UNIVERSITY OF
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School of Computing

Master's Thesis

Public transport applications for smartphones

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ABSTRACT

Public transports and their timetable are inseparable parts of the urban lifestyle. It is essential to know the public transport information to ensure the commute quality and time. This information can be fetched using a mobile phone app, which unfortunately are not available in the market. The popular public transport applications in the market are not satisfying the needs of all kinds of users, which is being reflected in their review comments. The number of cities, where the applications are providing their service is far less than the world's total city count. We have analyzed different types of public transport applications and identified different types of users to know the reason behind users' disappointments and the unavailability of service in most of the cities of the world. We proposed a model for public transport application and built a prototype to partially demonstrate the application. We have also described improvements which are neither available in any application in the market nor suggested by any user.

Keywords: Public transport application, mobile app, smartphone app, ticketing system

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1 INTRODUCTION

Time is one of the most valuable assets. But time can be misused due to lack of proper planning during travelling. Proper planning can play a significant role while travelling by means of public transport. We live in such an era where we can utilize different forms of technologies for making plans. There are several forms of portable technologies, but considering the processing power, battery life, size of the display and convenience of communication the *smartphones* are the most convenient device to carry.

The main concept behind smartphone was developed gradually over time. However, the word Smartphone was coined by a Swedish company Telefonaktiebolaget L. M. Ericsson by introducing their prototype product Ericsson GS88 (code name: Penelope) [1] in 1997 which never reached to market at the end. The phone had features like email, SMS, world clock, internet browser, loudspeaker, integrated modem, infrared technology and the ability to get connected with a computer.

Figure 1 Ericsson GS88 (Penelope)[1]

A phone with similar features has been released in 1994 by IBM named *Simon Personal Communicator* [2]. The definition of the smartphone has been changed over the years. People

aver[1,2] a communication device as a smartphone if it has an operating system that allows a user to install third-party applications with a wide range of functionalities, different kinds of sensors and internet connection. This idea has been established in people's mind after Apple launched their first smartphone named iPhone[3] in 2007 which has similar features described above.

Figure 2 iPhone (1st generation)
https://www.gsmarena.com/

Smartphones are also accessible to most people in the urban area around the globe. Moreover, nowadays smartphones are more capable than in the past and have comparable capabilities that of computers. Developing smartphone applications is not easy compared to computer applications but their distribution is just a matter of time.

Though applications of mobile devices are very handy and being used every moment at user-level, it is hard for a developer to build a mobile application. Previously it was difficult to develop because of the lack of computing resources such as processing speed and memory. Today the scenario is different as smartphones have higher configurations such as high memory and processing power. But still, a good operating system doesn't allow freedom to the application

[1] https://www.lifewire.com/what-makes-a-smartphone-smart-579597
[2] https://www.quora.com/What-makes-a-smartphone-smart-1
[3] https://en.wikipedia.org/w/index.php?title=IPhone_(1st_generation)&oldid=849788527

developer because of insufficient battery life[4]. Because more power will be consumed if more recourses are in use. Due to these problems modern, mobile operating systems are built such a way that no application can consume resource with unplanned way[5]. This made developers life harder compared to computer application developers.

Travelers or passengers not only look for the time needed to reach the destination but also the punctuality of the means of the transport system and its availability. During travel, the passengers also look for the cost to performance ratio, comfort and flexibility. Passengers often get bored and annoyed with an unpunctual transport system. To reduce boredom and annoyance, the passengers keep themselves busy with different tasks, the most common being engaging with handheld devices. Some passengers talk over the phone, some keep themselves busy in the social network sites and some play games or are engaged in texting. The goal of this thesis is to overview route planning of the passengers and utilizing the smartphones for this purpose.

The decrease in the use of the public transport system has been observed in [3]. The reason behind this is rapid motorization, lack of reaching the actual destination and long waiting time. Passengers prefer public transport less when they are obliged to wait for a long time before getting on it, and they also consider walking to a destination from a bus stop as an added burden. Those who still use public transport such as the bus, most of them usually keep themselves busy while waiting, while some of the passengers do nothing during the waiting times. It has been suggested in [3] that engaging in activities like chatting, talking over the phone, texting, reading books or playing games on the cell phone is very likely if the passenger sits on a bench. But not all bus stops have facilities for sitting while waiting for the bus. The most significant finding of [3] is that, in Japan, more than half of the users of public transports are elderly people and young ones usually avoid using it. It is because the young get irritated very easily while waiting.

[4] https://developer.android.com/topic/performance/memory
[5] https://stackoverflow.com/questions/14956018/can-i-create-the-object-of-a-activity-in-other-class

Figure 3 People doing activities while waiting for the bus

Created by Brgfx - Freepik.com

A similar result has been documented in [4]. In this paper, it is very clear that travelers do not prefer to spend time outside the vehicle while travelling. The travelers often get annoyed if they need to change their transport type. For example, assuming a traveler uses a bus to go to a certain place regularly. If some special situation forces him to travel by train, he is more likely to be annoyed and get disappointed. The travelers also prefer minimum waiting time during transfer from one means of transportation to another. According to [4], the waiting time depends on the service frequency of the specific means of transportation and reliability. While there are problems with the public transportation systems, the transportation agencies have to pay for the problems caused by the whole system as both [3] and [4] indicated the declining number of the usage of the public transport. At the same time in [5], it was suggested that there are some additional reasons that cause a decline in the public transport usage. It has been suggested in [5] that travelers prefer own automobile over public transport, which is a clear indication of motorization. People who owns cars do not usually use public transport regardless of the distance of the destination. But people who usually walk or cycle to close destinations may switch to public transport, specifically bus.

Several measures can be taken to make the public transportation more interesting and attractive to the passengers. A game has been suggested in [6] which can be played in multiplayer mode using peer to peer communication between mobile devices while travelling in the public transports. To attract passenger, it also suggests placing Wi-Fi or similar networking device in a public transport that can support *one-to-many* connectivity. The device will act as a common connecting station for multiplayer users. In [7] a mobile application has been suggested and a prototype has been made, which provides information of real-time transport location, route, the time needed to reach

destination and other public transport related information that already exists in other applications. Instead of commonly seen user interface (UI), they developed it like video game's navigation system that makes the application distinct from others.

A lot of researches have been conducted to reduce the hassles due to use of public transport. In [8] a *coordinated timetable design* has been proposed for connecting transportation systems. To understand coordinate timetable design let us assume in Figure 4 a person wants to travel from location A to location C. There is no transport that operates directly from A to C, therefore, he/she must change the transport at station B. In our scenario there are two operational transports T1 and T2. Their route has been drawn with blue and red color respectively in the figure. If the timetable of T2 has been designed such a way that T2 will leave the station after a few minutes of the arrival of T1 then it will be called coordinated timetable design. The paper [8] suggests that the coordinated timetable will not only reduce the transfer time but also increase passenger satisfaction by reducing the waiting time, which will result in an increased use of public transports.

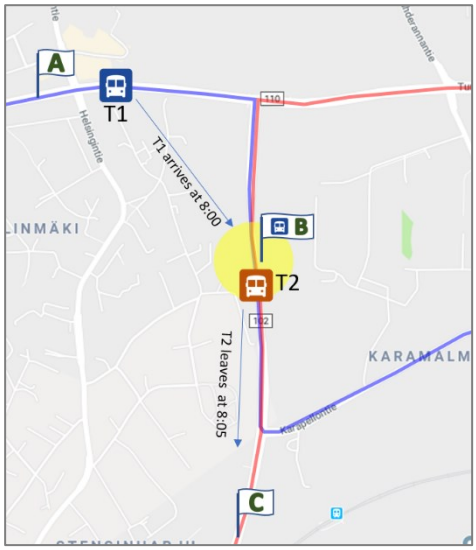

Figure 4 Transports are maintaining coordinated timetable

To design efficient transportation plan in an urban area, it is necessary to know about the users' daily travel pattern between selected places, for example, home and office. Mobile phone's *call detail record (CDR)* is a data record that stores telephone call detail which is produced by telecommunications equipment (e.g. cell tower) or telephone exchange. The detail includes caller's

location, the starting time of the call, call-duration and other call related data[6]. It is possible to parse CDR and get users mobility pattern after processing it through an algorithm as demonstrated in [9] by a case study in Singapore. In the case study [9], two types of location-points are being extracted from the CDR. One of them is anchor-points which are the locations where users stay a longer period and another one is pass-by points where users stay for a few amounts of time. From call start time and duration record, users' home and workplaces are being determined.

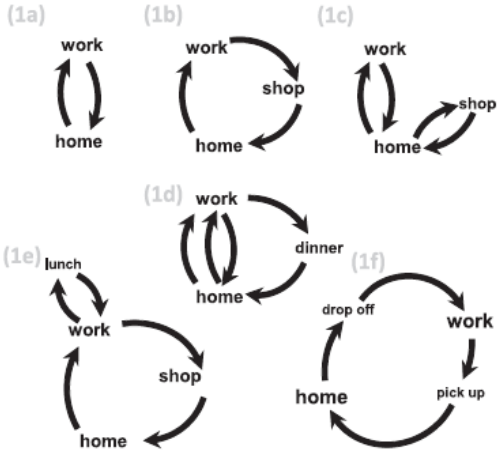

Figure 5 Six examples of daily mobility networks [9]

It is very important for a navigation based mobile application to get the users' current location accurately. Based on their current location, a mobile application can show personalized information of features that are only applicable to them. For example, to know about nearest restaurants from an application, a user must input their current location. This process will be much easier if the application itself determine the current location of the device. Nowadays, almost every smartphone contains a *global positioning system* (GPS) sensor, which is used by different applications to get the phone's current location.

The power consumption of a GPS sensor increases with positioning accuracy, which can be controlled by applications. GPS sensors that operate at high accuracy, consumes lots of power and causes the phone to run out of battery in a few hours [10]. To overcome this problem, a system named *Dejavu* is presented in [11], where *dead-reckoning* system is being used. Dead-reckoning is a process to get the current location of a device based on its moving speed, the direction of

[6] https://en.wikipedia.org/wiki/Call_detail_record

movement and its previous location. However, the dead-reckoning process can give inaccurate value (latitude and longitude). To increase the accuracy of this value, the system identifies unique landmarks. These landmarks are the combination of data of sensor arrays, which are presented in the smartphone. According to [11], when in-vehicle accuracy of this method is 8.4m (median) when the device is located in a city and 16.6m (median) when on highways. For pedestrians the accuracy is 3m (median).

According to World Health Organization's (WHO) report (published on 2011) [12], about one billion people of the world's population have some form of disability. Another report [13] by WHO in 2010 states that 285 million of world population are visually impaired among which 39 million people are completely blind. In [14] a system, *Talking-Cane*, has been suggested, where blind people can navigate and use bus by their own. To implement the system a modified white cane[7], smartphone, special foot paths constructed with *RFID*[8] implanted braille roadblocks, and application to communicate with nearly located bus drivers has been used.

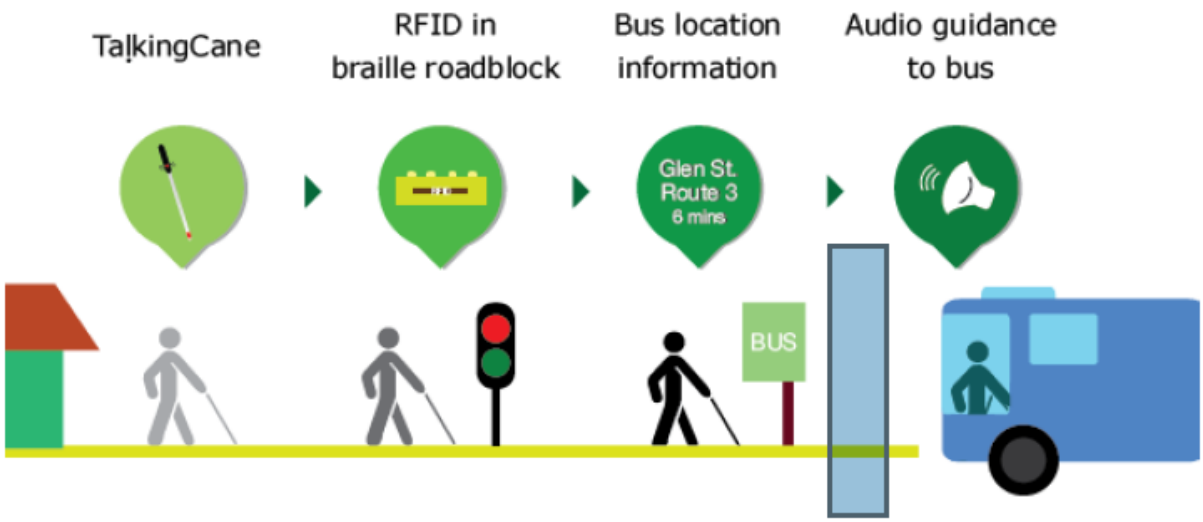

Figure 6 Blind person navigating and selecting the right bus using Talking-Cane [14]

In this system, an application has to be installed in the mobile phone. The person will initiate his journey by giving voice command to the application which will guide him/her the rest of the way.

