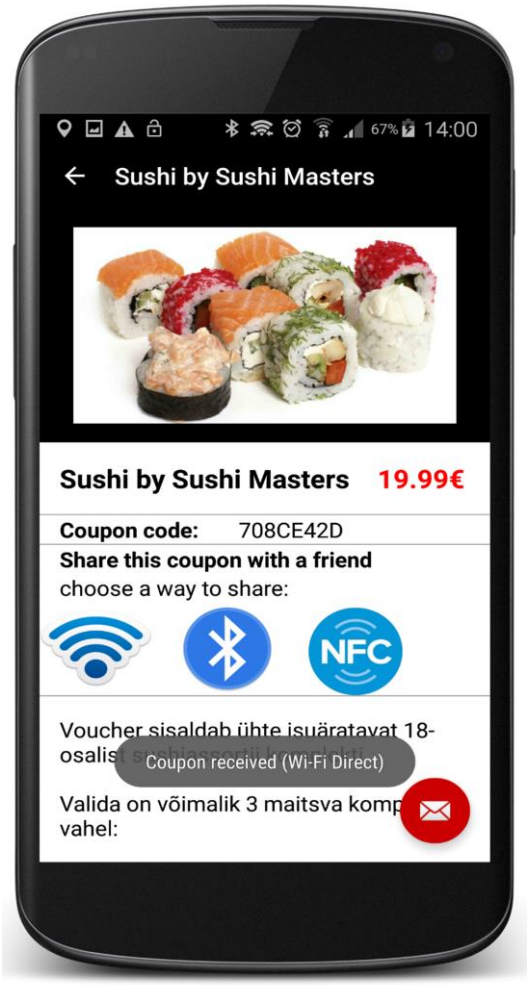

Figure 4.8. Receiving Coupon

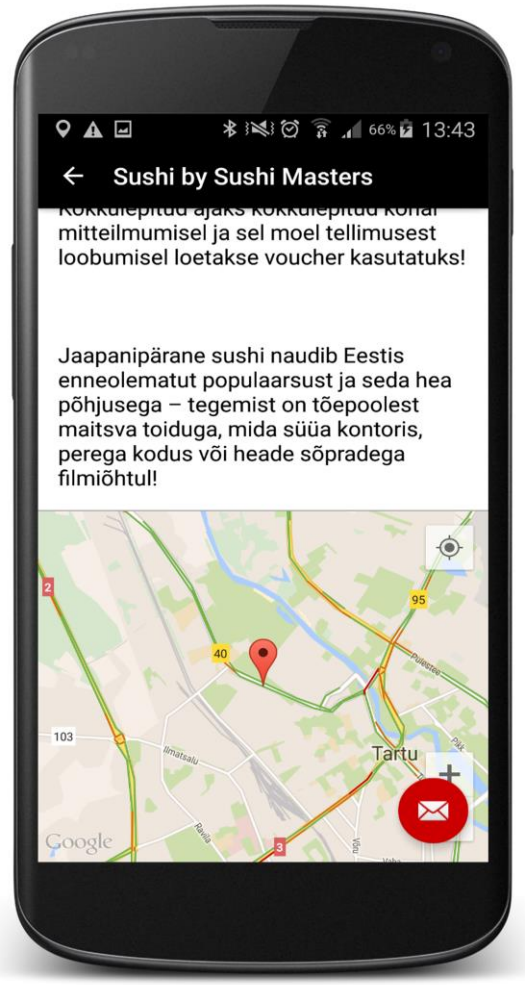

Figure 4.9. Google Maps

4.3 Summary

A P2P coupon sharing prototype was developed. It has local SQLite database for coupons, which are loaded in the main activity to display a listview of coupons. Choosing a coupon from the list opens a new coupon details activity and then the can share the coupon. The prototype lets the user choose between three P2P methods – NFC, Bluetooth and Wi-Fi Direct. Coupon code becomes available only after sharing a coupon or getting coupon shared to you by another user.

The next chapter describes experiments which were conducted to test P2P methods' performance and usabilty. Also, results of the experiments are presented and analysed.

5 Case Studies

In order to determine which of the P2P technologies implemented in the prototype suits the best for a coupon sharing application, they have to be tested and compared based on the results. More specifically, performance and usability will be put to a test.

