Appling Lean Startup Methodology for mobile application development: An Ethiopian context

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Master's Thesis
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Date 16.05.2016

Abstract

The original purpose of a mobile phone was designed for basic communication. Today, phones are used to perform different advanced activities, for example, to access location via GPS, to take photos, as media players, and to access the internet. The growing usage of smartphones highly contributed to the emergence of advanced mobile applications. In developing countries mobile phones are the most common device used to access the Internet. This study aims to provide train timetable mobile application for the new developed Addis Ababa light rail transportation system.

The purpose of developing a train scheduling app is to help users find train timetables easily and to improve time efficiency. Technology and mobile usage in Ethiopia are assessed to understand the current Information and Communication Technology (ICT) situation in Ethiopia. The study utilized the lean startup method for designing and developing the mobile application. In addition, the PSD model and a system's self-referential persuasion concept provided the theoretical framework. Persuasive system design's primary task support principles are utilized strongly in the design and development of the app by reducing complexity and providing a meaningful content.

Design science research integrated with lean software development principles was used to carry out this research. A literature review was conducted to support the thesis with background knowledge. Interviews were also conducted to gather user feedback with regards to the process of designing and developing the app. The study found that waiting for public transportation is time-consuming. The mobile application improves time efficiency and enhances punctuality.

Evaluating the mobile application on the actual market is one of the limitations of this study as the developed app was only evaluated between test groups. The newness of the train system in Addis Ababa and bureaucratic management has limited the present study's ability to gain accurate information about the train schedule and related information.

Keywords
Train scheduling app, lean startup, hybrid app, PhoneGap, self-referential persuasion, persuasive system

Foreword

I would like to thank all the people who helped me and supported me with writing of this thesis.

Firstly, I would like to express my sincere gratitude to my supervisor, Professor Harri Oinas-Kukkonen for his guidance with this thesis. Secondly, I would like to thank Michael Oduor the examiner of the thesis for his insightful comments and productive critics. Thirdly, I would also like to thank Eskindir Abdela for his continuous support and guidance.

Finally, I would like to thank my family and friends who supported and encouraged me throughout my studies and writing this thesis. I would also like to thank people involved on the evaluation and interviews.

Hana Kebede Asfaw

Oulu. May 16, 2016

Contents

1. Introduction

This thesis work emphasizes the application of lean startup methodology in design and development of a train schedule mobile application, to increase time efficiency. Plus to understand how new mobile applications are used and perceived in developing countries. Mobile platform provides a plethora social benefits apart from the intended usage. The mobile platform enhances health, business, education and other daily activities. Mobile phones used widely in the developing countries to access the web rather than desktops or laptops (Oinas-Kukkonen & Oinas-Kukkonen, 2013). Mobile data network and mobile services are still in the early stage in the developing countries. Even if mobile phones are used for accessing the web in the developing countries, there is a lack of technology availability and network coverage. Ethiopia is one of the developing countries that has a lot of room for improvement. The monopolized telecommunication control in Ethiopia contributes for the slow Internet and data communication development. "The absence of mobile banking and other innovative mobile applications that support social and economic development has been one of the major setbacks to Ethiopian's ICT progress in the recent years" (Adam, 2012). In today's highly sophisticated technology era, it is outdated to use only manually written paper transportation schedules. In developed countries the user knows what time their next transport comes before they leave from where they are. However, it is the only option to use manual timetables in some developing countries, which is written on paper and posted around transport stations.

Transportation has been the major challenge for the mobility and productivity of the population in Ethiopia. Ethiopia has the lowest road network in the world (Jensen & Sarroco, 2002). To solve this transportation problem and to enhance the public transport in the city, the government is implementing a new light train rail in the capital city (Addis Ababa). On September 20, 2015, the transportation service started its operation partially. This kind of transportation system is a new phenomenon for the population who mostly uses the bus and other vehicles. Since it is a new transportation system, the users will have a challenge finding the right time when the train departs and arrives. Since there is no pre-planned timetable system ready, developing a train schedule mobile app will be beneficial for the community.

The emergence of smartphones attracted most researchers in the different context. Generally, plenty of research has been done related to mobile app development for different platforms. There are different issues and challenges involved in the development of mobile apps. Researchers and scholars have developed and identified different standards and principles for developing mobile apps. However, limited research has been done in the context of developing countries mobile app development and smartphone usage. The main reason for choosing mobile app rather than web system is the easy availability. Currently, most people have access to smartphones than a computer and other electronic devices. According to Budde (2015) telecom research site, the mobile penetration rate in Ethiopia is 34%, fixed line 1.2%, and the Internet 1.3%. Due to its mobility, the app will help the intended user to use their time effectively. They will not have to waste their time by waiting for the next train. Hence, there are a lot of mobile platforms available today, and the proposed app should be platform independent. PhoneGap/Cordova framework used to create the mobile application. PhoneGap/Cordova is an open source framework used to create mobile apps by using Hypertext Markup Language (HTML), Cascading Style Sheets (CSS) and JavaScript. (PhoneGap, 2015).

There are several software development methods and methodologies introduced through time. Agile methodologies follow an iterative approach to build software with self-organized teams. The major advantages of using an agile methodology for mobile application development are to focus on the consumer market, to provide quick releases and to fix issues for small releases. Lean is one of the most used agile engineering paradigms in recent years (Flora et. al., 2014). "Lean management philosophy focuses on increasing value by eliminating waste" (Maglyas et al., 2012). There are five lean principles: value, value stream, flow, pull, and perfection. (Maglyas et al., 2012). The lean principles and theories are used for planning and developing the pilot mobile app. The developed mobile app called a pilot app because it is developed for trial purpose with major functionalities.

Design Science Research Methodology (DSRM) is applied in this study. Design Science Research (DSR) is an iterative process which seeks to create innovative artifacts to solve an identified problem. Moreover, design science process and guidelines used to have clear insights and steps.

The major contribution of this study is to design and develop easily accessible train timetable checking mobile application. It changes and improves the traditional way of presenting the transportation schedule. The study will provide a general insight how ICT is used and perceived in the developing countries. In addition, the overview of mobile application development and its ecosystem will be discussed to understand the technology behind mobile app development. The knowledge acquired during this study will be a base for further researches and studies. It will also inspire other transportation companies in Ethiopia, to adopt and develop more advanced easy accessible transportation timetable mobile apps. These will enhance punctuality and help the worker society to be on time on their work desk. Moreover, the study shows how lean startup methodology is applicable for mobile application development. Appling lean software development with DSR research will allow the use of positivist or scientific research principles through hypothesis test (Ruhi and Akhigbe, 2016).

This thesis has seven chapters. Chapter two discusses the theoretical background of mobile application development and mobile app development methods and methodologies. This chapter also analyses the mobile network and application usage in Ethiopia and the Self-referential persuasion concept. A system's self-referential persuasion can be measured in users staying "as part of its ecosystem and are persuaded to frequently use it, even though the system may not necessarily be persuasive in itself". Chapter three explains the design science research method. Chapter four examines the problem and solution hypothesis and discusses the development of the Minimum Value Product (MVP).Chapter five includes the evaluation of the artifact and chapter six discusses the results of the study. Finally, chapter seven includes conclusions and discusses the research's limitations, challenges of the research project and directions for further research.

2. Background

In this chapter, the existing theories and backgrounds are discussed, in order to develop a mobile application. ICT usage in Ethiopia is discussed in the first section to understand the current state of the case country. The second section summarizes the general overview of a mobile app development. The third section discusses mobile app development methods and methodologies. Finally, the last section presents the self-referential persuasion concept to support the study theoretically.

2.1 ICT usage in Ethiopia

This section discusses the general usage and access of ICT in Ethiopia. It is important to understand the intended country's ICT infrastructure, before planning and developing any ICT application and services. Since, ICT is a broad concept, only mobile and internet services are discussed more specifically.

The role of ICT has had a tremendous impact on social and economic growth and for solving worldwide problems. The development of modern ICT application and services will be a means of tackling poverty and hunger in the developing countries (Oinas-Kukkonen & Oinas-Kukkonen, 2013). Innovators and startups are adopting ICT in Africa to improve agriculture products, financial services, education systems, health services, regional trade integration and cross-border communications. Lack of ICT literacy is the major challenge for adopting new ICT technologies and services in Africa. The young generation has the power to solve the problems and challenges in their communities because they have grown up with this technology (Yonazi, Kelly, Halewood, & Blackman, 2012). The current state of digital technologies changed our daily life. The generation that grew up with digital technology and before the digital technology are divided into two groups as digital natives and digital immigrants (Oinas-Kukkonen & Oinas-Kukkonen, 2013). In the case of rural areas in the developing countries, it does not matter whether they are digital natives or digital immigrants as they do not have full access to current digital technologies. The digital immigrants are born before this technology emerged and they face some challenges to adopting the new technologies.