[7] Stick for blind people by which they can determine their path.
[8] Radio frequency identification (RFID): A device/tag that has a unique number and can be read by an electronic reader. The RFID does not need any kind of power source and uses readers power when needed.

The person's white cane will have two vibrating-motors, a RFID reader in the bottom-end and an integrated bluetooth device. The motors will vibrate such a way that the user will understand if he/she has to go left or right. The white cane's RFID reader reads the RFID tag that implanted in the pathway and sends the unique code to the mobile-phone. The mobile-phone identifies the number and gets the location and speaks it to the user. The application guides the user by vibrating the white cane's motors using bluetooth signals. If the person reaches to a bus station, then a voice communication will be initiate with the bus driver when the bus arrives. The driver will help the person to get on the correct bus.

2 USER TYPES AND THEIR BEHAVIOR ANALYSIS

Day to day travelling is an inseparable part of human life especially in urban areas. In that sense, every people from young to old is a part of our user group. However, it is hard to satisfy everyone with only one solution as different users have different expectations depending on their current state. The state might be their age, willingness of adopting new technologies or educational background. For example, younger users are usually more willing to adopt newer technologies compared to elderly users [15].

2.1 CATEGORIZING BASED ON WILLINGNESS

If we think about the willingness of users to use a mobile application, then they can be divided into two groups. One of them appreciates technology and try to use it in their life to make it easier. We will call this user group as *enthusiastic-group*. People who do not like using technology can be called *non-enthusiastic*-group. Usually, old users fall under this group as they are susceptible to difficulties in learning to use and operate newer technologies [16]. It has also been noticed that the old user group can adopt a technology if they are convinced that technology has value, for example, maintaining a healthy life [17]. Unwillingness can also come from the lack of technological education.

2.2 CATEGORIZING BASED ON USER'S LOCATION

A user may expect different types of features in the application based on their current location. A user who lives in the neighborhood usually knows about the surrounding places. They also may be aware of public transport lines and their timetable as well, if they are regular users. This type of users may not be interested in the timetable of public transport. Disruption alert such as road accident, delay or cancelation of a line will be useful to them. There is a higher chance that users who do not live in the neighborhood do not know the timetables and routes of that area's public transport, therefore, the application must provide different information that will help him to roam around that new area with public transport.

2.3 CATEGORIZING BASED ON TRAVEL FREQUENCY

The pattern of using mobile application for transport information can vary depending on the frequency of public transport usage. Regular users may need different information than occasional users. Regular users' behavior is more predictable as in their daily life they will be travelling on a fixed route most of times. It is possible to record their path and predict their movement and inform them any unusual activity that might cause problems in their daily routine such as line disruptions. It is hard to predict occasional users travel pattern, but the application can suggest the history of users' previous travels and show related information to them.

2.4 DISABLED USERS

According to [12], 15% of the word population is suffering from some sort of disability. There are different forms of disability and some of them are not capable of using mobile applications, for example, a person who has intellectual disability or has multiple form of disability that stops him/her to use a mobile device. We exclude this type of disabled person from our user group. However, disabled people, who are able to use mobile application falls under our targeted user group.

By taking the summary of this different type of categorization we can estimate different types of users. A list of user types and their personas are described below.

2.5 USER'S PERSONAS

Regular enthusiastic: Pekka lives in Joensuu, Finland. He is 22 years old and does his Bachelor of Science at the University of Eastern Finland. He does not like to ride a bike, instead, he uses a skateboard for near distances. He does not own a car, therefore, has to travel by bus on the way to university. He plays different types of video games in his mobile phone during travel. He has been living in Joensuu for a very long time and knows about the city very well. He does not need to know about public transport information as he already knows well about the route he commutes. However, when he needs to know the timetable of a route that he does not usually travel, he uses the internet to get the information.

Pekka
(www.zcool.com.cn)

Regular non-enthusiastic: Mr. Heikki owns a second-hand product shop in Espoo City center. He is 61 years old and thinks about his retirement from work nowadays. He lives about ten kilometers away from his shop and uses a bus to go there. He already memorized the bus timetable of the route that leads him to the shop. He is not comfortable with technology, like operating smartphones. Though he owns one and uses it to call his friends and family. Whenever he needs to travel on some unknown route, he uses a paper map which is printed from HSL website (public transport company in Helsinki region) by his granddaughter.

Mr. Heikki
(all-free-download.com)

Occasional enthusiastic: Mr. Jukka lives in Vuosaari, Helsinki with his family. He is 38 years old and works at a software company at Helsinki city center. He owns a car and uses it daily in his way to the office. However, sometimes his wife borrows his car, and he needs to use public transport occasionally. He uses a mobile application to know the information about public transport on the way to his office.

Mr. Jukka
(freedesignfile.com)

Occasional non-enthusiastic: Mr. Antti lives in Oulu, Finland. He is 34 years old and teaches sociology at a university. He lives about six kilometers away from his university and drives there every day by his car. He does not use smartphones instead he uses a mobile phone that has a very few static functionalities like calling, messaging and alarm. He relates to different kind of social clubs and usually spends his free time with those. In the winter he avoids driving the car as he does not like to clean snow from his car every morning instead, he takes a bus. He has been living in the same neighborhood for a long time, therefore, he knows which lines operate which route and checks the timetable of the bus from the bus stop.

Mr. Antti
(all-free-download.com)

Tourist: Ahmed is 30 and from Dubai. He visits Finland for the first time in his life. He gets hard time to roam around the city as the city names are very uncommon to him. Before coming to Finland, he has listed some places where he wants to visit. He uses an internet browser to get public transport information and he also installed a mobile application in his smartphone that can guide him to his destination. Whenever he uses public transport, he cannot get out at the right station every time mostly because the names of the places are confusing to him. His application helps him

to get down from the transport by giving notification. This happens by invoking popup menu with vibration or audio clip but is not accurate every time.

Ahmed
(all-free-download.com)

Disabled: Mrs. Kulsum is an immigrant and lives in Vantaa, Finland and work as an accountant in a company. Both of her legs got paralyzed after a brain stroke. She uses wheel chair to move around places. She goes to her workplace by bus and train, and fortunately, both of her transport has wheel chair access. She often thinks what would have happened if she stayed in his own country where there is no opportunity for disabled people to travel by public transport.

Mrs. Kulsum
(http://www.clker.com/clipart-9447.html)

3 FEATURES OF MODERN TRANSPORT APPLICATIONS

There are multiple applications[6] that dominate the application market (Google Play Store) of the Android operating system in different areas of the world. Except for some unique features, most of the features of these applications are same or similar. Some of the online blogs[9,10] have written about these applications. The applications use different names for the same features. For better understanding, I am giving some names to these features so that they become application independent. As an information source, I am using android's marketplace profile of these applications where one can find all the important statistical information.

3.1 A TO B ROUTE PLANNER

This feature allows users to choose location A (usually current location of the user) and B (the destination of the user). The application then provides recommended routes combining multiple transportations. Users can either select location by typing the address or by tapping on the map provided by the application. It is also possible that user can select one of their favorite places and use it as point A or B. This is a very common feature among the applications.

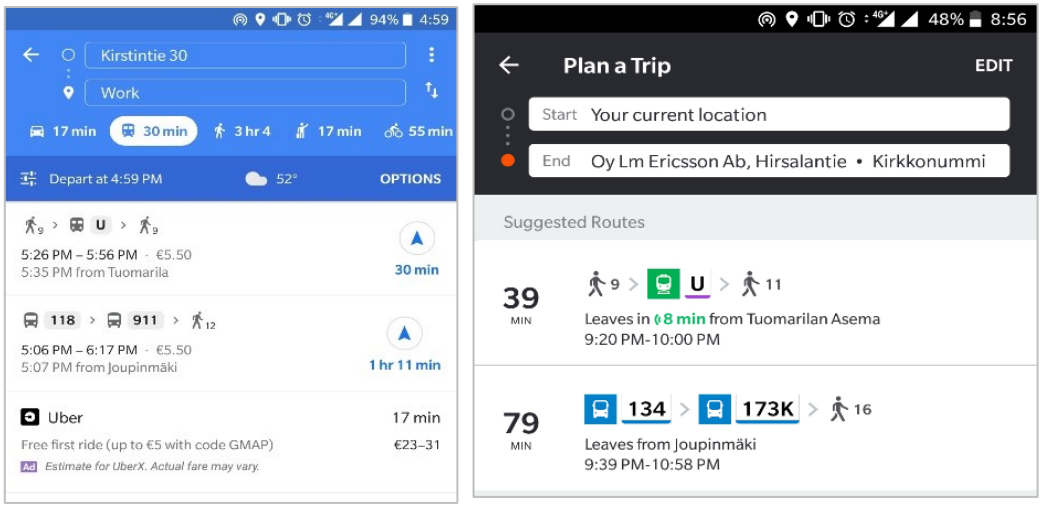

Figure 7 A to B route planner of Maps and Moovit app respectively

[9] https://www.androidauthority.com/best-transit-apps-android-782796/
[10] https://www.androidcentral.com/best-transit-app

Most of the applications of the market populate their suggested route list using different algorithms, that is why the suggestions are not always the same for every application. Usually, they show the routes ascending to the shortest time to reach the destination. Some application has an option to customize their suggestion list based on different attributes such as: *fewer transfers*, *less walking*, *greenest mode*. Figure 8 represents the option-menus for customizing suggestion list of *Maps* (by Google) and *Whim* application.

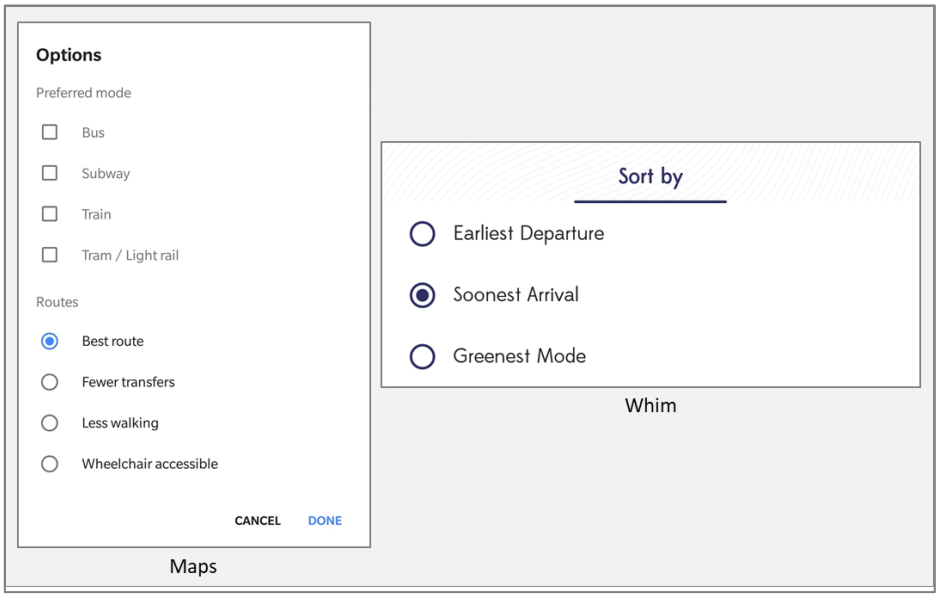

Figure 8 Option for customizing route suggestion list of Maps and Whim

3.2 REAL TIME DEPARTURES AND ARRIVALS

Applications inform real-time arrivals and departures to their users. This information can be either accurate or an estimation. Some applications like *Moovit* collect this information from GPS devices placed on the transport itself. Where other applications are estimating the information. The algorithm of their estimation is not available publicly. Maps uses the location of the android phone users to estimate road traffic density[11]. Although they do not use these data to predict arrival or departure time. Instead, they predict road traffic density with these data.