5.1 P2P Experiments

First of all, to test performance, the prototype will be modified. Instead of just transferring JSON object of the coupon, 1MB worth of data will be sent with it. This is for measuring transfer speed of sending a medium sized portion of data in case we wanted to also share some more space consuming characteristics (such as images) of the coupon in the future.

Three different Android devices will be used: Samsung Galaxy S4, Samsung Galaxy S5 and Nexus 5. For every data sharing method, a total of 30 experiments will be executed to get an adequate average result. Every phone shares a coupon 5 times to both other phones which ultimately results in 30 experiments.

For Bluetooth and Wi-Fi Direct, discovery time will be measured separately. As there is no discovery time for NFC, only data sending time will be measured. Also, to eliminate human factor, pairing and connection accepting process for Bluetooth and Wi-Fi will be automated programmatically.

Usability will be tested by an experiment, where participants are just told to share a coupon to another user. They can choose any of the three methods available for coupon sharing by themselves. After sharing, they will fill up a questionnaire [Appendix A], which was composed to get feedback about the experiment and gather data about user preferences regarding P2P technologies. Sample size calculator was used to get the optimal number of participants needed which turned out to be 30 [10][11].

5.2 Results

Performance

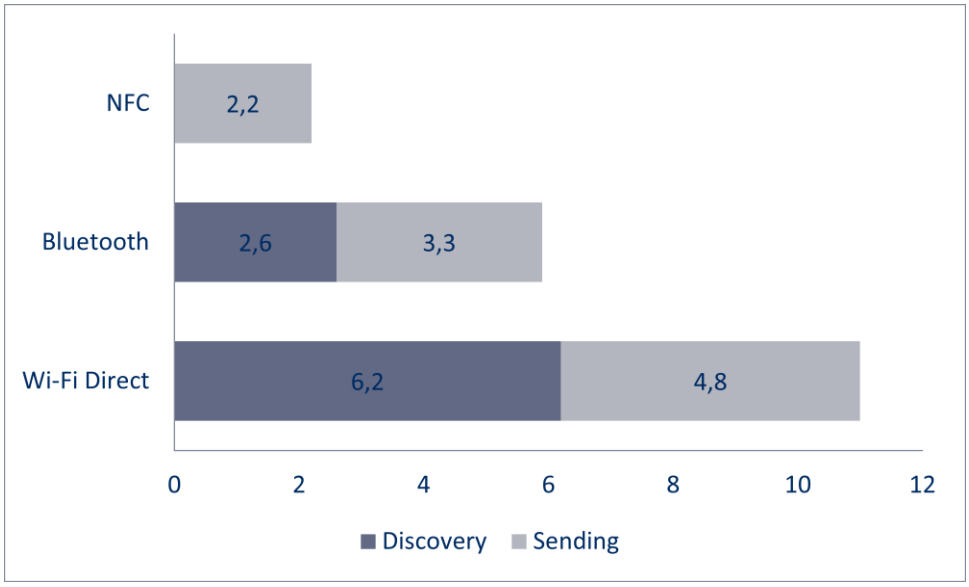

Figure 5.1. Average transfer time in seconds

The results of performance testing are presented as a column chart as seen in Figure 5.1. As expected, average total sharing time was the lowest for NFC because no discovery is needed. Longer sending time is explained by the fact, that Bluetooth and Wi-Fi Direct sending time also includes connecting and pairing time.