Today, mobile phones are the most common ICT device to access the internet and applications in developing countries. Social media is the main factor for adopting the internet in developing countries (Oinas-Kukkonen & Oinas-Kukkonen, 2013; Yonazi et al., 2012). Based on the survey conducted in eleven African countries, individual users use mobile phones for accessing social networking applications rather than checking emails and other services. (Calandro, Stork, & Gillwald, 2012). The study also outlines that 67 percent of Internet users use the internet first on mobile phones. According to World Bank study, mobile phone subscribers are increasing every year in Africa, 16.5 million subscribers in the year 2000 and more than 648.4 million in 2011. The study shows how fast the mobile penetration increases within ten years duration.

Mobile phone adoption is increasing in Africa. However, the penetration rate is very low in some parts of sub-Saharan African countries. Ethiopia is part of sub-Saharan Africa with a population of 94 million (Sprague et al., 2014). As a developing country, the usage of ICT technologies in Ethiopia has been increasing slowly. However, Ethiopia is still at the lowest stage of adopting new ICT technologies (Jensen & Sarroco, 2002; Yonazi et al., 2012). According to the World Bank's report, 82 percent of the population lives in

the rural areas of Ethiopia. Internet penetration is high in the urban areas when compared with rural areas. However, the Internet penetration is among the lowest in Africa with 1.9 Internet penetration (Sprague et al., 2014). Gender difference also matters in accessing ICT technologies in Ethiopia. Mostly, in the rural areas, the control of ICT devices and services are owned by the men. Women's responsibility for the household services means they do not have access to such kinds of technologies (Adam, 2012; Geldof, 2008). The poor ICT infrastructure affects the quality of education, health, commercial and international communication of the country (Jensen & Sarroco, 2002). It is known that Ethiopia's economy depends on agricultural products which contribute 41 % of the total gross domestic product (GDP) (Adam, 2012). Since the network coverage and electric penetration is very low in the rural countries of Ethiopia, it is challenging for the farmers to know the current market price for their products. Due to lack of electricity coverage, it is also challenging to charge their phones whenever they needed even though they own a mobile phone (Zhenwei Qiang, Kuek, Dymond, & Esselaar, 2012). To overcome these challenges, the government is showing an effort to expand ICT in the country. The usage of mobile and landline phone is increasing slowly in the rural countries of Ethiopia.

The telecommunication sector in Ethiopia (Ethio telecom) prevent direct foreign or private investment to the market. The Ethio telecom controls the fixed, mobile, broadband and value-added services. Ethio telecom also controls the internet backbone that connects Ethiopia to the international Internet. Mobile handsets, voucher reselling, handset repair shops and Internet cafes are owned by the private sector. Internet cafes need to purchase a license from Ethio telecom. Ethio telecom provides Broadband Fixed Wireless Access (BFWA), Global System for Mobile (GSM), Code Division Multiple Access (CDMA) and Wideband Code Division Multiple Access (WCDMA) wireless infrastructures (Adam, 2010). The growing ICT business has started to attract foreign and local companies to enter the mobile market. Huawei and ZTE are examples of companies who entered the telecommunication market in Ethiopia by providing telecommunication devices and services. Mobile service expansion and an introduction of CDMA services are one of the major projects that ZTE implemented (Adam, 2012). FINNFUND is another example of a foreign company that provides short and long term investments for developing countries. FINNFUND is a shareholder of the MOSS Ethiopia ICT consultancy who introduced the first mobile money service in Ethiopia. (FINNFUND, 2014) Another local company is TANA Communication who started producing mobile phones in the national language (Amharic) (Rao, 2012). Negi (2009) studied the quality of mobile communication in Ethiopia based on the services quality dimensions. These were represented as tangibles, reliability, responsiveness, empathy assurance, network aspect, and convenience. 52.7 percent of respondents rate the service quality mobile communication in Ethiopia as below average.

There are different factors and reasons that prevent Ethiopia from adopting Internet. Sprague et al. (2014) categorized four major barriers to Internet adoption in the country. The four categories are:

- Lack of incentives: There are more than 90 languages spoken in Ethiopia. Therefore, it is challenging to find devices that can support their specific language, most of the devices available being in English. These devices serve only the English speakers.
- Low income and affordability: The price of mobile internet services is low when it compares with other developing countries. However, the low capita income and the high poverty rate is the major factor for the case of affordability.

- User capability: The low literacy rate in Ethiopia stands at 39 percent. Lack of knowledge and device constraints are the major factors that limit people to access the Internet.
- Infrastructure: Ethiopia has poor ICT and electricity infrastructure which fall short in fulfilling the daily need of the population. (Sprague et al., 2014)

Mequanint (2011) also identified similar factors that force Ethiopia down to the digital economy. Moreover, the study shows that 79.59 percent of the respondent use personal computers and 38.1 percent use mobile phones to access internet. The availability of computer and software is very low in the county. According to Adam (2012) Ethiopia's mobile internet connection fee is the lowest in the world and broadband pricing is the highest in Africa. The demand for fixed line services is decreasing through time. The main reasons are the number of documents required for subscription, the length of time required before maintenance is completed, lack of tracking calls and the highest subscription fee when compared to a mobile phone. On the other hand, the popularity and penetration of a mobile phone are increasing. Mobile phone consumers are shifting from the ordinary mobile phones to the latest internet use capable smartphones. However, the high cost of the mobile handset and the poor quality of service (QoS) are the main barriers for the user to adopt mobile services. There is a high demand for internet among individuals and business organizations. According to research ICT Africa survey, 25% of individuals access Internet at home, 21% at schools and universities and 42% at internet cafes (Adam, 2012). To fulfill the internet demand Ethio telecom launched the Fourth Generation Long-Term Evolution (LTE) service in Ethiopia. (ethiotelecom, 2015). However, the customers are still experiencing poor Internet connection.

Fleischmann & Srikantaiah (2011) conducted SWOT analysis on mobile phone industry to understand the relationship between mobile technologies and economic growth in Ethiopia and in other developed countries. The analysis stated that the strong development in the capital city of Addis Ababa contributed for the growth of mobile industry. Ethiopia's openness to adopt new technologies and the government support considered as strength. The absence of resource and lack of training for technical staff are the major weaknesses of the country. In terms of opportunity, Ethiopia could attract and invite external investors and venders to enhance resources and improve the mobile industry. The political instability and the friction between private and the government sector is considered as a threat.

The Ethiopian government is working with Cisco and the Internet Business Solution Group (IBSG) to improve the infrastructure of ICT in the country. The goal is to provide better services and to reduce poverty through ICT platforms. The government aims to expand and improve four major areas, such as education, rural connectivity, capacity expansion and e-government (Cisco Systems, 2006). WeredaNet ICT infrastructure designed to increase federal and rural connectivity. The ICT services include video conferencing, voice and the internet. WeredaNet consists of one national and eleven regional datacenters (Belachew, 2010). IBSG also worked with the Ministry of Education to increase school connectivity throughout the country which is called SchoolNet. In SchoolNet network, more than 756 schools are connected. The network provides e-learning, digital library, and the internet. (Cisco Systems, 2006; Belachew, 2010). The aim of capacity expansion is to increase skilled manpower in the area of ICT. Cisco Networking Academy Program provided training in the area of PC operation, maintenance, construction of IP-based networks and other required IT skills (Cisco Systems, 2006). The last transformation plan is the e-government project which aims at

increasing governance capacity and citizen satisfaction through well-developed ICT infrastructure (Cisco Systems, 2006; Belachew, 2010).

Duga & Getachew (2014) suggested key solution to improve mobile services and network economy in Ethiopia:

- Telecom agencies need to provide competition environment to share experience and services from neighboring countries.
- Network APIs should be opened up to apply third party network infrastructure for new services.
- Entrepreneurs and innovators need to solve mobile development problems through understanding of the principles of mobile services and applications.
- Multidisciplinary researchers and academic institutions should work together to bring innovative mobile technology solutions to multidisciplinary research problems.

2.2 Overview of mobile application development

To design a successful mobile app, it is necessary to understand the mobile app development process and its ecosystem. This section discusses the mobile application ecosystem briefly and the tools and techniques required for this thesis project. Since hybrid mobile app development is chosen for this thesis project, hybrid app techniques and technologies will be discussed in more detail. In addition, the challenges of mobile application development and success factors are discussed.

2.2.1 The mobile ecosystem

As end users, we do not usually care about what is behind mobile technologies and applications. Therefore, understanding the overview of the mobile ecosystem will be beneficial for app developers to understand how mobile application reaches the end user. The mobile ecosystem illustrates the correlated factors and technologies that make mobile services available for the end user. Mobile technology evolved through different stages in different timelines.