[11] https://www.businessinsider.com/how-google-maps-knows-about-traffic-2015-11?r=US&IR=T

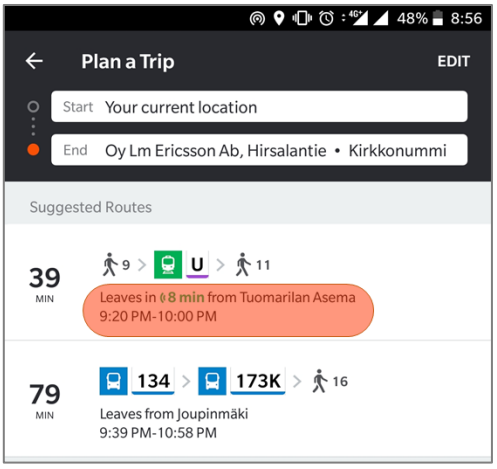

Figure 9 Moovit showing real time departures

3.3 ALERTS

Applications keep its users updated by giving alerts about different issues related to transits. For example, changes of timetable of a certain line, delay of a line and service disruption. Almost all the popular applications have this feature including Transit, Moovit and Citymapper and Maps. Applications show alerts in two different ways. One way is to show alert in a separate section where all alerts of a certain city are listed. Users must open that section to view the alert list. Figure 10 is an example of an alert list which is captured from the Moovit application. In this kind of alert showing method users will not be notified unless he checks the alert section manually. Another way of showing alerts is by notification which is typically implemented as popup menu with vibration or audio clip. In this way, users always get to know of alerts, but it might be disturbing to get notification of those alerts which are not relevant to the users. There might be alerts that may not take effect on certain user's daily life. In that case, showing those alerts to them is irrelevant. Applications must make sure that users are getting relevant alerts if they want to show it by notification.

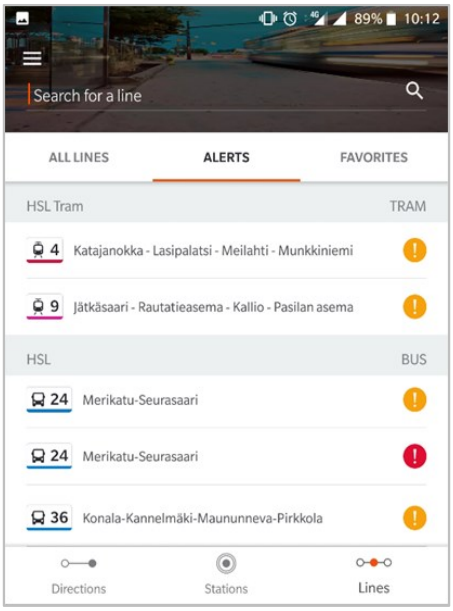

Figure 10 Service disruption alerts shown in Moovit

3.4 STEP BY STEP GUIDE

This feature allows users to be guided by the application while they are performing a travel. The feature guides the users based on their current position, current time and the overall situation they are currently in. For example, if they are on a bus it will notify them when to get off by notification. If they need to travel on multiple transits, then they will also guide the next transits time. It may also happen that one of the transits of their selected route got disrupted, the feature will also notify this phenomenon. In Figure 11, Moovit's *live direction* is showing user step by step messages during his/her travel. The application will not show step 2 unless he/she performs step 1.

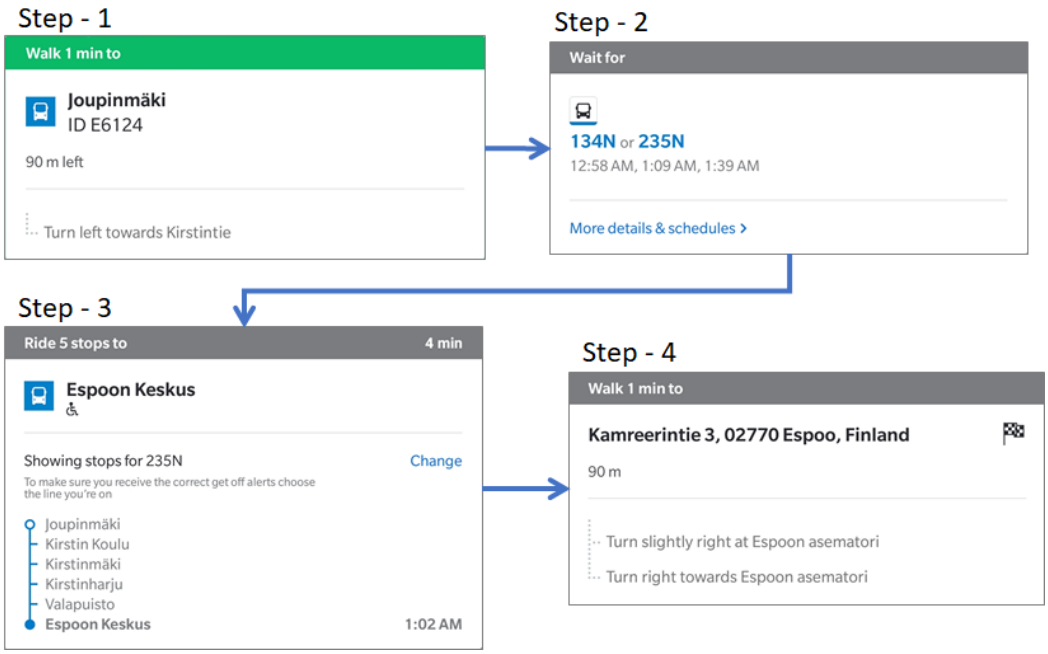

Figure 11 Live directions of Moovit app

3.5 FAVORITES

This feature allows users to save their favorite entries. These entries can be many types, for example, address, line, station. Users may save their home and work address as favorites. In this case, favorite is address type. They may also save their favorite transport stations. It is possible to determine favorites from user's history and suggest them if they want to add it to their list.

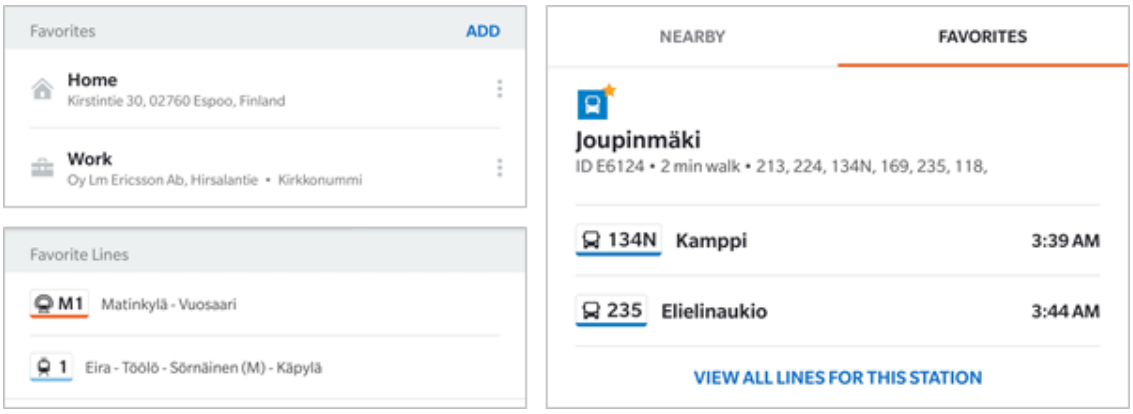

Figure 12 Saved address type, line type and station type favorites of Moovit application

3.6 TRIP COST ESTIMATION AND TICKET BUYING

Trip cost estimation feature lets users know about the cost of their trip. Ticket prices are applied based on different criteria of the user, for example, if he/she is a student or elderly citizen his price will be different than other users. In the Helsinki area, if someone buys a ticket with HSL application then the ticket costs less. Most of the popular application has this feature. Ticket buying feature is not available among popular application. The most downloaded and rated applications do not have this feature at all. Usually, applications that cover only one country or some cities have this feature. In Finland, HSL application allows users to buy tickets for public transports but the application covers only Helsinki, Espoo, Vantaa, Kauniainen, Kerava, Kirkkonummi, Sipoo, Tuusula and Siuntio areas. *Whim* application also allows its users to buy tickets in Finland. Basically, Whim is using HSL's *Application programming interface (API)* to sell the ticket of HSL.

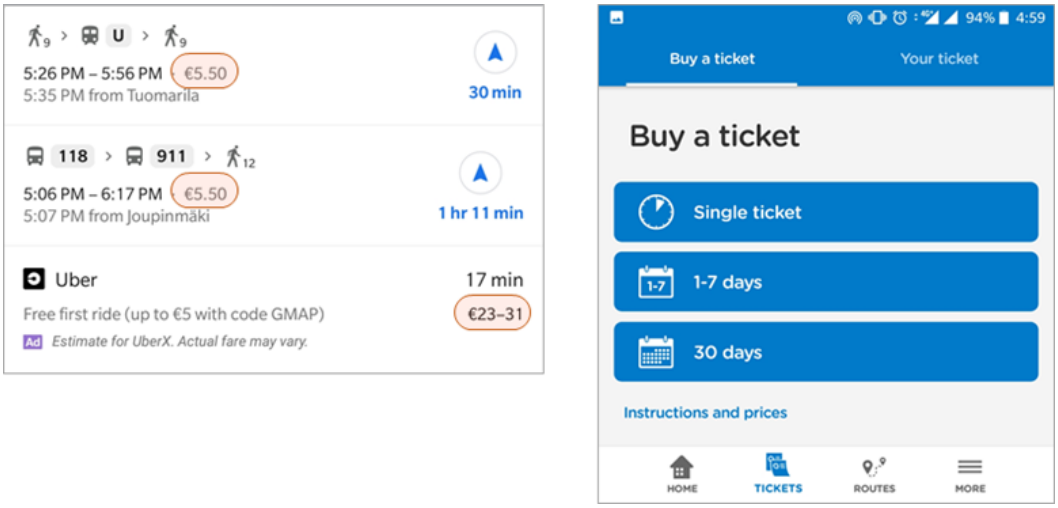

Figure 13 Maps app's price estimation feature and ticket buying feature by HSL app

3.7 NEAREST TRANSPORT STATION INFORMATION

This feature shows user information of nearest transport stations. The information usually includes the location of the nearest station, which lines are leaving from that station. Most of the time the data are shown ascending to the departure time of the lines. The basic concept of showing nearby station is almost same in all the applications which have this feature. Some applications like Moovit show nearby stations of all kind of transportation in one list while others like Citymapper shows it in a different list for different transport types. Figure 14 shows the nearest transport list of Moovit application where all kind of transport information is being shown.

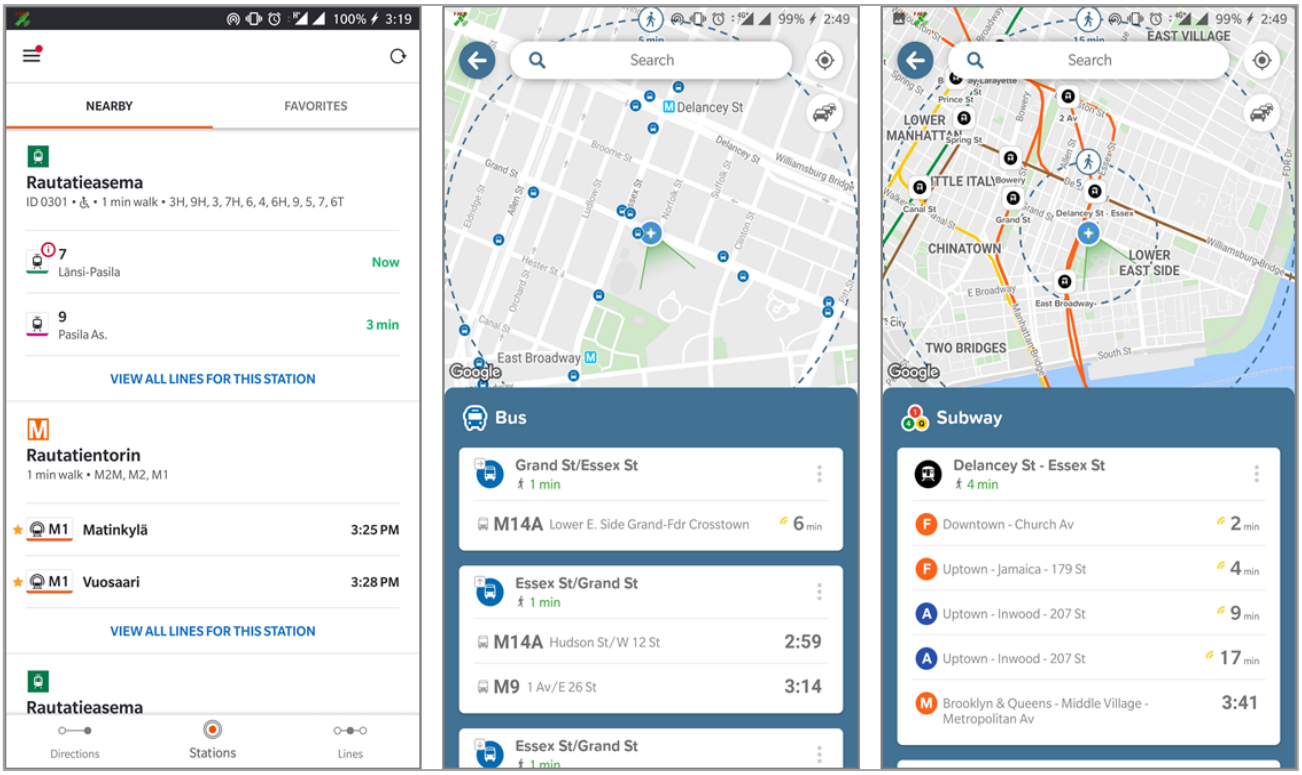

Figure 14 Nearby stop list of Moovit application (First screenshot), nearby bus stop list (Second screenshot) and subway station list (Third screenshot) of Citymapper application.