Usability

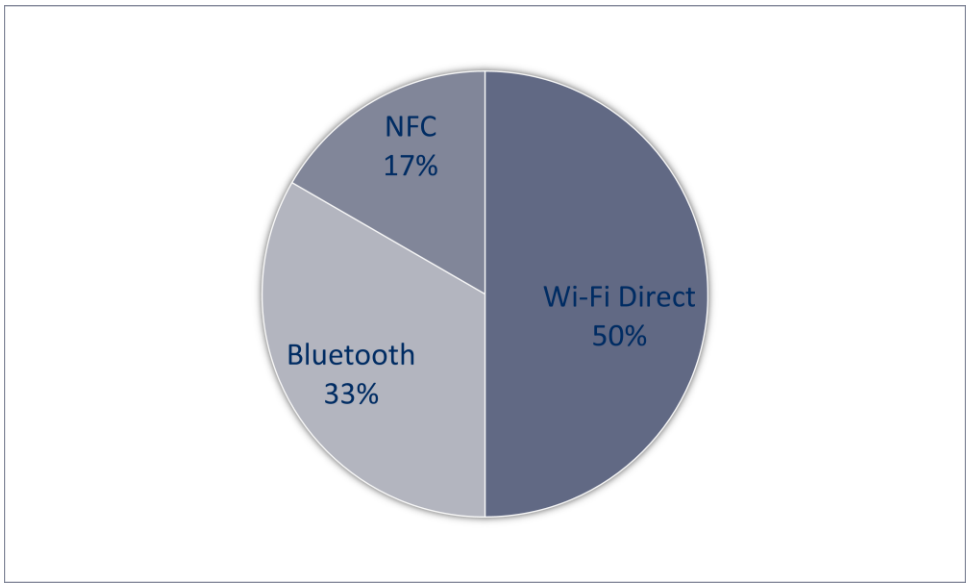

Figure 5.2. Percentage of technologies chosen by participants

The results of usability experiments are presented as Figure 5.2, Figure 5.3, Figure 5.4 and Figure 5.5. Based on the survey's question number one, pie chart (Figure 5.2) was created to represent the answers given.

Firstly, exactly half of the participants chose Wi-Fi Direct as a way to share the coupon. This could be explained by the fact, that Wi-Fi button is the first in the row as seen in Figure 4.3. Another factor could be that Wi-Fi is the most commonly used P2P technology among participants as 73% of them have it enabled which can be seen from Figure 5.5.

Secondly, NFC was only chosen by 17% of the participants. That could be explained by the fact that NFC was introduced only lately and only 7% of the participants have used it before as can be seen from Figure 5.4.

Thirdly, 33% of the participants chose to share the coupon by Bluetooth. On the one side, Bluetooth has been around for more than two decades [17]. This means that some of the people may consider it out dated and were less likely to choose it. On the other hand, Bluetooth's "age" is also the reason why 93% of the participants had used it before as can be seen from Figure 5.4 and were more likely to choose it.

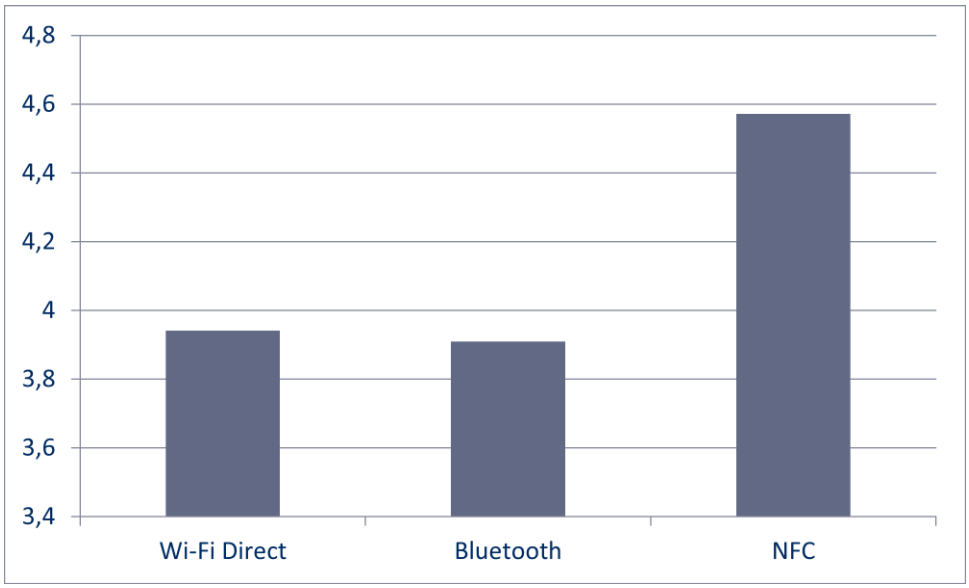

Figure 5.3. Easiness of sharing rated 1-5 by participants

Based on the survey's question number two, column chart (Figure 5.3) was created to represent the answers given. It appears that participants who chose NFC rated their sharing experience to be the easiest. This could be explained by the fact that NFC requires no discovery initiation was the quickest way to share coupons as seen on Figure 5.1 [18]. Furthermore, NFC requires only one touch on the screen by the sending user.