According to Fling (2009), the mobile ecosystem is made up of different parts to access the Internet and it's identified as nine consecutive layers. The bottom layer of the mobile ecosystem are the mobile operators who operate cellular towers and make services for subscribers. The second and the third layer in the mobile ecosystem are network and devices. Network is one of the services that mobile operators provide. Mobile networks also evolved through time like the mobile devices from the second generation mobile standard and technologies to the current fourth-generation broadband technology. The data speed and compatible devices are different for those standards and technologies. (Fling, 2009, p. 14-18.) Affordability is one of the constraints for developing countries to access 4G networks. However, the study shows the number of adopting smartphones will increase by 2.9 billion by 2020.(GSMA, 2015)

Platforms and operating systems are part of the mobile ecosystem. A platform is a hardware or software environment that enables us to access devices. Mobile platforms are divided into three categories: licensed, proprietary and open source. Licensed platforms can be sold for device makers but proprietary is designed and developed by device makers only for their device usage and open source platforms are available for free

that any user can download and change under open source licenses. The application framework is needed to support and create a mobile application which often run on operating systems. Most mobile devices come with pre-installed applications which are designed and installed by the device manufacturer like camera and media player. The app stores provide tons of applications to install both paid and free. The last layer of the mobile ecosystem provides a different kind of services. These services include accessing the Internet, playing games, taking a picture, using map and location and anything the user able to do with the application installed. The Internet makes all these applications available to be accessible by the end user. The figure below shows the layers of mobile ecosystems from bottom to top.(Fling, 2009, p. 20-26)

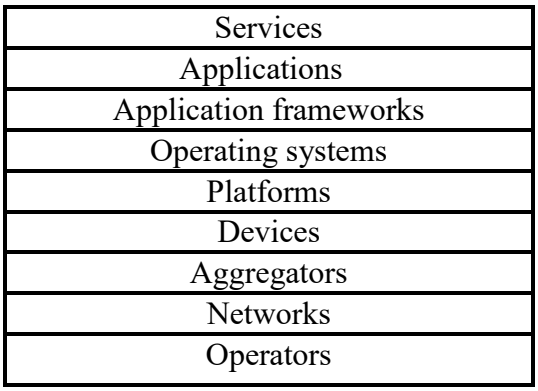

Figure 1. Layers of mobile ecosystem (Fling, 2009).

2.2.2 Mobile app development tools and techniques

The mobile app development categorized into two groups: native and cross-platform application. Understanding these categories will help the developer to choose what kind of app to develop and helps to examine the required skill. A native app is an application developed for particular devices and operating systems which require different programming skills. The apps can be downloaded from the app stores. Apple's IPhone and Google's Android mobile platforms are controlling the mobile application market with billions of downloads. IPhone and Android are late comers to the mobile market when in comparison to Nokia. (Oinas-Kukkonen & Oinas-Kukkonen, 2013). For instance, if the current major mobile platforms are considered, iOS app development requires mainly Object-C, android and Blackberry OS requires java and Windows phone requires C# and other programming skills (IBM, 2012; Xanthopoulos & Xinogalos, 2013). Usually, mobile app developers are skilled and talented on specific programming languages. Developing a native app takes time and it is expensive, companies in the app business need to hire different people with different skill sets and capabilities otherwise, they will address only a specific segment of the market.

Xanthopoulos & Xinogalos (2013) categorized cross-platform application into four main parts: web, interpreted, generated, and hybrid apps. Cross-platform mobile apps can be developed once and run on different platforms. Web-apps are browser-based applications using HTML and JavaScript. In the case of web-apps the user is dependent on the Internet connection speed because it requires extra time to render the webpage. There is no need to install web-apps on a mobile phone. Different technologies have emerged today to adopt functionalities of native applications. HTML5 is the latest version of HTML, it is one of the best technologies and widely used for web-app development. HTML5 brought

advanced functionalities and changed the old elements and attributes. The usage of HTML5 technology is substantially increasing for client-side applications, due to its capability and availability (IBM, 2012; Xanthopoulos & Xinogalos, 2013). Interpreted and generated apps are the other techniques for developing cross-platform apps. Interpreted apps are developed by generating native source code to implement the user interface and the application develops independently using different programming languages. Generated apps developed for each intended platforms. It is challenging to work with generated apps because of its automated structure (Xanthopoulos & Xinogalos, 2013).

Most cross-platform app developers are choosing hybrid mobile apps because it combines both the native and mobile web app features. Hybrid apps can be installed on a device and can access data through APIs. PhoneGap/Cordova and other containers can be used for creating the hybrid app after it is developed and executed as a browser based. The term PhoneGap and Cordova are used interchangeably by different scholars. Adobe PhoneGap framework is an open source distribution of Cordova using the recent technologies. It provides a consistent JavaScript interface across different platform and operating systems (Charland & Leroux, 2011; IBM, 2012; Xanthopoulos & Xinogalos, 2013). The PhoneGap structure allows the native code to interact with the underlying operating system and it transfers information to the JavaScript app (Charland & Leroux, 2011). The native app feature can be developed independently and the web app can be stored on the server or on a local device. Hybrid apps can be developed by following different patterns. Anand and Wasmer (2013) describes hybrid app patterns as pure, blended, mullet, fallback and API patterns. Pure patterns comprise a single web view in which all the content and navigation tools are implemented in HTML5. Each platform UI web view serves to render the HTML and JavaScript files. But in the case of blended pattern, the main UI navigation is developed with native components and the content with web view. Mullet pattern uses exclusively a native component for the part of the user flow. The fallback pattern comprises the web views for frequently changing content. The API pattern is used to get data from a server without rendering from a server. The major hybrid app building blocks are HTML, CSS, and JavaScript.

HTML is the Hypertext Markup Language which tells the browser the structure of the document. HTML is getting outdated with web designers shifting to HTML5. Hence, computing technologies are changing and improving every day, web developers need to keep up and learn the new technologies to stay successful in the market. The most common changes brought by HTML5 are categorized into six groups (Harrel, 2011; w3schools, 2015):

- New Structural elements like<section>and<aside>to create consistency,
- Introduced scalable vector graphics (<SVG>) to draw graphical elements,
- Improved multimedia to deploy in websites,
- Enhanced form elements to validate user data,
- Better font usage to display the correct font in the browser,
- Improved geographical location to determine user's location when users visiting the site.

CSS is a Cascading Style Sheets language which is used to define the visual presentation of the HTML document. The latest CSS standard is CSS3 with new features and capabilities. Some of the most important features of CSS3 are selectors, box model,

background and borders, image value and replaced content, 2D/3D transformations and others features.

JavaScript is a scripting language added in the HTML code to increase the interactivity of a website or application. It runs in the browser and users can turn on or off their JavaScript. The <script> tag used to write the JavaScript program and <type> shows the script is JavaScript.

The figure below shows how the hybrid mobile app works with the technologies needed. The application made with HTML, JavaScript and CSS wrap in PhoneGap container and access through different devices (Babu & Bhat, 2013)

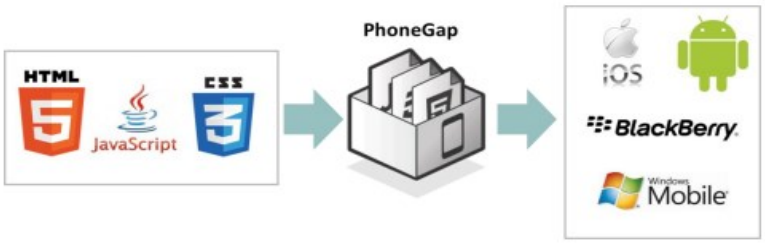

Figure 2. Hybrid app development (Babu & Bhat, 2013)

Hybrid apps use a web view control to render the HTML and JavaScript file. Hybrid application design, development, and testing should be considered differently to gain best user experience, optimized performance, and enhanced security. The developer should give better attention for the UI features to bring native looks. The most common mobile UI features are slide and swipe. (Babu & Bhat, 2013)

2.2.3 Mobile application development success and challenges

Today, we are living in social web era, where people are connected to each other without any geographical limitation. The availability and accessibility of smartphones have greatly contributed to the revolution and recognition of the social web. The PC-based era is shifting to the mobile and handheld platform to browse the web and to use mobile applications (Oinas-Kukkonen & Oinas-Kukkonen, 2013). A mobile application could be successful when the software application meets the user expectations and the user is satisfied with their experience. Charland and Leroux, (2011) divided user experience into two general parts: the context of the application and implementation. The context of an application includes hardware affordability, platform capability and usability of the screen. The implementation of the application depends on the platform feature. The performance, design, and integration ability with the platform should be considered during implementation. It is obvious that users prefer to use attractive designs. The performance of an application lowers, whenever sophisticated designs are used for a software application, especially, when the availability of Internet and data network infrastructure is low.

Apart from hobby and interest mobile applications, apps are usually developed to earn money. Therefore, there is a need to follow certain strategies to accomplish the intended

business goal and to be successful in the market. Five key strategic business goal steps are identified by New Relic a software company these steps are strategy, design, development, marketing, and maintenance. The first step is plan for the strategy, by identifying why the mobile app is being developed. Some of the strategic decisions that should be made by the developer or the organization are choice of platform, condition of payment, type of device, type of audience and other detailed decisions. After making the strategic decisions the next step is designing the app. In the designing phase, the developer should focus on the user experience which is the user interface, functionality, and performance of the application. The main issue in the developing phase is choosing the right platform and development environment. The fourth phase is marketing. Marketing is the best way of introducing the existence of the product into the market. There are many mobile apps available in app stores. The app that will be developed should break this crowd to reach the intended users. To reach as many users as possible, the app's name should be easily recognizable and there should be an awareness that the app exists on the app market. Social media play a big role in introducing mobile apps on the Internet. The last phase of developing a successful app is maintenance and management. Releasing mobile apps on the market will require maintenance and modifications for bugs and improvements. Usually, app users see the description of the app and understand what the app can do before they download the app. Users are concerned about the function, security, speed and stability of the application (New Relic, 2014).