3.8 FEATURES FOR DISABLED PEOPLE

There are some features that can make disabled person's travel easier. For example, a feature that suggests users only wheel chair accessible transports. In Maps application[12], user can configure route suggestions so that it only shows routes that are wheel chair accessible. This feature is only available in London, New York, Tokyo, Mexico City, Boston, and Sydney. The system called Talking-Cane [14] can also be implemented for visually impaired user's public transport navigation.

[12] https://www.blog.google/products/maps/introducing-wheelchair-accessible-routes-transit-navigation/

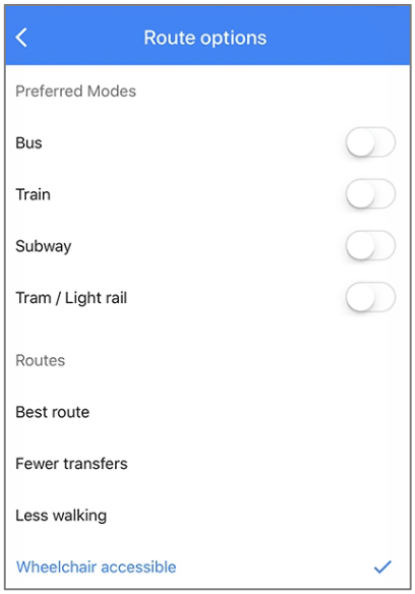

Figure 15 Wheelchair accessible route options in Maps application

3.9 OTHER FEATURES

Some other minor but useful features often found in the popular applications. Features like bike route planner help users to get a route combination of public transports and bikes. Information on bike share station can also be found in these applications. Some applications allow users to book shared vehicles through their application.

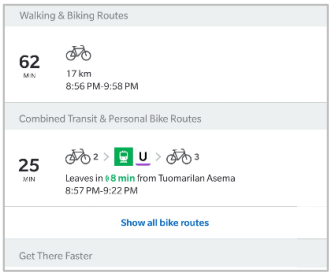

Figure 16 Moovit suggesting route combinations of bikes and public transport

4 PUBLIC TRANSPORT USERS IN FINLAND

A survey has been conducted by me to learn about how Finland's public transport users get information about public transports. There was a total of eighteen participants of five different age groups from four different cities. Ten of the participants were service holder and five of them were students. Rest of the participants were engaged to other professions. Among these eighteen participants, ten use public transports on a regular basis of which five use occasionally. Two users use both public and private transport in their daily life. To get the public transport information surprisingly no participant uses manual time table sticker attached in transport stations. They all use either mobile applications or browse websites. Five different applications are being used by our sample population. The applications are Maps, Moovit, HSL, *Nysse* and *Andropas*. Among these five applications HSL, Nysse and Andropas are developed in Finland where Maps and Moovit cover multiple locations in different countries.

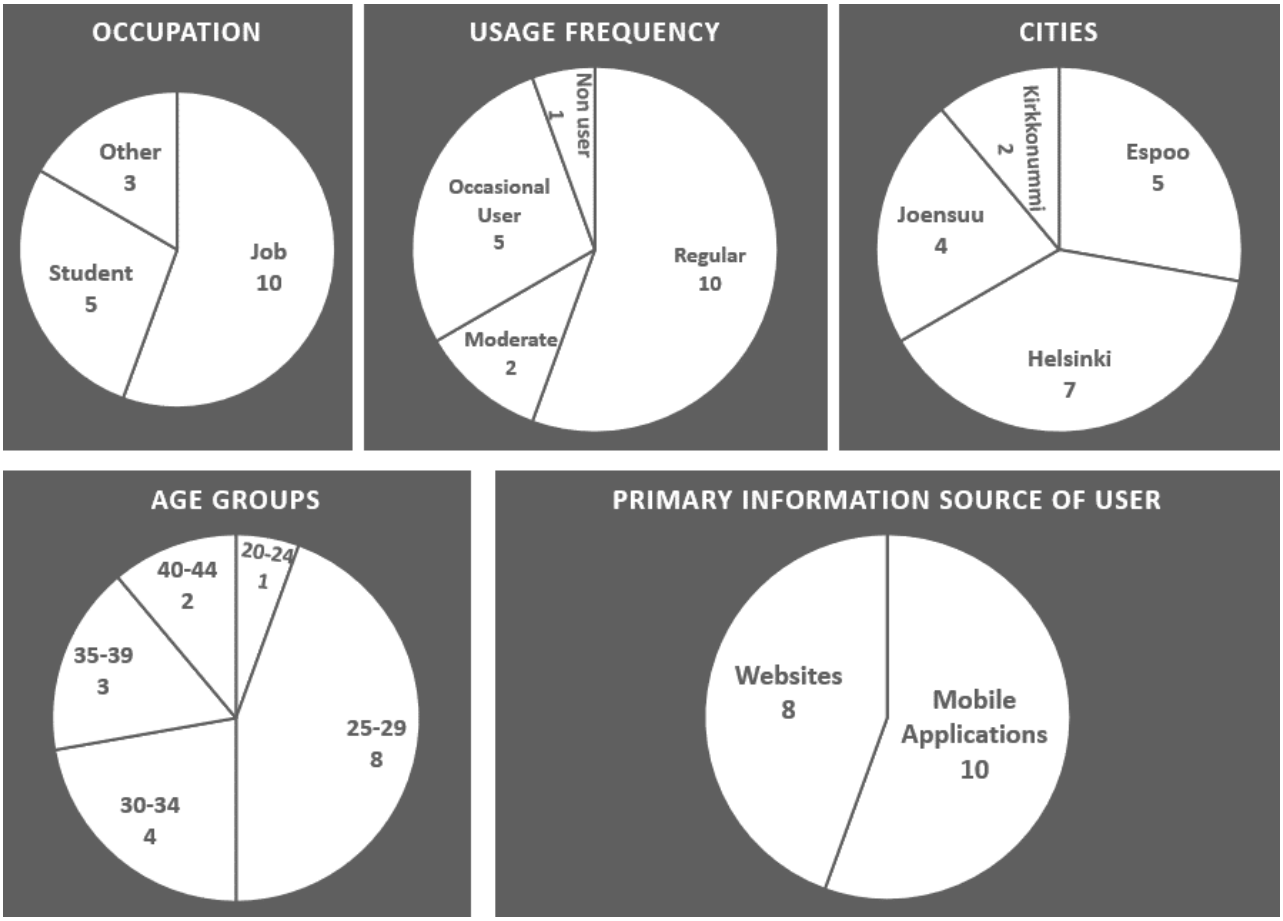

Figure 17 Characteristics of the Participants

It is possible to map our participants with user types I described in Chapter 2. As no participants use manual systems, we can say that all of them are technology enthusiastic users. Twelve participants use public transport regularly, so, they belong to the group of regular enthusiastic users. Five participants fall under occasional enthusiastic group as they use public transport occasionally. One user says that he is a new resident of Joensuu city and uses Moovit application which makes him a tourist type user as he doesn't know much about the city.

Maps users: Five participants among ten of the mobile application users use Maps and they think it is easy to use and has high information accuracy. Although one participant suggested (Table 1, comment 4) that he would like to have a feature that will show him a list of stops in a route including upcoming stop and the stop that he passed recently. The feature he demands is already in the application and he somehow did not understand it. Another participant wishes to have an option to buy tickets from the application.

Table 1 Suggested improvements users like to see in Maps

1	Telling me if the bus will be late or earlier
2	Adding a link to the bus company app to purchase tickets. This can be valuable to tourists specially for the train travels within the city limits.
3	Perhaps public transport timetables integrated with google maps would be nice
4	To indicate which (next) stop on the stop list we have passed and we going to.

Moovit users: The second most used application is Moovit. In our survey participant was asked to give scores on the scale of zero to ten on different criteria of the application, for example, *how easy is it?* and *how accurate is it?*. Moovit has got average easiness score of 7.5, and average accuracy score of 6.5 unit on the same scale. Though the rating is lower than Maps application, it has a very nice qualitative review (Table 2). However, one participant claims that the departure and arrival times it shows is not correct all the time and suggested to have the real-time location of the transport.

Table 2 Qualitative review and improvement suggestion from a user for Moovit

Review	As a new resident of Joensuu, I feel very comfortable and find the app (Moovit) very helpful. Bus stops are spread throughout the city and it had been difficult to find which bus goes where, to add to this, language was also a barrier. But the app provides the bus schedule, and bus stop where the desired bus would be stopping. It helped me and still being benefited by it. Sometimes the time are not accurate, I think because the buses are not tracked in real time.
Improvement Suggestion	Real time location of the public transport could have been of great value.

Finland's in-house application users: HSL, Nysse and Andropas are the three applications that have been developed in Finland and have a lower number of users. Only three people from the participants use one of these applications. In term of coverage, HSL and Andropas covers Uusimaa region only where Nysse covers almost whole Finland. One of the good features of HSL application is that one can buy tickets with this application.

Another application Andropas is favorite to its users due to lightweight[13] and accuracy according to a survey participant, though it has very few features. A broad local user experience can be found in google play store review section as this application has only been served in Finland. By observing some random comments (Figure 18), we can conclude that Andropas is light and very easy to use but it often becomes buggy when a new update comes.

Table 3 Reviews and Suggestions of Finland's inhouse applications

	Review	Suggestion
Nysse	Sometimes the app does not consider better routes	-
Andropas	Light weight, fast, accurate but having only basic features	Transport tracking would be useful but using HSL for that
HSL	-	-

[13] Lightweight application means the application consumes low memory and processing power of the operating device, in this case smartphone.

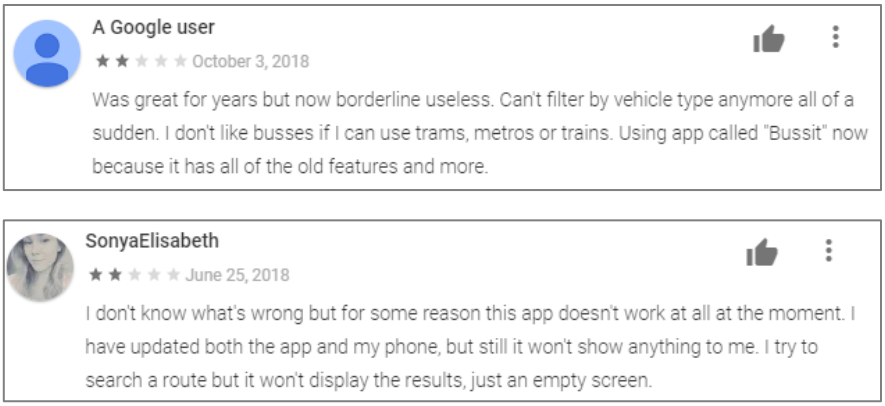

Figure 18 Review of Andropas users in google play store

Nysse is another simple and easy application serves in Finland covering a large area. According to survey participants and play store reviewers, it is very stable and easy application. Users can plan A to B route and find the nearest bus stop information with this application.