[17] http://www.oxfordreference.com.ezproxy.utlib.ut.ee/view/10.1093/acref/9780199651467.001.0001/acref-9780199651467-e-0034, 12.05.2016
[18] http://www.androidcentral.com/gingerbread-feature-near-field-communication, 12.05.2016

Wi-Fi Direct and Bluetooth averaged almost the same result. This is probably due to the fact that sharing flow (tap button, choose device, confirm) of these methods is very similar. People also mentioned the same issues for Bluetooth and Wi-Fi Direct, when answering to the third question of the questionnaire "explain what were the difficulties". They mostly pointed out that they didn't know which device to choose from the list as they did not know the name of the device they had to share the coupon with. Device names could sometimes be unrecognizable, like „DEH-P70BT" as can be seen from Figure 4.4.

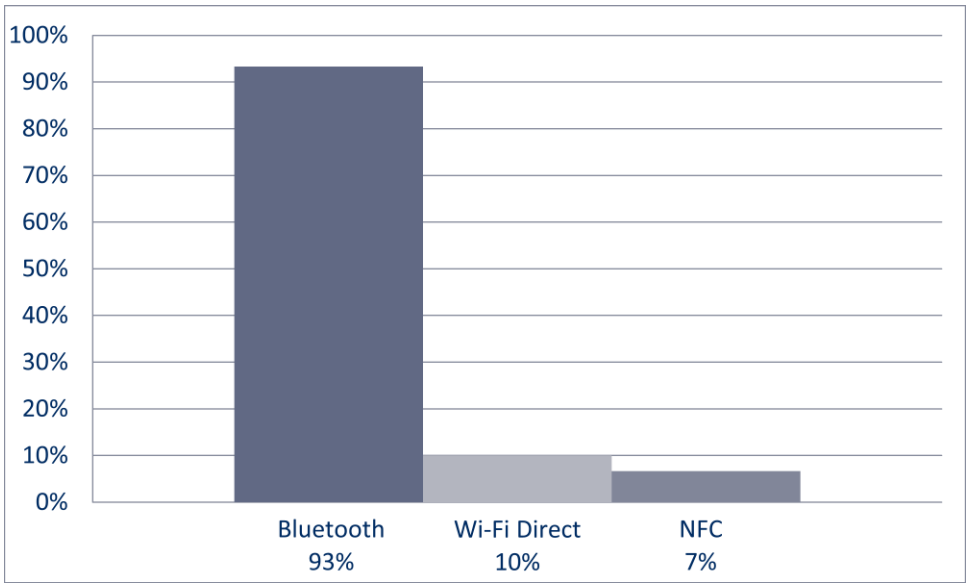

Figure 5.4. Percentage of participants who had used the technology before

Based on the survey's question number four, column chart (Figure 5.4) was created to represent the answers given. As much as 93% of the participants had used Bluetooth before, opposing to only 10% and 7% of participants who had used Wi-Fi Direct and NFC accordingly. This is easily explained by that fact that Bluetooth has been around for a longer time as noted earlier.