Researchers and scholars identified different quality attributes and standards to overcome the challenges encountered during mobile application development. According to Oinas-Kukkonen and Kurkela (2003) mobile services can be classified as "high goal-driven services" and "entertainment-focused". High goal-driven services give a solution for a specific question, for example if a person needs to know when the next train departs from a specific place. Entertainment-focused services provide users entraining services like game, videos and chatting services which are used to spend their spare time on. High goal-driven mobile services should fulfill seven principles; mobility, usefulness, and relevance, ease of use, fluency of navigation, user centeredness and personalization.

In similar study quality assurance factors identified based on ISO 9126 quality standards. The main mobile app quality factors are functionality, reliability, usability, efficiency, maintainability and portability (Spriestersbach & Springer, 2004). Functionality is the feature that the app provides to satisfy the intended user. Functionality includes five sub factors; suitability, accuracy, interoperability, standards and security. Reliability is the quality and performance of the application for the required functionality. Reliability includes three sub factors: maturity, fault tolerance and recoverability. Usability consists of ease of use of the application and it includes understandability, learn ability and operability. Efficiency means resource availability and time reduction in providing the planned application. Maintainability is the ability to make small changes and improvements. Maintainability includes analyzability, changeability, stability and testability. Portability is the ability of the application to transfer from one environment to another. Portability includes conformance, adaptability, stability, and replaceability.

Developing a mobile application has its own challenges and limitations which are encountered from user and developer point of view. Even though mobile app usage highly increases, there are many challenges comes with the app and the device itself. Not all web apps and systems are meant for mobile phones and tablets, the user gets frustrated when they are trying to use web apps on mobile phones. This might prevent the user to use the system again and stick with the desktop version.

The challenges of mobile app development and usage divided into three groups: device, user and developer challenge. The major limitations of mobile devices are its small screen size, limited bandwidth, small memory, high latency, low battery life and a smaller keyboard. From the user's point of view the major challenge are usability issues. The small screen limits the amount of information, limit input fields, and restrict navigation. These usability factors affect the user experience with the application and require more user attention to control the application. Technology is the other challenge, users have difficulty to cope up with the rapidly changing technology. Whenever there is a large amount of time and cost needed to learn new technology, users give up and prefer to stay with the previous incarnations of the technology. Users are concerned about the security of mobile applications. It is getting easier to access mobile data networks, users use wireless networks to access the Internet on their mobile phones. Usually, these wireless networks are public networks without any authentication, which is the major security concern. The developer should give attention to the level of security needed as not all applications require the same level of security. For instance, money transfer application requires detail personal data which needs a high level of security. (Oinas-Kukkonen & Kurkela, 2003.)

Joorabchi, Mesbah, & Kruchten (2013) identified major developer challenges based on their semi-structured survey. Fragmentation is the major challenge of the developer. Each mobile platform is different from another, for example, UI, user experience, user expectation, required programming skills, API/SDK and supported tools. Fragmentation can also occur within the same platform, whenever that platform is updated and changed. There are memory, CPU speed and graphical resolution differences from version to version. Developers should give attention to provide consistency across platforms. It requires hard work from the developer's side to understand all these different platform characteristics. To provide quality mobile applications, the application should be tested against different operating systems. Since the current tools and emulators do not support the important features of mobile testing. This limits developers to achieve quality testing. Moreover, developers require more time, effort and budget to develop native applications for different platforms.

Beside its limitation and development challenge mobile usage decreases social interaction on the move. Whether it is in transportation center or social gathering, people tends to play with their phone. If this mobile phone dependency increases, it will affect our daily social interaction to the fullest.

2.2.4 Mobile application development taxonomy

Nickerson, Muntermann, Varshney, and Isaac (2009) developed a taxonomy of mobile applications based on the interaction of users and applications. Taxonomy could be defined as the classification and identification of similarities and differences of a specific object to understand and analyze complex domains. A beneficial taxonomy should fulfill the following attributes:

- It should be concise by limiting the number of dimensions and characteristics.
- It should be sufficiently inclusive by containing the most interesting dimensions and characteristics.
- It should be comprehensive by containing all the current available objects.
- It should be extendable by leaving room for additional dimensions and characteristics in the case of any additional objects.

The proposed taxonomy consists of seven dimensions, aims to understand the use of a mobile application and how the users interact with different applications. The seven dimensions and their characteristics are discussed below (Nickerson, Muntermann, Varshney, & Isaac, 2009):

1. Temporal dimension. The user interacts with the mobile application virtually without any intervention. Since, user interactions are different from application to application. The Temporal dimensions proposed two characteristics:
    - Synchronous, when user and application interact in real time.
    - Asynchronous, when user and application interact in non-real time.

2. Communication dimension. It is the flow of information when the user interacts with the application. When information transfers only from one direction, called uni-directional and when information transfer from both users and application, it is called bi-directional.
    - Informational: when information transfers from the application to the user.
    - Reporting: when information transfers from the user to the application.
    - Interactional: when information transfers from both directions, from user to the application and from the application to the user.

3. Transaction dimensions. Some mobile applications allow financial transaction and some do not allow. The transaction dimension is characterized by:
    - Transactional: the application allows the user to purchase goods and services.
    - Non-transactional: the application does not allow a user to purchase goods and services.

4. Public dimension. The availability of mobile applications differ from one another, some are accessible by the public user and some by specific groups.
    - Public: any user can access the application or can be part of the group without limitation.
    - Private: users are pre-selected by a third party and can only access the application.

5. Participation dimension. Users might use a certain mobile application as a single user or as a group. For instance, some mobile games are available for multiple users, often user considers they are a single user.
    - Individual: a single participant is using the application.
    - Group: multiple participants are using the application as a group.

6. Location dimension: Some mobile applications seek user location to provide customized functionality and some do not require user locations.
    - Location-based: the mobile application uses the user location
    - Non-location-based: the user's location is not required by the mobile application.

7. Identity dimension. The mobile application requires user identity to interact with the user identity.
    - Identity-based: the mobile application requires user identity

- Non-identity-based: the mobile application does not use or require user identity.

2.3 Software development methods and methodologies

Currently, there are plenty of lightweight software development methodologies practiced and customized according to the organization's needs. The most known Lightweight development method includes agile process model, Rapid Application Development (RAD), Extreme Programming model, Scrum model, crystal and lean development. There are pros and cons of choosing a specific development path. The developer needs to understand the development methodologies and choose the right method based on the project and the deliverability of the product.

Some of the major agile practices are planning, flexibility, predictability, documentation, privacy and security (Miski, 2014). In 2001, a group of software specialists and consultants published the agile software development manifesto. The practitioners stated that the major values for developing a better software were as follows (Agilemanifesto, 2001);

- **Individuals and interactions** over process and tools
- **Working software** over comprehensive documentation
- **Customer collaboration** over contract negotiation
- **Responding to change** over following a plan.

Once the popularity of mobile applications increased, developers and practitioners could start adopting the agile methodologies for mobile projects. The major advantage of using the agile methodologies for mobile applications is that it helps the developer to focus on the consumer market, the quick release helps to meet the market demand, it is easy to fix any possible bugs for each release and it is possible to manage and work easily with geographically distributed teams. The other reasons for choosing agile methodologies includes, "faster time to market", "better quality", "release before major OS upgrade" and "fast feedback based on tangible results".

Lean development is one of the agile methodologies. The method is adapted from the Toyota production system. The concept of lean emerged in 1990 to produce the most efficient high quality motor vehicles. Even though the process of manufacturing products differs from producing software, the concept and principles are applicable to increase the overall quality of the software development process. There is a significant difference between the agile approach, scrum, and the lean approach. In the scrum, there are small sprints for fixed releases but the lean approach avoids random deadlines because rushing to meet specific deadlines might be the cause for poor quality software. The other difference is the agile approach gives focuses on people but lean rely on data (Middleton & Joyce, 2012).

Different scholars presented the lean principles in different contexts. "The lean management philosophy focuses on increasing value by eliminating waste." There are five lean principles developed based on Toyota's original 14 principles. The five principles are value, value stream, flow, pull, and perfection. Companies need to understand and identify the additional value of each product and service. The main reason for providing product and service is to give additional value for the intended customers. After identifying the value, the next step is to establish the value stream. The value stream

is a plan that includes all the essential steps from concept creation to delivery by eliminating unnecessary steps. After value stream, lean principle suggested that companies need to focus on the flow of value creation process rather than working in isolated departments. The pull principle stated that a customer sends a product request and the company sends the product to minimize the time needed for concept generation to delivery. The final lean philosophy suggests that companies need to consider a certain principle and a mindset to increase efficiency and profitability (Maglyas, Nikula, & Smolander, 2012)

2.3.1 Lean Startup methodology (LSM)

The lean startup methodology introduced by Eric Ries aims for "a synthesis of Customer Development, Agile Software Development methodologies, and Lean (as in the Toyota Production Systems) practices" (Maurya, 2012). Lean is an iterative process. The first step is understanding the problem. After defining the problem, the next step is to define a solution and validate that solution qualitatively and quantitatively. The five lean startup principles are presented as follows (Ries, 2011):

An entrepreneurs are everywhere: the term startup is used when new products and services are created under extreme uncertainty. The lean startup can be used for small and large enterprises.