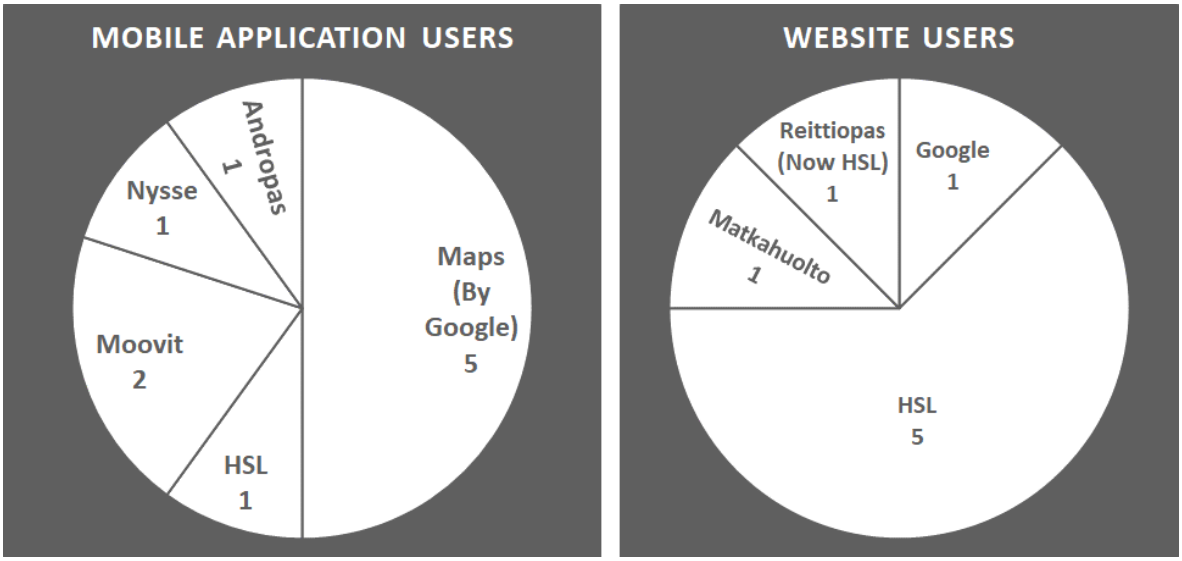

Figure 19 User distribution among different information sources

Website users: Beside mobile applications, participants get transit-related information from websites which they use both from mobile phones and computers most of the time. The mostly browsed mobile website are www.reittiopas.fi, www.hsl.fi, www.matkahuolto.fi, www.vr.fi and www.google.com/maps/. Some of the users of this group used mobile application previously but they do not use it now. In Table 4 we can see that one user is not a frequent timetable checker and has not kept application installed to his mobile phone and in another comment, a user says he/she does not want to waste memory.

Table 4 Some users stopped using mobile applications and switched to browser based transit information system

1	I find myself in front of a computer every day. I'm much faster at using that than any mobile device.
2	Not a frequent time table checker
3	I use google Map. It's easy to use and provides real time update. I don't want to waste my mobile space using a mobile application.
4	It's not possible to run multiple instances of the app to compare different scenarios at the same time.

According to the survey, HSL application has a small number of users, but the website hosted by HSL seems popular based on the number of users. Mainly because it loads faster in the browser (lightweight) and can be used in different tabs at a time.

We have got some nice suggestions about features for mobile application from the survey. By observing their suggestions and experiences, it is clear that there is no balanced application in the app market for the Finland region that have all the useful features. Every application has pros and cons. For example, Maps by Google contains lots of features users seem happy with it, but it does not contain a ticket-buying option. Also, some users claim that certain feature is absent in an application but in reality, the feature does exist in that application. They do not understand because its UI is not that self-explaining. There are some unique suggestions from the participants such as one user wants to know if his friends plan to travel with similar transport line as him.

Table 5 Suggestion for features participants want to see in a new application

1	Would like to see if any of my friends are planning to go on same or similar bus as me.
2	Real time, updated information, find out the shortest way, cost effective way, last week what was the condition on the road at the same time.
3	Clear UI. Andropas does not have an intuitive way to switch between screens.
4	At least the same features that of reittiopas.fi (live information of delays, location-based route detection, individual stop time tables etc.)
5	Light and fast
6	Possible less transfer route and google maps.

5 MOST USED APPLICATIONS AND USERS VIEW

Unlike desktop applications, mobile phone applications are distributed through an application store. For Android operating system mostly *google play store* (play store) distributes the application to the market. it is possible to get an overview of an application by analyzing reviews of play store.

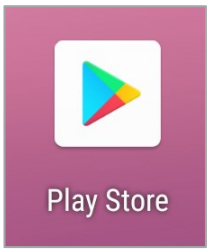

Figure 20 Google Play Store

In the rating system of play store, a user can give stars in the scale of 1 to 5 where 1 means very bad and 5 means very good experience. There is an option to give written review with the stars as well.

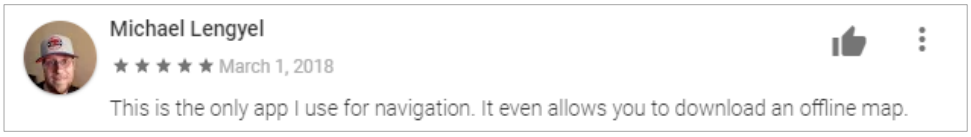

Figure 21 Example of play store rating

It is hard to define an application as good or bad from ratings entirely. Sometimes users are so generous and give very good ratings despite they have a bad experience of the application that has been described in their written review. Sometimes it also happens that the user gave 1 or 2 stars and described in the review that they have very good experience with the application but recently after some update, it is not working well. Application development company should consider this type of users very seriously and make sure their new update is not buggy. However, if we consider a larger population of reviewers then the overrated and underrated reviews cancel each other, and it can be possible to get a good idea about the application from the average rating.

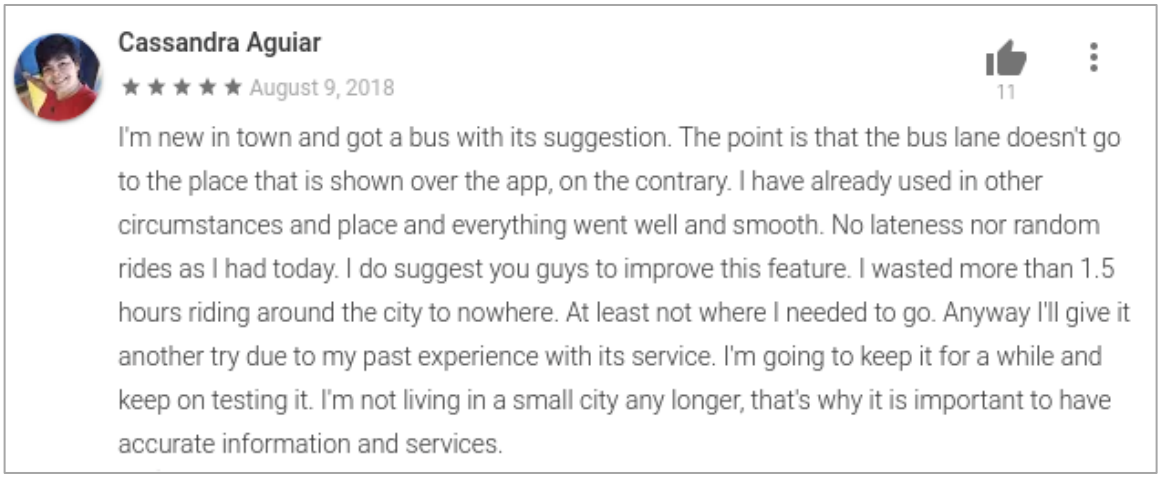

Figure 22 Given stars does not reflect the comment review

There are four most downloaded public transport application leads the google play store. They are Citymapper, Moovit, Transit and Maps. Maps also provides information related to private transportations. In the case of coverage, only Maps covers almost the entire world although not all the features are available everywhere. Compared to Maps the other three applications have very low coverage area. If we focus on the features of these applications, we can see that all these applications have the same or similar features accept one or two unique features. It is noticeable that none of the applications has a ticket-buying feature in their application but Maps and Citymapper show users the fare of the route they select.

Table 6 User numbers and their satisfaction of four popular android applications that provides public transport information (29 November 2018)

	Total downloads	**5-star ratings**	**4-star ratings**	**3-star ratings**	**2-star ratings**	**1-star ratings**
Maps (By Google)	1 Billion +	6,362,777	1,771,661	695,777	249,576	607,428
		66%	18%	7%	3%	6%
Moovit	50 Million +	448,673	119,866	43,371	20,204	38,011
		67%	18%	6%	3%	6%
Transit	5 Million +	28,537	7,993	3,539	2,274	4,115
		61%	17%	8%	5%	9%
Citymapper	5 Million +	51,089	9,753	2,927	1,543	3,061
		75%	14%	4%	2%	4%

Most of the features described in Chapter 3, are present in these four applications. All the features that are presented in these four applications and three other applications from Finland have been mapped in the table below. The tick mark (✓) represents the feature presence in the application and the plus-minus sign (±) represent that the feature is not available or partially available at all the supported locations.

Table 7 Feature availability in different mobile applications

	Maps	**Moovit**	**Transit**	**Citymapper**	**HSL**	**Nysse**	**Andropas**
A to B route planning	✓	✓	✓	✓	✓	✓	✓
Real time departure and arrivals		±	✓	±		✓	
Alerts		✓	✓	✓		✓	
Step by Step guide	✓	✓	✓				
Favorites	✓	✓	✓	±	✓	✓	
Trip cost estimation	±				✓	✓	
Ticket buying option					✓		
Nearest transport station information	✓	✓	✓	✓		✓	
Feature for disabled people	±	±					

6 MOPSI NEXT BUS

Mopsi Next Bus is a travel planning android application with the ability to get nearest public transport stops/stations/docks location and all the available transport leaves those places in near future without any kind of UI interaction. The project has been inspired by the bus timetable system built-in application named Mopsi. Beside many other features, Mopsi application has a nice *Guide* feature where a user could get the nearest bus stop locations and all the buses leaves from that location. Along with this specific feature Mopsi Next Bus also contains step-by-step route tracking system that allows user to know about the next stop and estimated time to reach that stop while they are travels.

When a user opens the application a home screen will appear. In Figure 22, the home screen is shown, where the red-dotted rectangles represent different segments of the screen. More details of each segment are described below.

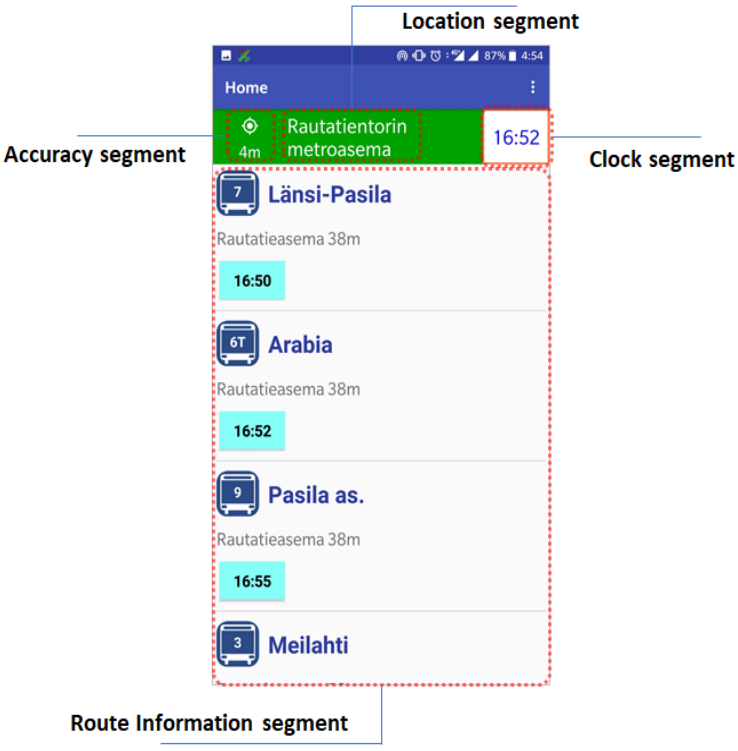

Figure 23 Multiple parts of home screen

Accuracy Segment: In this segment, a user can view the current GPS status. Is the devices location service being on or off? How accurate it is? The user will get answer to these question by one glimpse. However, the whole title bar also changes its color with location accuracy. Such as it will turn green if the location obtained from a device that has a high accuracy. It will go reddish if the accuracy is low.

Location Segment: In the location segment, a user can see the name of the location. If the application fails to get the name of the location, then the latitude and longitude value will appear at the same place. If the user taps on the location, a custom location selector window will appear where he will be able to select a custom location.

Clock Segment: In this segment, a user can select their custom time and able to view transport stops relative to the given time. The time can be changed by up-down scrolling or through time selection dialog which will appear if the user taps on the time segment.