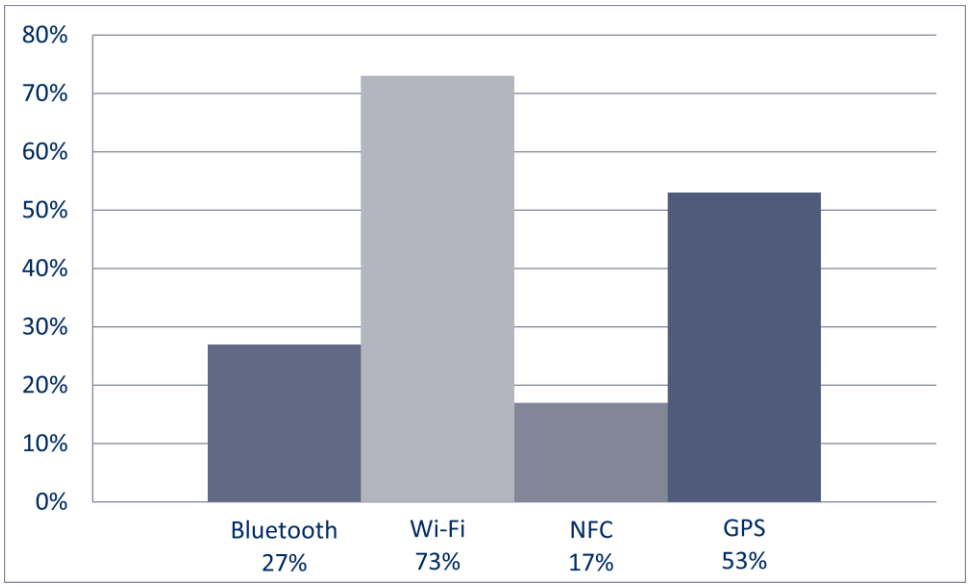

Figure 5.5. Percentage of participants who had the feature enabled

Based on the survey's question number five, column chart (Figure 5.4) was created to represent the answers given. 17% of the participants had NFC enabled, which makes the fact that only 7% of participants said they had used NFC before seem strange. Although, this is probably because of people trying to enable different settings without actually using them.

Wi-Fi being the most often enabled among participants with 73% and GPS placing second with 53%. Such high numbers are explained by the fact that many smartphone users use GPS and Wi-Fi regularly. For example, 74% of smartphone owners used geo location services in 2012 [19].

5.3 Summary

All participants were chosen randomly from people walking around the town hall of Tartu. Performance and usability experiments were conducted in order to find the most suitable P2P data sharing technology for coupon application. Based on the results, participants considered NFC to be the easiest form of coupon sharing. NFC was also the quickest way to share a coupon, being more than 2 times faster than Bluetooth and 5 times faster than Wi-Fi Direct. On the other hand, only 17% of the participants chose NFC and only 7% of participants had used NFC before.

Half of the participants chose Wi-Fi Direct as a way to share the coupon, it turned out to be the slowest in terms of overall sharing time. By 93% Bluetooth had the highest percentage of people who had used the technology before.

[19]http://www.pewinternet.org/2012/05/11/three-quarters-of-smartphone-owners-use-location-based-services/, 12.05.2016

6 Conclusions and Future Directions

Each of the three P2P data sharing technologies – Bluetooth, Wi-Fi Direct and NFC, has its upsides and downsides. Although they all serve the same purpose, to share data from device to device, they shine in different fields. In general NFC being the easiest to use, Wi-Fi Direct being most suitable for sharing over longer distances and Bluetooth LE being the best option for devices with limited battery [20].

Bluetooth is the oldest and most well know technology out of the three. 93% of participants had already used it before according to the experiment. Still, only 27% of the participants had it turned on and it was more than twice slower than NFC in terms of total sharing process.

Wi-Fi Direct was chosen by half of the participants to share data and 73% participants had it turned on. But still, the fact that it took on average 5 times more time for coupon sharing compared to NFC is a red flag in terms of usability.

It may seem that NFC could be most suitable. It is the easiest and the quickest way of sharing coupons according to the experiment. But as it is a relatively new technology, all devices do not support it yet. Moreover, only 7% of experiment participants had used it before and only 17% had it enabled.

At this point, we have no clear winner. This means that the best option would be not to choose one technology, but to let the user make the final decision which technology to use. This way every user can find the most suitable method of sharing coupons themselves. Furthermore, all three technologies are already implemented in the prototype application so in terms of P2P coupon sharing, no extra man-hours are required for creating final product.

As the application is currently in a prototype stage, the goal would be to fix some minor bugs and develop the application further, so it could be ready for real world use. For that to happen, application design should be reviewed by someone competent in that area. An online database should be connected to the local database and backend interface should be developed to easily add new coupons to the database.

[20] http://developer.android.com/guide/topics/connectivity/wifip2p.html, 12.05.2016

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Appendices

I. A

1. Which of the following data sharing technology did you use for coupon sharing?

   (choose 1)

   Bluetooth Wi-Fi Direct NFC

2. Rate how easy was sharing a coupon with the prototype application provided

   (5 is easiest)

   1 2 3 4 5

3. If you chose less than 5, explain what were the difficulties

   _____

   _____

   _____

4. Which of the following data sharing technologies have you used before?

   (choose 0 or more)

   Bluetooth Wi-Fi Direct NFC

5. Which of the following features are enabled on your personal device right now?

   (choose 0 or more)

   Bluetooth Wi-Fi NFC GPS

6. Have you ever used a coupon to get a discount?

   YES NO

II. B

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