Entrepreneur is management: a startup is not a product it requires a sort of management mechanism. The management should be educated about entrepreneurship for creating and adopting innovative products and future growth.

Validate learning: startups should learn their customer needs and changes in the market frequently because the aim is to build a sustainable business not to gain temporary income. The vision of the company should test and verify continuously by scientific experiments.

Build-measure-learn: this process is called a feedback loop. In this process, the customer needs and requirements are identified and then the idea is changed to a product, then the customer reaction to the product is measured. After learning from the data gathered the next decision to pivot or preserve. The figure below shows the feedback loop process (Ries, 2011).

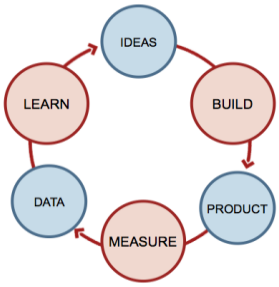

Figure 3. Build-measure-learn (Feedback loop) (Ries, 2011)

Innovation accounting: entrepreneurs need to measure the development of the business and prioritize work to improve the business outcome and to keep innovators accountable.

The lean canvas is adopted from the business model canvas. The lean canvas is a one-page validation tool, which is fast, concise and portable to plan a business model. Lean canvas is divided into nine boxes which hold different labels. The first step is identifying the problems worth solving and the customer segment. The most important steps in business are knowing the target customers and their needs. After identifying the customers, the next step is identifying unique value proposition. What is an alternative value that the company can provide from other early adopters? In the solution box, every single issue should be addressed to satisfy the target customers. There are different channels to deliver the product to the intended customers, some may prefer free over paid and some may use a referral to introduce their product rather than direct marketing. The revenue stream box is where the price of the product is stated and in the cost structure the cost of the product calculated and the cost spent on product development and customer acquisition. The final two boxes are key metrics and unfair advantage. The key metrics includes five elements, acquisition, activation, retention, revenue, and referral. The process of acquisition is how the product of the company appear for the first time for the user. Activation is how the user finds the promised product and service during first time use. Retention identifies how often the user returns to use the product. Revenue measures the income gained from the product, not all products get paid during the first visit. Referral measures how happy the customers are to recommend the product to other people. The last box is the unfair advantage. The unfair advantage is the value that the company owns which cannot be copied by other companies. Insider information, existing customers, and large networks are some examples of unfair advantage (Maurya, 2012). The lean canvas is discussed in section 4.2 for Addis light train business model.

2.3.2 Lean user experience (UX)

Software and system designers give more attention for UX than before. The user involvement increased in software development, to solve user problem easily and to deliver a great user experience. The lean principles can be applied for UX to eliminate waste during UX design process and to measure how ideas fit the goal. Lean UX consists of three building blocks: design thinking, agile software development, and lean startup method. Design thinking is the way designers directly observe the customer problems and need to match it with the current technology and available resources. Design thinking also helps the designer and the non-designers to work together as a collaborated team. The lean UX applies agile methodology principles to increase customer value. One of the lean startup principles is the feedback loop, applied in lean UX to minimize project risk and to learn from customer feedback as quickly as possible (Gothelf & Seiden, 2013)

Some of the lean UX principles are discussed below:

- All product development departments should be involved in the whole process to increase team efficiency.
- Core project team members should be kept small to increase accountability and communication between team members.
- Lean UX should be measured against the business outcomes to identify the features of the product which are well constructed and which are not.
- Project teams should focus on the business problem to initiate teams to provide creative solutions and increase ownership of the solution.
- Unnecessary design processes should be removed to eliminate waste and increase productivity.

- Lean UX advocates permission to fail, new ideas should be experiments without any fear of failing, it helps the team to take a risk and learn from their mistakes.

The Lean UX goal is to provide outcomes not just deliverable for this purpose different assumption and hypothesis should be coined for a future experiment. In lean UX process, the first step is creating assumptions. The second step is creating an MVP, then running an experiment and finally feedback and research. The process of the lean UX process is an iterative process. A hypothesis statement includes outcomes, personas, and features. The outcome might be any outputs that planned to achieve the project. It can be a number of clicks or the number of rates. Personas help to understand the potential user of the system through assumption and validate it with research. The feature of the product and services should be planned carefully to achieve the target outcome. Creating an MVP helps to learn and understand the market need and the value of the solution. In the design stage, an MVP might be sketches, prototypes, and visual designs. The easiest and fastest way of prototyping is the low-fidelity prototyping which is sketched on paper or on clickable wireframes. There are also non-prototype MVPs which learn customer needs and validate a hypothesis. Email and Google Ad words are some of the techniques for non-prototype MVPs to learn from potential customers. After the MVP is ready the next step is running an experiment. The experiment can be held with project members or with potential customers. Lean UX is a continuous and collaborative research. Interviewing and discussion with potential customers are some of the techniques to get customer feedback (Gothelf & Seiden, 2013).

2.3.3 Lean application management

Applying lean principles for software application management reduce IT cost. Just in time and jidoka (built in quality) are the two pillars of lean production management. The aim of jidoka is to eliminate defects in the early stage of production and identify the cause of the defects. This principle can be implemented in IT organizations in three parts of the development process: application development, application maintenance, and application assets. Identifying and examining defects after the completion of the software product, requires a lot of effort and the rework requires more time. There are three ways of eliminating rework in lean application development. Detect and remediate defect early: in this way each software components are analyzed for defects and repaired before they are added to the source code. The other way is eliminating the cause of the defect. Moreover, developers should be trained to develop defect free work. (Curtis, 2011)

In lean application maintenance, the cause of waste is through poorly designed application or badly coded software. Understanding the source code takes a longer time in the rework process. There are three ways of eliminating waste during maintenance: improve application changeability, reduce defect-fixing releases and sustain the lifespan quality of the software. Some defects are more critical than others because it may cause operational problems. The maintenance team should identify the critical defects early and act quickly. Lean application asset is part of the lean application management. Hence, software applications are obsolete through time, it is necessary to control and avoid unnecessary codes. Design in quality, performance, and manage size proposed for eliminating waste during lean application asset. Developers should consider software quality characteristics at the beginning of developing phase. The most known software quality characteristics are robustness, changeability, security, and efficiency. The figure below shows the lean application management and subparts (Curtis, 2011).

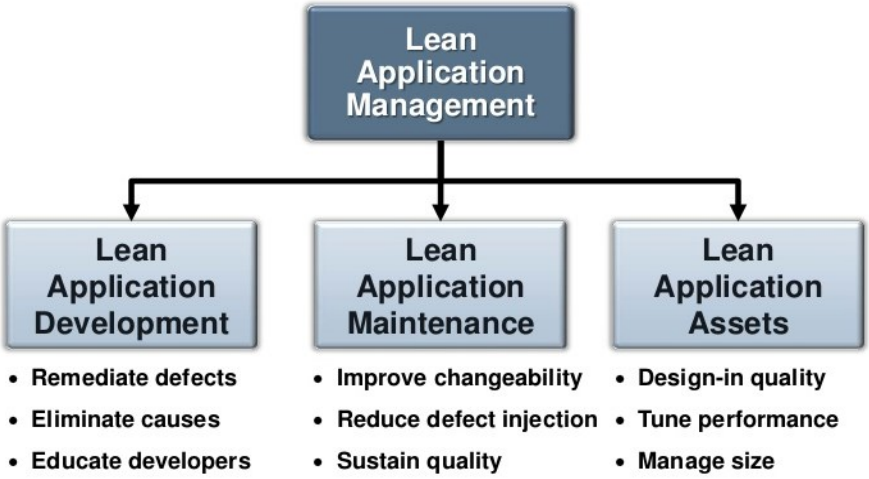

Figure 4. Lean application management (Curtis, 2011)

2.4 Self-referential persuasion

As a theoretical framework, I adopted Oduor &Oinas-Kukkonen's (2015) a system's self-referential persuasion concept which was originally introduced for social web users. Even though the train scheduler is not a persuasive app by itself, it is possible to adopt the self-referential persuasion concept. Addis Light train timetable could be a persuasive mobile app indirectly if we consider time management as a persuasive function. Self-referential persuasion systems regard a persuasive system in a situation where the system refers to itself by utilizing persuasive strategies and software features to commit its users in order for them to stay as contributors of the ecosystem it forms. (Oduor & Oinas-Kukkonen, 2015)

The current public transport demand is very high in Ethiopia. The new light train system brings many social and economic benefits. In Addis Ababa, the main reason for workers' lateness involves transportation problems. Being late to any appointment is becoming a culture. If a new technology is introduced to a certain country, related and supporting technologies should be adopted at the same time. For instance, when the Addis light train was implemented in Addis Ababa, train operators, and other technical staff were trained with new technologies. Mobile application is one of the current technologies used to check real-time transportation status in most developed countries. Therefore, the train transportation system requires a mobile application to minimize users waiting time.