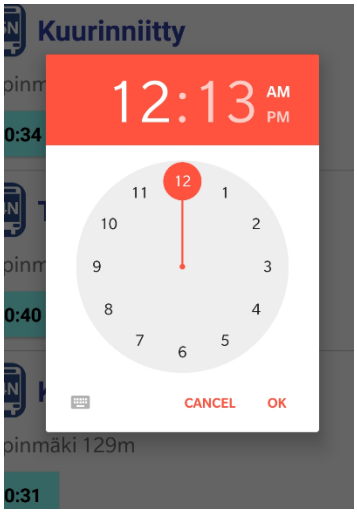

Figure 24 Time selection dialog

Transport Stop Segment: Here a user can see a list of transport-lines leaving from nearest stops relative to the location user chooses or relative to device's current location. The time will be near future from the current time or from selected time depending on the user's decision. Each entry contains transport number, destination stop name, nearest stop, distance from the current place or selected place and time of departure from the nearest stop.

Figure 25 Transport List Item

Location Selector Window: By moving the pointer on top of the map a user can select their own location. After location selection is done user can simply go back to home screen and every operation will be performed respect to the custom location instead of devices real-time location. the user can reset his custom selection and go back to GPS mode by pressing the current location icon at the top-right of the map of the location selector window.

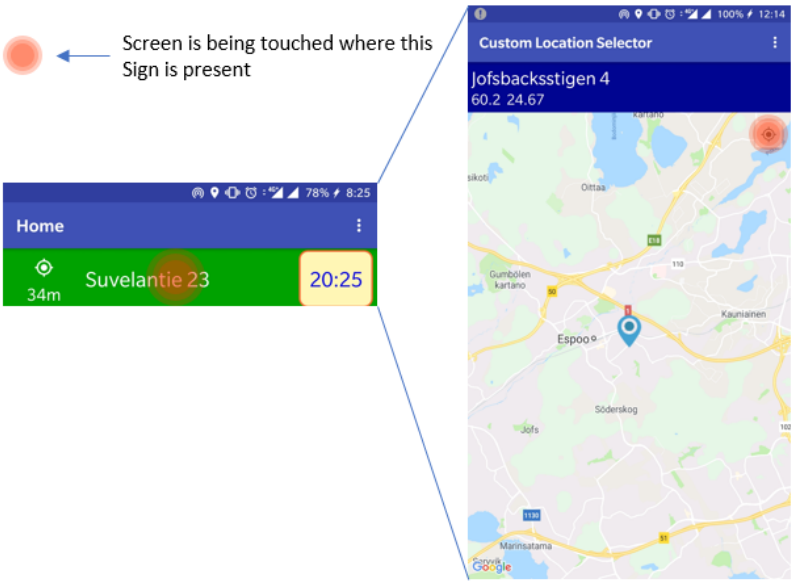

Figure 26 Custom Location Selector

Transport Information window: If a user selects a transport-line from the list, more details will be shown. In the window, all the information will be shown that were on the list. In addition, there will be a map that will show the route between terminal transport stop and nearest stop's location. Both places will be marked in the map including the current position of the user's device.

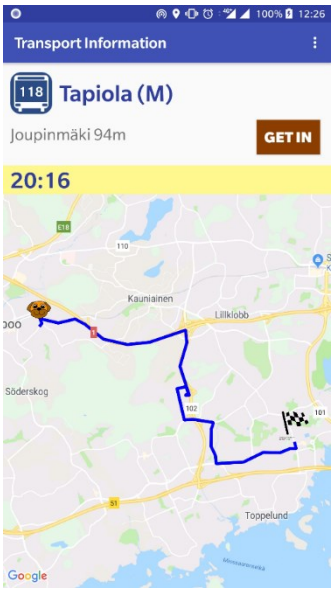

Figure 27 Details information of selected transport-line

There is a *GET IN* button located in this window. When a user clicks that button, the application will assume that user will get on to that transport and gives user more details information about the transport route depending on the user's current location. It will show which specific place user is currently located, which transport stops he crossed, last stop's name, the estimated arrival time of the next stop, is he on stop or on the route. If the user minimizes the application, then he will get notifications on the status bar with a long vibration. The notification is also visible when the screen is locked. It also shows all the written information without the map. The map will follow the user's current location when the transport starts to move. However, if the user touches and moves the screen this feature will be turned off, but the user can resume it by clicking the current location button located on the top-right corner of the map.

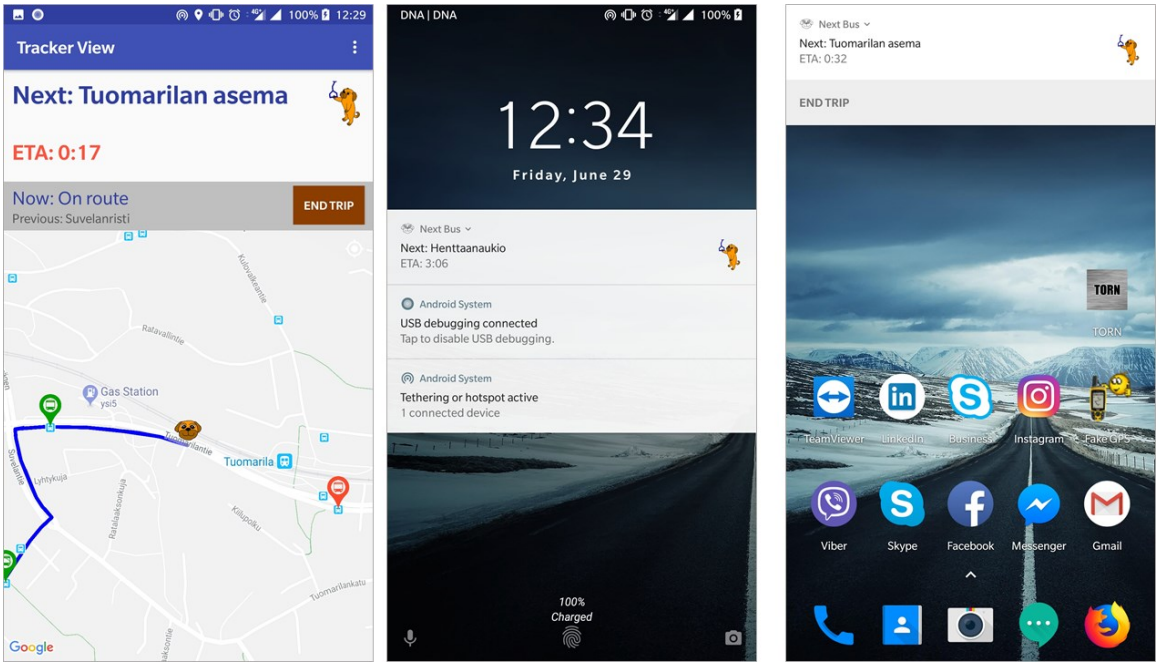

Figure 28 Overview of Tracking window

6.1 DEVELOPMENT TOOLS AND APPLICATION DESIGN

The application has been developed using *Android Studio* without any kind of cross-platform framework and has been tested with two different mobile phones which run a different version of Android operating systems. Besides that, the application is also tested on different emulators. *Java* has been used as a main programming language and *XML* (*Extensible Markup Language*) for user interface (UI) design as suggested by Android Studio. During the development process, *GIT* has been used as a version controlling system.

The application is well divided into multiple parts and classes for a better understanding of code and to maintain better object-oriented behavior. There are some controller-classes where operation logics are being described in the other hand, there are some model-classes which are being used for storing data in a well-structured way. The views (front-end designs) are mostly written in an XML file which is a suggested way of doing work with the Android framework. However, due to dynamic content such as bus stop list, some parts of the front-end creation have been written under controller classes. The following activity diagram shows the overall coding design of the application.

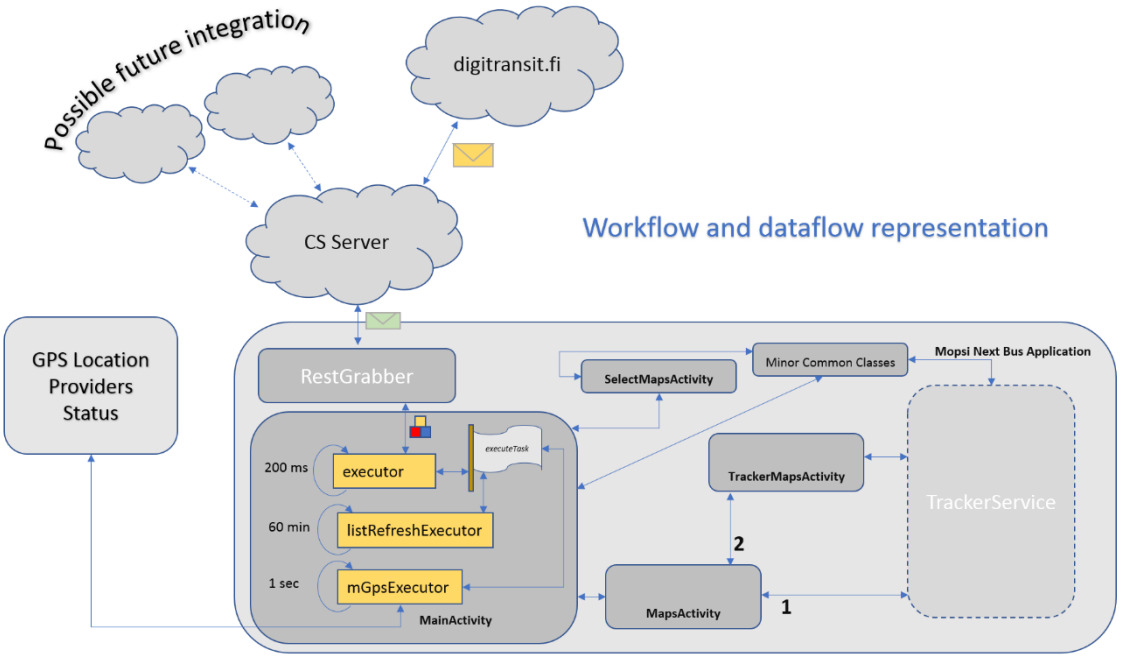

Figure 29 Work and data flow representation

6.2 DATA SOURCE AND TRANSACTIONS

The application gets the necessary data from the University of Eastern Finland's (UEF) CS-server. An *application programming interface* (API) service has been implemented in the server side which returns *JavaScript object notation* (JSON) response (Figure 30). The server-side application gets information from a third party opensource transport information provider named *Digitransit* owned combinedly by HSL and the Finnish Transport Agency[14]. UEF's CS-server processes the responses received from Digitransit and redistributes through RESTful API. The necessity of having a middle server will be very important in future when the application will provide worldwide service. It will need different information sources from different areas and processes different types of data on a mobile phone will take lots of memory and processing power. So, it will be an efficient way to preprocess data in a middle server and redistribute it to mobile phone application with a fixed format.

[14] https://digitransit.fi/en/

```
{
  "bus_stops":[
    {
      "name":"Pataluoto",
      "latitude":"62.612929358891",
      "longitude":"29.83036045874",
      "address":"Ranta-mutalantie 89, Joensuu",
      "lines":[
        {
          "line":"7A",
          "departure_time":"0654",
          "destination":"Rantakyl\u00e4"
        },
        {
          "line":"8A",
          "departure_time":"0624",
          "destination":"Rantakyl\u00e4"
        }
      ]
    },
    {
      "name":"Siianpolku",
      "latitude":"62.614556111254",
      "longitude":"29.835602828593",
      "address":"Ranta-mutalantie 86, Joensuu",
      "lines":[
        {
          "line":"7A",
          "departure_time":"0653",
          "destination":"Rantakyl\u00e4"
        },
        {
          "line":"8A",
          "departure_time":"0623",
          "destination":"Rantakyl\u00e4"
        }
      ]
    }
  ],
  "request_type":"get_nearest_bus_new"
}
```


Figure 30 JSON response of a request from UEF's CS-server

6.3 USER'S LOCATION DETECTION

To know a mobile phone's location in an Android operating system (OS), developers need to request location to the OS. Based on the request the OS responses with location value (latitude and longitude) and the accuracy of that value. Users must request location with a location provider. Location providers are the source of location from which the OS gets the location. There are three different location providers available in latest android phones.

1) **GPS provider:** The OS directly get the location from GPS satellites using GPS sensors. This process consumes relatively[15] higher energy and gives data with high accuracy.
2) **Network provider:** The location is retrieved from cell towers and WiFi access points. This process 's accuracy varies based on the phone's current location and consumes relatively[15] medium to low power.
3) **Passive provider:** In this process, the location is collected from cached data. For example, if there is another application runs in the background and requests data for its own purpose then the operating system will get the data from there instead of requesting it from an outside source (GPS or Network provider). This process has very low accuracy as the location is not being refreshed directly[16].