The planned app is designed to attract more users and retain them while retrieving information regularly. The usability and the intended purpose of the app are the main factors to attract more users and to keep users using the app continuously. Lack of punctuality has become a habit by the majority of the people in Addis Ababa. Transportation is given as one of the causes for bad timekeeping. Addis Light Train app will enhance user's punctuality. Hence, users reduce their waiting time, it is possible to be on time. To make the self-referential persuasive app, I adopted some of Oinas-Kukkonen & Harjumaa's (2009) persuasive system design principles. Oinas-Kukkonen and Harjumaa (2008) defined persuasive system design as "computerized software or information systems designed to reinforce, change or shape attitudes or behaviors or both without using coercion or deception". There are three persuasive system design and development phases. These are, understanding key issues behind the persuasive system, evaluating the persuasive context and design system qualities. It is necessary to

understand the key issues behind persuasive systems, before designing a persuasive app. Oinas-kukkonen & Harjumma (2009) propose seven criteria that need to be considered behind persuasive systems. There are three factors needed to be considered when persuasive systems are analyzed, the intent, the event, and the strategy. The intent determines the intention behind the technology. The persuasive event is concerned about the use context that arises from the problem domain. Users' interest, culture, abilities and other related factors might affect the use context. The other aspect of a persuasive system is defining the strategy by identifying the message and the route, whether direct or indirect (Oinas-Kukkonen & Harjumaa, 2009).

The four categories of persuasive system design principles are primary task support, dialog support, system credibility support and social support. The primary task support design principles are a reduction, tunneling, tailoring, personalization, self-monitoring, simulation, and rehearsal. Addis light train app embraces the principles of primary task support system by providing actual timetables, by reducing the time required for the train and by offering simple and clear user interface and functionality. Dialog support design principles include praise, rewards, reminders, suggestions, similarity, liking and social role. One of the dialog support features is the ability to "like". The app will be visually attractive for users and together with the "like" function. I used a combination of gray and green colors to simulate the actual train color scheme. System credibility features include trustworthiness, expertise, surface credibility, real-world feel, authority, third-party endorsements and verifiability. The app should provide truthful information by providing the right information about the train schedule and it should include some information about the railway organization. The social dialog support principles, embraces social learning, social comparison, normative influence, social facilitation, cooperation, competition and recognition (Oinas-Kukkonen & Harjumaa, 2009.) The app doesn't apply any of the social dialog principles. However, the application could be shared in social Medias to share the usage of the app for others.

The user can be persuaded to use the current mobile technologies and apps continuously if it is simple and easily accessible. After users start using the intended mobile application it will improve their waiting time and they will arrive on time to accomplish their daily activities. In this case, the app changed their usual habit, which is being late on their daily activities caused by lack of enough information.

3. Research Method

This chapter discusses the research method used to carry out this study. The first section discusses the design science research in an information system. The second section elaborates the design science research methodology and its process.

3.1 Design Science in Information System Research

Design science research method is the main research area in scientific research. Design science aims to solve problems by engaging design-science and behavioral science research paradigms. The behavioral science research is concerned with the interaction between people and technology by identifying and justifying theories for efficiency and effectiveness of an organization. The Design science research (DSR) paradigm aims to create innovative artifacts to solve identified problem. IT artifacts can be defined as constructs, models, methods, and instantiations. These artifacts are made to solve a specific problem and the result measures to what extent the real world problem solved (Hevner et al., 2004). The lean canvas will be followed as a starting point for creating an innovative artifact in DSR (Ruhi and Akhigbe, 2016).

The design science research framework compares design science and behavioral science paradigms to understand the relationship between environments, IS research and knowledge base. The environment defines the problem which includes people, organization, and technologies. The IS research includes theories and artifacts. The knowledge base includes foundations and methodologies that will be used to carry out the IS research. Organizational business needs and problem defined based on the organization's existing technology infrastructure, business process, structure, and culture. Based on the identified business need IS research conducted into two parts, behavioral science, and design science. To accomplish the identified business need, the behavioral science research develop and justify theories and the design science research build and evaluate artifacts. Design science research applies computational and mathematical methodologies, to evaluate the quality and effectiveness of artifacts. Appling existing foundations and methodologies leads the researcher to achieve rigor. (Hevner, et. al., 2004).Iivari (2007) argued that the design science research process should be transparent. He proposed four sources of ideas to make design science transparent: practical problems and opportunities, existing artifacts, analogies and metaphors, and theories.

Hevner, et al. (2004) proposed seven guidelines for design science in information system research based on the understanding of design problem and its solution, which are found in the building and application of an artifact. The list below discusses the seven guidelines:

1. Design as an artifact: Design science research must provide a useful artifact in the form of a construct, model, method or an instantiation to solve an organizational problem.
2. Problem relevance: Design science research problems must be relevant and important to provide a useful technology-based solution.
3. Design evaluation: IT artifact utility, quality and efficiency should be evaluated rigorously.
4. Research contribution: Design research should provide a valuable contribution in the form of design artifact, foundations, and methodologies.

5. Design rigor: Design science research should use a rigorous method to construct and evaluate the artifact.
6. Design as search process: Design science research is an iterative process to get an effective solution by respecting the existing laws and applying the available means in the environment.
7. Communication of research: Design science research result should be accessible for both technology-orientated and management-oriented audiences. (Hevner, et al., 2004)

3.2 Applied DSRM process

The aim of developing DSR process in IS research is to provide valuable and rigorous IS research. DSR methodology includes conceptual elements; practice, rules, and process. DSR has six steps: problem identification and motivation, objectives of solution, design and development, demonstration, evaluation and development. DSR in IS research process should be consistence, it should provide a nominal process and it should provide a mental model for conducting a design science research. A nominal process helps other IS researchers to use it as a roadmap. A mental model is a "small scale" explanation of the real world. There four possible entry points of research in the design science research process model, which are a problem centered approach, objective centered solution, design and development centered solution and observing a solution. (Peffers et al., 2006)

The first step in the design science research process model is problem identification and motivation. Identifying and defining a specific research problem is useful in providing an effective solution. Justifying the value of a solution will help the researcher and the audience understand the reason behind the problem and the result. It is necessary to have a good understanding of the state of the problem and the importance of the solution to accomplish this activity. The second activity is defining objectives of a solution for the identified problem. The objective can be presented as qualitative or quantitative term based on the problem specification. The third activity is design and development to create a solution. Theoretical knowledge is required in this activity to determine the functionality and architecture of the desired artifact. The forth activity is a demonstration. This activity shows how the artifact solves effectively the intended problem. The demonstration can be presented as experiment, simulation, case study or any other possible activity. The fifth activity is an evaluation. In this activity, the actual solution compares with the objective of the solution and evaluates how well the artifact solves the problem. To make an effective evaluation, it is required to know relevant metrics and analysis techniques. This is the stage at which the researcher decides to continue to communication activity or to iterate back to objective solution activity. If the solution requires improvement, it can be done at the end of this activity. The last and the sixth activity is communication. The problem and importance of a solution can be communicating to the audience in the form of research paper. Communication requires knowledge of the disciplinary culture (Peffers et al., 2006)

It is not necessary that the design science research starts from the problem identification phase. The researcher has the right to start almost from any activity of the process and move to the next step. The origin of the research could be an object centered solution when the research started from activity 2. When the research started from activity 3 the origin of the research is a design and development centered approach. When a researcher works backward to apply rigor to the research, it can be started from activity 4 by observing implemented practical solution.

Design science research methodology applied to carry out this study for production and presentation DR. The DSRM is the appropriate research methodology because the study focuses on producing an artifact based on a problem centered approach. The figure below shows the nominal process of this study and discusses the process in detail.

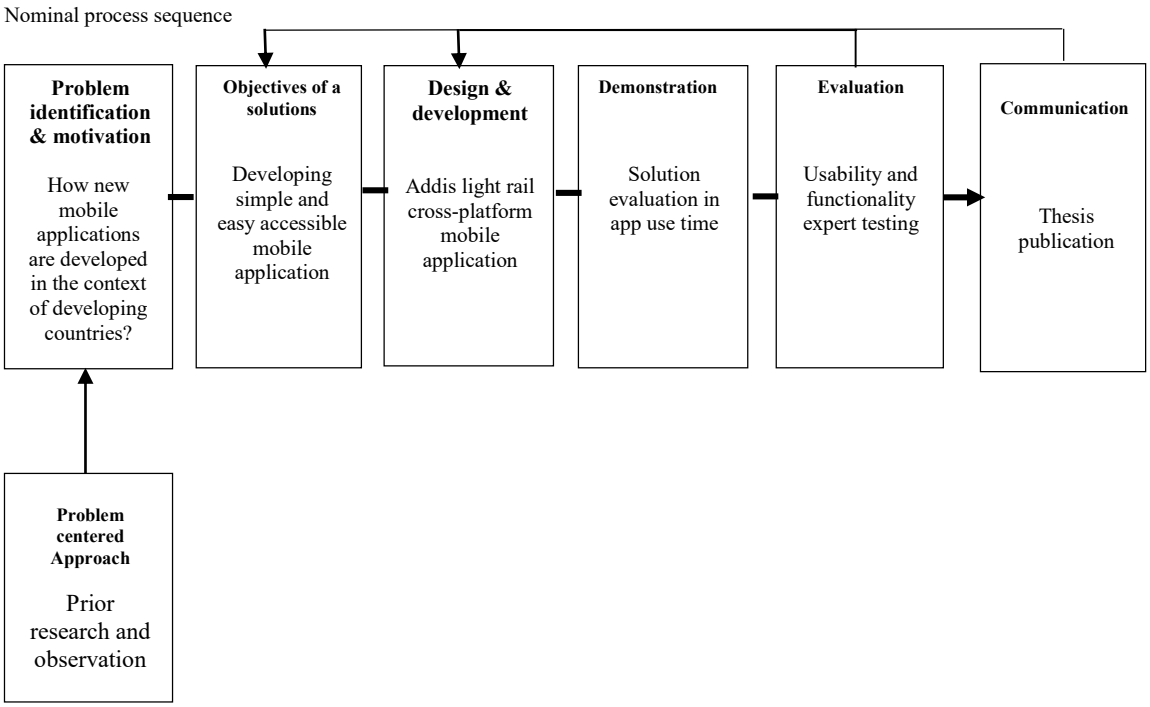

Figure 5. Applied DSRM process (Peffers et al., 2006)

Problem centered approach. The idea emerged from a discussion with a friend. The city and intercity transportation does not acquire information quickly enough. Usually, the available transportation information system is static and manually accessible. There is a limited amount of research found in relation to new mobile applications development and implementation in the case of developing countries.

Problem identification and motivation. The identified problem for this study is lack of accessing real time, organized and easily accessible transportation timetables in Ethiopia. Since Addis Ababa is implementing a new city train transportation system, the user needs to access quickly the train schedule from their mobile phone from anywhere.

Objective of a solution. The objective of the study is to design and develop a cross-platform train schedule mobile application that enables users to access the timetable easily from a mobile phone. The mobile application helps the user by providing full arrival and departure information of the train from a particular station. The basic functionality of the app could be downloaded for free to access offline train timetable information. Moreover, the research outlines how a new mobile application is perceived by the users in developing country of Ethiopia.

Design and Development. The design and development of the artifact is an iterative process. The lean startup method used during the design and development of the artifact. The app will be cross platform mobile application developed by HTML5 and implemented through PhoneGap platform.

Demonstration. After sketching the early mock-up wire frame the next step is in demonstrating the pilot app. The mock-up is designed as a proof concept to demonstrate the objective solution for the target users. Since, the application is designed and developed for the new train system in Addis Ababa, Ethiopia, the app will be demonstrated for the test users in Addis Ababa.

Evaluation. The pilot mobile application and the lean development method will be evaluated. The objective of the evaluation is to understand the usability and applicability of the application and the development methodology.

Communication. The result of the research will be presented as a thesis work for the University of Oulu. The application and the research result will be used for future improvement and reference for Ethiopian Railways Corporation. Moreover, it will serve as a base for other transportation systems in the country.

4. The software Artifact

In DSRM, the third step is design and development of the artifact (MVP) after setting up the objective. The lean principles and guidelines integration fails at this point. Even though both methods follow an iterative pattern, there are distinctive features found in the lean software development. For instance, lean startup principles, lean iteration meta-patterns used along the DSR process. This chapter outlines the development process of the artifact, based on the lean startup method. The lean startup method is applied to identify and involve users at the early stage of the idea generation and application development phase. In this chapter, the problem and solution are identified and validated with user interviews. The interview questions aim to understand whether or not the target audience has a problem and to test if the planned solution is feasible for the users. An early layout mockup was made to test the solution and the functionality of the application. The scope of this thesis is limited to the first iteration cycle which is the MVP. Moreover, the functionality and the development process of the artifact are discussed in more detail.

4.1 Problem identification and hypothesis creation

A common lean software development starts with problem identification and hypothesis. Then the hypothesis breaks down into different parts to make it more understandable and testable. The identified hypothesis should answer “what we are going to do?”, “Who are our customers?” and “How it is going to be done?” (Ries, 2011).

The concept of developing a train scheduling mobile application emerged based on previous public transportation experiences. Before the new light rail project which was completed recently in Addis Ababa, buses and taxis were the major public transportation system used by the majority of the population. Ethiopian Anbessa Autobus is the major public transportation service which provides city bus services in the area of Addis Ababa. The bus service doesn’t have any mobile or web application developed to check its timetables. It is common that passengers wait for some time until the bus reaches the intended stop, with no change to timetable times regardless of whether it is a hot or a rainy day. As a major transportation system, the company should have developed its official mobile or web app to provide more accessible and convenient service. However, the author recognized that a private app developer released “Ethiopia Anbessa Autobus” app in Google play, which only let users search bus numbers, can place, distance and price. The app doesn’t show the exact departure and arrival time of a specific bus. The app is rated 4.5 in Google play and it has 1000 downloads. This indicates that there is a demand for this kind of mobile technology in the country.

During problem identification process, we also analyzed the Ethiopian railways corporation official website to understand if there are any future development plans. However, we didn’t find any future plan in regards to the web and mobile app development. We only found Addis Ababa Light Rail project plan which was written in 2011. It indicates that the website is not up-to-date. Moreover, some of the links and images are not displaying properly. We believed that it is necessary to develop and awaken the train corporation to prioritize new technologies and updates.

Hypothesis. The mobile application provides easy and timely accessible train schedule. The user can search the estimated departure and arrival time from their mobile phone. The author observed that the new light train in Addis Ababa doesn’t have any pre-planned

train scheduling system, lack of information regarding the train schedule may cause dissatisfaction and frustration for the train users. We believe developing a train schedule mobile application will enhance the utilization of the transportation system, increase user satisfaction and time efficiency.

Testable hypothesis. The mobile application is simple and easily downloadable, advanced aesthetic features are limited (for example 3D images) because of the country's poor Internet infrastructure. Users can search the app name on any application stores or follow a shared link to download the app easily. Downloading the basic offline app doesn't require any credential information. The success of the mobile application can be measured through a number of downloads, ratings and number of shares.

In lean user experience, creating personas help to understand better the customer segment. Persona includes demographic information, user needs and service needs to be provided. Persona information is divided into four quadrants, the top-left box includes name and sketches, the top-right box includes basic demographic information, the bottom-left includes user needs and bottom-right includes the potential solution (Gothelf & Seiden, 2013). We created a persona to represent and simulate one of the application users. The figure below shows the potential user persona called Beza.

Table 1.Persona

<table>
<tr>
<td> 
• Beza
• 27
• Working</td>
<td>• Married
• 2 kids, age 2&4
• lives in C.M.C 1
• Works as bank clerk in Mexico square</td>
</tr>
<tr>
<td>Needs
• Doesn't know the train departure time from C.M.C
• She needs to drop her kids to the day care at Adwa square
• Doesn't know when the train departs from Adwa square to Meskel Square</td>
<td>Services
• Provide the train departure time from C.M.C
• Easy to check when the train arrives
• Easy to know when the train comes
• Easy to know if there is delay
• Easy to know how long her journey is</td>
</tr>
</table>

Lean canvas. The lean canvas used to document the necessary hypothesis based on Maurya's lean canvas. Lean canvas focused on entrepreneur's business plan. The major top three problems are lack of dynamics and organized way of checking train schedules, users do not have enough information when the train departs and arrives and are left waiting for the next train which is time consuming. Moreover, the user fails to schedule according to the train schedule. If users know the train timetable in advance they can schedule their daily activities beforehand. The other problem is the user does not know the exact stops. The target customers or users of the mobile app service are Ethiopian Railways Corporation (ERC), residents of Addis Ababa and any tourists or visitors of the city. The planned solution allows users to check departure time, arrival time, specific stops and to check how long their journey takes. The unique value proposition of Addis

light train is to save time and make people to be on time on their daily activities. Application markets will be used to distribute Addis light rail app for the intended users. Sharing the mobile app through Social Medias like Facebook and twitter could be the major way to introduce the app for the intended users. Moreover, friends, families and word of mouth will be used to deliver the mobile application for target users.

Freemium revenue model chose as a business model for Addis Light Train mobile application. Freemium revenue model is a combination of free and premium user types. There is no direct revenue source for free model. (Vannieuwenborg, Mainil, Verbrugge, Pickavet, & Colle, 2012.) The first release of Addis light rail mobile application is an offline app with basic functionalities. The offline app will be available for free download and use for the target users. After downloading the first experience of the user will be checking their first journey. When the train service fully functional and the company provide integration environment, the online app will be developed with live updates as a premium app. Users could pay approximately 0.99 € to have the premium functionalities. Moreover, creating partnership with Ethiopian railway is the future revenue stream to add more features and functionalities based on user feedback. Time and customer acquisition is the most fundamental cost to develop the application and to conduct the user feedback. The unfair advantage of Addis light train is the community. It is advantageous to develop this kind of mobile application because the community have existing problem and they are looking forward to have the solution. The figure below shows the Addis light train lean canvas.