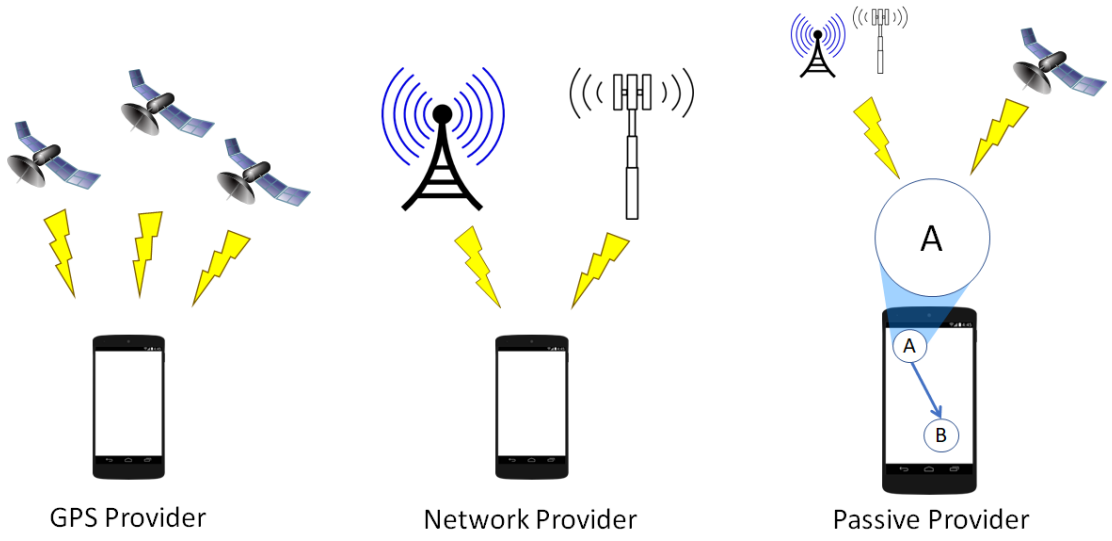

Figure 31 Different types of location providers
(http://www.clker.com/)

In our application, we focused on high accuracy and ignored the passive provider. In any type of navigation application, getting accurate location is mandatory; otherwise users might get wrong information. Our application checks both GPS and Network provider and uses the location which has higher accuracy. Figure 32 shows the flowchart of getting the most accurate location by our application.

[15] GPS provider consumes the maximum power among other three providers. Other power consumption references are being compared to GPS provider.
[16] https://developer.android.com/reference/android/location/LocationManager#PASSIVE_PROVIDER

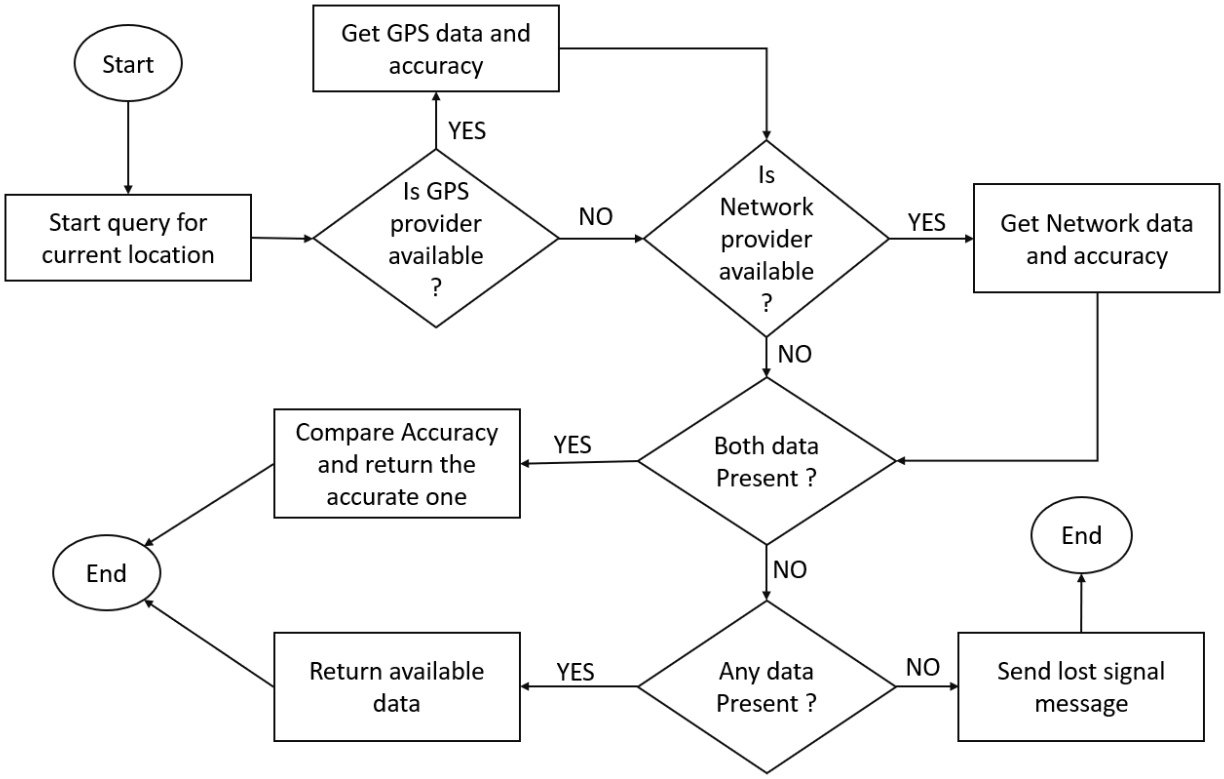

Figure 32 Flow chart of location determination

7 FUTURE IMPROVEMENTS

As discussed in the previous chapter Mopsi Next Bus has two features from the popular feature list discussed in section 3.1. As we can see, lots of features are missing from Mopsi Next Bus which is present among popular application. We need to include these features in future to make the application more acceptable to its users. There can also be a sector of research to make the existing features easier and more useful to its user. By keeping these points in mind, we can speculate the future development of Mopsi Next Bus in three different ways.

7.1 INTEGRATION OF EXISTING POPULAR FEATURES

Before including features that exist in other applications, we need to do elaborate research on the UI of those features. A user will not stop using their application if they do not get more comfortable with the new application. Reducing the number of user interaction can be a good step towards a good user-friendly UI. Unnecessary features should be avoided to keep the application from getting more complex from the users' perspective. In conclusion, when we add a new feature to our application it should be kept in mind that we are not making it more complex than previous.

7.2 INTEGRATION OF TICKET BUYING FEATURE

We have noticed that the transport application that targets the international market does not include the ticket-buying feature in their application. It seems easy to include this feature in this modern e-commerce era, but if we think deeply then we can understand that to implement such feature the application company must consider lots of aspects. To be clear, if we look at other e-commerce sectors, we can see that there are lots of e-commerce site that has only one vendor and multiple customers and the vendor is the website owner. The receiver of every transaction is the vendor that makes the total business easier. However, E-commerce website like Amazon, Ebay or Alibaba has multiple vendors and customers. These companies/websites work as third-party agents who makes sure that asset exchange between vendors and customers are occurring smoothly. The number of this kind of website that serves internationally is very few. Also, cross-border transactions must follow lots of different rules from different countries. Maintaining these transactions will also need an increased number of employees.

Besides transaction related difficulties, we will have ticket checking related difficulties. In Finland, mobile tickets are checked by the bus driver manually. The checking can be automated by *near-field communication (NFC)* sensor, but it will be too optimistic to assume that every phone will have this sensor. The checking can be done by NFC for partial the population but in case of a highly populated country like China, it's not possible to check ticket unless the total process is automatic.

Figure 33 Overpopulated transport in UK | Photograph: Guy Bell / Alamy

Integration of this single feature will cost the application company lots of difficulties and an increased number of employees. To solve this problem an entire research can be conduct in this area in future.

7.3 SUGGESTION OF DESTINATION

Smartphone users might have noticed that when they use their keyboard in their phone to write text messages, there is a suggestion bar above the keyboard that suggests the user the next word he might want to type. For example, if someone writes *How* then *are you* will appear on the suggestion bar. Again, if someone writes *Happy* then *Birthday* will appear. This suggestion system is totally user independent. Every user will get suggestion depending on their previous use. This feature also works for other languages too. The translation of *How are you?* in Bengali is Kemon achen. On my phone, if I write *Kemon* it suggests *achen*. Even it does not have to be a proper language. If someone uses some word sequence repeatedly then the feature will start to suggest the words by following that sequence.

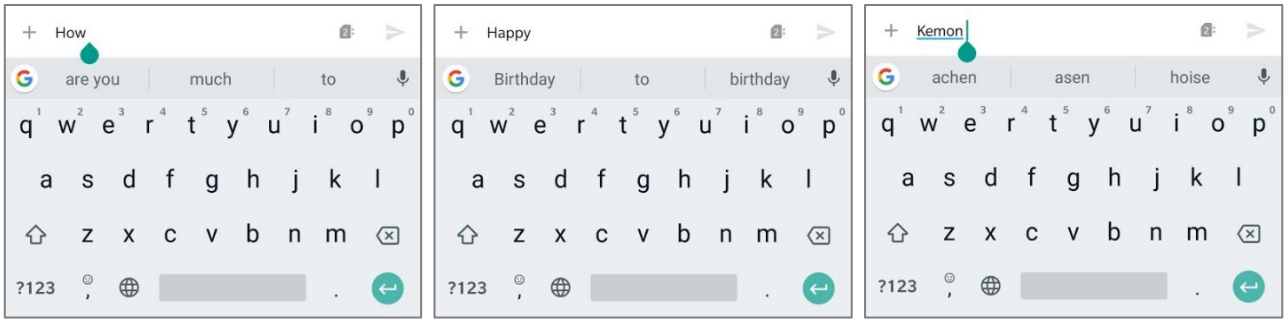

Figure 34 Next word suggestion by google keyboard

The same logic can be implemented as a feature that suggests your next destination. Most regular public transport users use the same route repeatedly most of the time. For example, a user repeats the route A-B-C-D and E-B-C-F in his daily life where A, B, C, D are E are the places or checkpoints he visits. Now in a certain time if the user is at C then depending on his travel path the application can suggest either related to D or F as his destination or maybe both with priorities in ascending order. The suggestion mind includes the next bus leaving to D or F. This destination suggestion system can be implemented in Mopsi Next Bus in future.

7.4 ZONE BASE A TO B SUGGESTION SYSTEM

A feature has been described in Section 3.1 of this thesis where applications suggest routes to users based on a source and a destination location. Most of the applications' default preference is to suggest the fastest routes in ascending order. However, the suggested list can be customized with different factors like *less walking*, *earliest departure* (Figure 8). By observing their customizing criteria, we can conclude that all applications want a user to have a fastest and most comfortable journey possible. But some users might want the cheapest way instead of the fastest way. In many cities, the ticket cost of public transports is calculated based on zones. Zones are the selected areas on a city map. Ticket price is fixed between any two zones. In some cities like Amsterdam (Figure 35), the ticket price is calculated based on source and destination zones only[17]. It does not matter which other zones a user travels to reach the destination by transport, the ticket price will always be calculated based on his source and destination location.

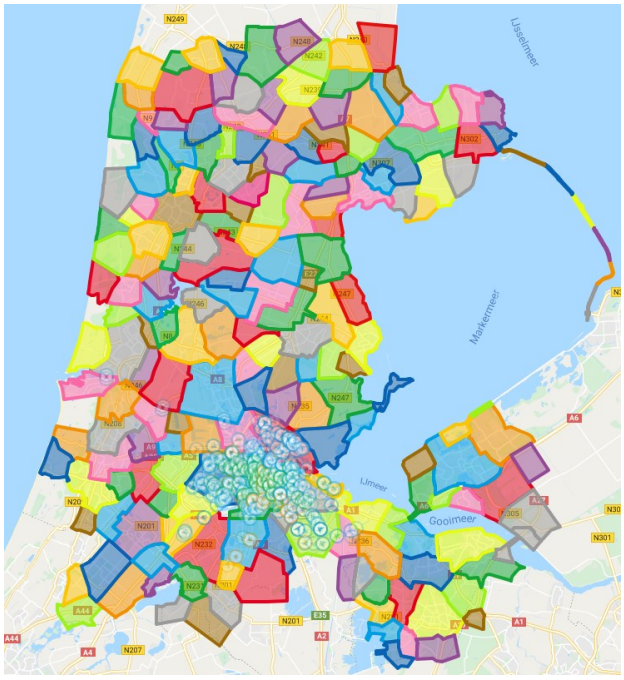

Figure 35 Different zones[17] of Amsterdam, Netherlands

In some cities, if a user travels through other zones then the ticket price will be calculated differently. For example, in the Helsinki region, the transport company HSL is going to implement a new zone system where there will be four zones. If someone travels from one end of Zone-C to other ends through Zone-B, then he will be charged with two zones' ticket price.

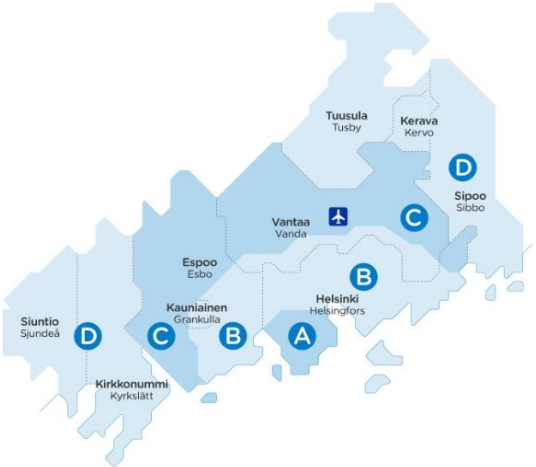

Figure 36 New zone system of Helsinki

[17] http://maps.gvb.nl/en/zones

In Figure 37 (a), a suggestion of Maps application is being shown where both source (Tuomarila) and destination (Tikkurila) are in Zone-C, and all routes of the suggestion list intersect both Zone-A and Zone-B to reach the destination from the source. An option can be introduced in A to B feature where the suggested list will be based on selected zones only.

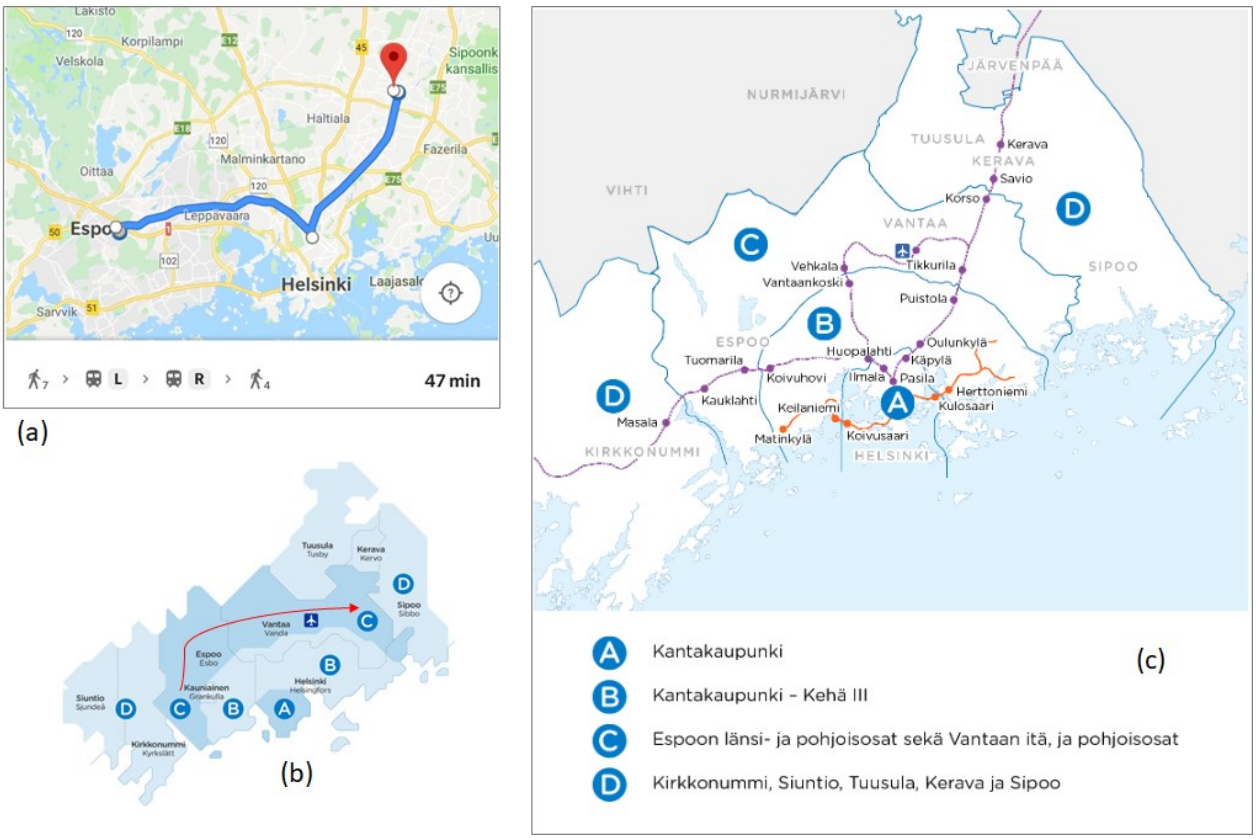

Figure 37 (a) Suggestion by Maps where source and destinations are in zone-C
(b) Zone based suggestion where the transports will not go outside the selected zone
(c) New zone system of Helsinki region

8 CONCLUSIONS

In this thesis, a model for public transport application for mobile phones is presented, which will be useful for most of the users and can be used in most of the cities of the world. We have categorized three different attributes of the users and extracted five unique user types. Based on the most successful applications available in the market and online reviews, we have extracted most demanding features for the model application. A survey has been conducted in Finland to know the currently used public transport applications of the country and what are the expectations of their users. The user view of the most used applications is analyzed, and city coverage of these applications was determined.

A prototype of the model application named Mopsi Next Bus is developed with two features. In one feature user can know about the nearest transport stops and the transport leaving that stop in near future and other feature will guide a user step by step while he/she performs a travel. The application has been developed such a way that a user can get services with a low amount of interactions with it.

Possible improvements of Mopsi Next Bus have been discussed that will take the application closer to the model application. The reason behind the absence of ticket buying feature among popular applications has been analyzed. Two new features have been suggested to improve the model application. These features are not presented in any application in the market.

9 REFERENCES

[1] S. Davey and A. Davey, "Assessment of Smartphone Addiction in Indian Adolescents: A Mixed Method Study by Systematic-review and Meta-analysis Approach," *International Journal of Preventive Medicine,* vol. 5, no. 12, p. 1500–1511, 2014, ISSN: 2008-8213.

[2] M. Kevin, "Simon says: Super-phone is giant step," USA Today, November 3, 1993.

[3] N. Ohmori, T. Hirano, N. Harata and K. Ohta, "Passengers' Waiting Behavior at Bus Stops," in *Proceedings of the 4th International Conference on Traffic and Transportation Studies*, Dalian, 2004.

[4] H. Iseki, B. D. Taylor and M. Miller, "The effects of out-of-vehicle time on travel behavior: Implications for transit transfers," in *CA: California Department of Transportation.*, Los Angeles, 2006.

[5] L. Hu and R. J. Schneider, "Shifts between Automobile, Bus, and Bicycle Commuting in an Urban Setting," *Journal of Urban Planning and Development,* vol. 141, no. 2, 2015, ISSN: 0733-9488.

[6] D. Maggiorini, C. Quadri and L. A. Ripamonti, "Opportunistic mobile games using public transportation systems: a deployability study," *Multimedia Systems,* vol. 20, no. 5, pp. 545-562, 01 October 2014, ISSN: 0942-4962.

[7] S. Beul-Leusmann, C. Samsel, M. Wiederhold, K.-H. Krempels, E.-M. Jakobs and M. Ziefle, "Usability Evaluation of Mobile Passenger Information Systems," in *Design, User Experience, and Usability. Theories, Methods, and Tools for Designing the User Experience*, A. Marcus, Ed., Springer International Publishing, 2014, ISSN 0302-9743, pp. 217-228.

[8] M. Takamatsu and A. Taguchi, "Train and bus timetable design to ensure smooth transfer in areas with low-frequency public transportation services," in *Proceedings of the 6th*

International Conference on Railway Operations Modelling and Analysis, Narashino, Japan, 2015.

[9] S. Jiang, J. Ferreira and M. C. Gonzalez, "Activity-Based Human Mobility Patterns Inferred from Mobile Phone Data: A Case Study of Singapore," *IEEE Transactions on Big Data,* vol. 3, no. 2, pp. 208 - 219, 23 May 2017, ISSN: 2332-7790.

[10] I. Constandache, R. R. Choudhury and I. Rhee, "CompAcc: Using Mobile Phone Compasses and Accelerometers for Localization," in *INFOCOM*, 2010, ISSN: 0743166X.

[11] H. Aly, A. Basalamah and M. Youssef, "Accurate and Energy-Efficient GPS-Less Outdoor Localization," *ACM Transactions on Spatial Algorithms and Systems (TSAS),* vol. 3, no. 2, pp. 1-31, 29 August 2017, ISSN:2374-0353.

[12] UN World Health Organization (WHO), "World Report on Disability : Summary," 2011, WHO/NMH/VIP/11.01, available at: https://www.refworld.org/docid/50854a322.html.

[13] UN World Health Organization (WHO), 2010, WHO/NMH/PBD/12.01, available at: https://www.who.int/blindness/GLOBALDATAFINALforweb.pdf.

[14] J. S. Lee, H. Choi and J. Lee, "TalkingCane: Designing Interactive White Cane for Visually Impaired People's Bus Usage," in *MobileHCI '15 Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct* , Copenhagen, Denmark, 2015, ISBN: 978-1-4503-3653-6.

[15] S. J. Czaja, N. Charness, A. D. Fisk, C. Hertzog, S. N. Nair, W. A. Rogers and J. Sharit, "Factors Predicting the Use of Technology: Findings From the Center for Research and Education on Aging and Technology Enhancement (CREATE)," *Psychology and Aging,* vol. 21, no. 2, pp. 333-352, 2006, ISSN: 0882-7974.

[16] N. Charness, C. Schumann and G. Boritz, "Training older adults in word processing: Effects of age, raining technique and computer anxiety," *International Journal of Aging and Technology,* vol. 5, pp. 79-106, 1992, ISSN: 0891-4478.

[17] M. Heinz, P. Martin, J. Margrett, M. Yearns, W. Franke, H. Yang, J. Wong and C. Chang, "Perceptions of technology among older adults," *Journal of Gerontological Nursing,* vol. 39, pp. 42-51, 2013, ISSN: 0098-9134.

APPENDIX

Perfect strategy to publish an into application Market

When the development work is finished, the application needs to place in a marketplace from where users can download the application into their mobile. To publish an application into the market we need to go through certain procedures to make the application more successful. These processes are equally important for both first time and updated version publishing. We need to make sure that we follow these procedures strictly each time before the application goes into the application market.

There are some very effective instructions written in androids official documentation site's *Launch checklist*[18] section which should be followed before publishing an application. However, I am going to discuss some off-book instruction which I have learned through my observations and by online research. If we look at the rating system of google play store, we can see that the ratings are not version independent. That means if someone's application is rated poorly in the beginning then after releasing the second version will not increase its rating dramatically even the next version is flawless. So, to release the original version of the application a beta version should be released to capture reflections of the users.

We can observe both from the play store reviews and the small survey that has been conducted in this thesis that some users complain about missing features in an application, though they liked that application. Despite having a low number of features, people like the overall application. On the other hand, there are some applications in the market that seems to have all the feature present in it. But users do not like it because they are too complex. It can be also observed that some reviewers say that the application was very good before, but it became complex after a certain update. Clearly, when an application introduces new feature their existing users do not want to learn the new way of operating. So, it is important to research thoroughly before introducing a new feature that it's not making the application complex or unfamiliar to its existing users.

[18] https://developer.android.com/distribute/best-practices/launch/launch-checklist

Beside Android developer site's instruction, there are different off-book procedures described in different sites that can be effective while publishing a new application. One of the tricks that have been described in a Stack Overflow [19]site is that to release application before the weekend. The logic behind this trick is that successful application-updates will not release before the weekend because there can be an unnoticed bug in the latest release that can cause a bad experience to their user and hence the rating will go low during the weekend. The new companies or solo developer can take that chance and release their application before the weekend and during that time play store will suggest the new releases of their application. If the application is good, then it might get popular overnight. Similar kind of off-book suggestion has been described in different websites and we should consider these while releasing an application into the application market.

[19] https://stackoverflow.com/questions/5119633/to-do-list-before-publishing-android-app-to-market