<table>
<tr><td rowspan="2">Problem

Knowing the exact arrival time is a problem

Waiting public transport is time consuming

No mobile app to check schedules

Failing to schedule oneself</td><td>Solution

A mobile application to search the exact time of departure and arrival timeof train</td><td rowspan="2">Unique Value Proposition
Make people to be on time on their everyday lives and saves time

Includes self-referential persuasion and persuasive system principles</td><td>Unfair Advantage
Community</td><td rowspan="2">Customer Segment
Residents and visitors of Addis Ababa who use train transportation system</td></tr>
<tr><td>Key Metrics
Download
Check the first trip
Number of downloads
Share for a friend</td><td>Channels
Word of mouth
Facebook
Twitter</td></tr>
<tr><td colspan="3">Cost Structure

Developing cost + time

Customer Acquisition cost</td><td colspan="2">Revenue Streams

Free first release offline app

0.99 € online app</td></tr>
</table>

Figure 6. Addis Train mobile app lean canvas

4.2 Hypothesis validation

This section validates the problem and solution hypothesis. We first tested the proposed problem through user interviews to understand if users really have the problem. Then after we learned from the hypothesis interviews, we validated the proposed solution to understand if the intended solution is applicable.

4.2.1 Problem hypothesis validation

Problem validation interview consists of eight questions.The questions are constructed to understand how people in Addis Ababa checks public transportation timetables and to examine the current state of smartphone and mobile application usage. Because geographical limitation the author used Skype, Viber and Facebook to conduct the interview. Maurya (2012) suggested ten interview samples are enough to understand if the problem really existed. The interview question were translated to the national language to make the questions more understandable and to make interviewees more comfortable to respond for the interview questions. To get more reliable data fifteen random train users were interviewed, seven men and eight women. However, the interview sample excluded the aged group because the majority doesn't have mobile phone and they are not interested to use such kind of technologies. Problem validation interview questions are attached in the appendix.

Interviewees were asked if they are using the new light train in Addis Ababa and how they check timetable. All of them are using the new train and they don't have any means to check the timetable. One of interviewee said to know when the train comes he asks different people or he waits until the train comes. Seven of the interviewee find waiting the train is not time consuming when it is compares with bus and taxi transportation service. The rest of the interviewees find waiting the train is time consuming. Except two of the users, the rest of the users don't have enough information when there is transportation disruption. Moreover, interviewees were asked if the train users know how long it takes their journey. Most of the users doesn't know how long it takes their journey. Some of them said they can't be sure even if they know because they might now get the transport on time.

We learned that waiting public transportation is time consuming, users doesn't have enough information about any changes that might have occurred about the train and users don't know how long it takes their journey. Therefore, developing timetable checking mobile application can be a solution. To validate if the mobile application solves these problems, solution hypothesis test presented through user interview by showing users the layout mock-up of the mobile application.

After validating the problem through user interviews, there is a need to decide on the type of mobile application. There are three ways to develop mobile application. Each approach has its own pros and cons. We all choose one development environment over another based on different reasons. Choosing the right development approach depends on different factors, such as budget, timeframe, internal resource, target market required functionality, IT infrastructures and others (IBM, 2012). We choose hybrid mobile app because of two major reasons. The first reason is that, we want the application run on different devices and reach for the majority of the user. If we consider developing a native application, it is costly to develop for each specific platforms and time taking. More than 3 million population resides in Addis Ababa. It is challenging to know the number of user

for specific mobile platform, some might not using a mobile phone at all, some might use feature phones and some might use classy smartphones.

During problem validation interview users were asked if they are using smartphones and mobile apps. Only two of the interviewees doesn't use smartphones. Among smartphone users seven of them uses Samsung, five of them uses iPhone and one of them uses Blackberry phone. Most of the interviewees use social media apps like Facebook and Viber. We understand that majority of the people are using different kinds of smartphones. Hybrid mobile development is the only way which addresses the majority of the people. And the other reason for choosing hybrid development path is the skill required for it. Since, the author has background on HTML and CSS from previous studies, the time needed to study other native programing languages and the time required to familiarize with the development environment will be reduced. It is more feasible to provide the app as soon as the train start functioning because users can experience both new transportation system and new way of timetable checking app as the same time.

The other challenge emerged after choosing what kind of app to develop is choosing between offline app and an online app. There are different constraints that limit us from developing online mobile application in the context of Addis Ababa. An online application backend system and a mobile devices are connected most of the time. Due to the countries poor Internet infrastructure it challenging to make an online mobile application, since online applications require real-time response. Bureaucratic structure of the country prevent us to develop online application in a short period of time. Since, the train service is new for the country, there is no integration capacity to third party application. However, other well developed and organized railway companies provide open Application Program Interface (API) for developers to create their own solutions. Therefore, we chose to develop offline app. Offline apps can be accessed locally without network connectivity. (Kovachev, Cao, & Klamma, 2011).The disadvantage of choosing offline app is that users cannot be aware of for live changes and delays of the train schedule in a timely manner. The government and Ethio telecom is showing an effort to expand and increase Internet infrastructure throughout the country. Online application can be developed when the necessary pre conditions are met.

4.2.2 Solution hypothesis validation

Wireframe mock-ups are provided to evaluate if the intended solution is usable and needed by the users. Balsmaiq software used to sketch the early mock-up layouts. Balsmaiq is a wireframe tool that helps to sketch early mock-ups fast. To test the solution, screen shot of the user interface provided for the users. The solution validation interview questions also used to understand the actual value of the product. Solution hypothesis interview questions are attached in the appendix.

The figure below shows the early mock-up of the mobile application. The user interface sketched with Balsmaiq. The first figure shows the front page of the app which will appear when the app is opened. The top label of the app shows the logo and the app name. The drop down menu allows user to choose from the listed stops and the text field allow users to write specific stops. Finally, users can choose specific day and time and place their search. When the search button touched another page will be displayed which shows detailed journey plan. The route detail shows the departure time, stops and arrival time. Moreover, the app displays the duration of the journey and the available number of stops.

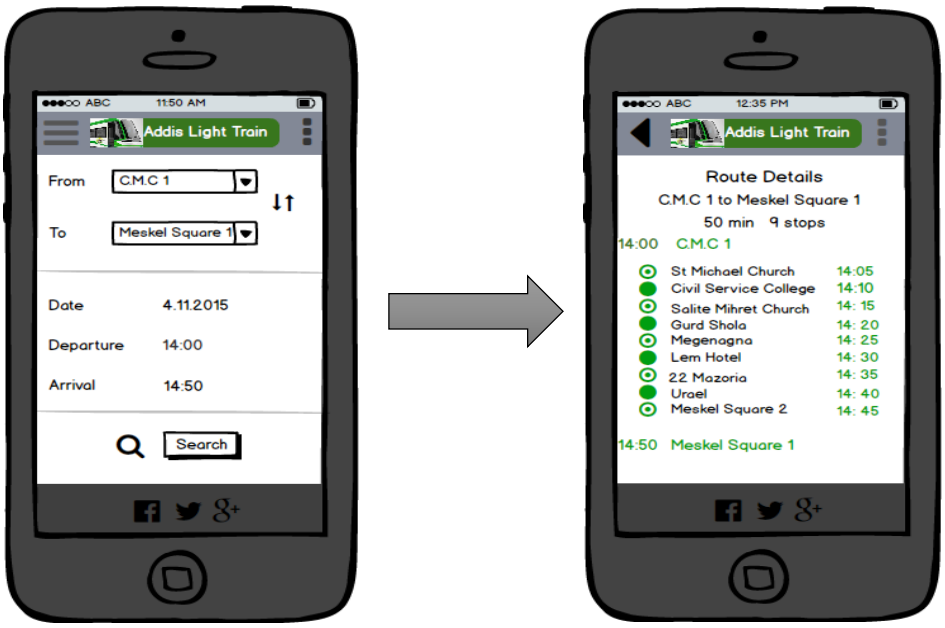

Figure 7. Addis light train mock-up

To get reliable user feedback, I chose one busy station and interviewed random people who were waiting for the train. First the aim of the interview introduced for each interviewee to get their willingness. Then the mock-up presented and the author asked them if they understand what the mobile application mock-up is about and what they can be able to do with it. All of them understood that the mock-up is designed for checking Addis Light Train timetable. They said they can use it to manage their time properly and it will help them to be able on time to their intended destination. All of the interviewees are willing to download and share it to a friend. All of the users believes that the process of searching the train schedule seems simple. Two of them believes it is easier for young people who uses mobile phone the most. I also asked them if there is anything to improve. Three of the users believes it's challenging to know what needs to be improve before they see the actual app, five of them didn't have any recommendation. One of the user suggested that "it would be nice if there is alarm system to remind us the departure time in case if we forget it" and the other user suggested that it would be nice "if the app shows red or green light to show us if the train is full of passengers or not". Finally, I asked them if they are willing to pay for the app, only one of the user prefers to get the app for free but the rest of them willing to buy for the app if the price is affordable.

I learned that the planned solution is acceptable by the majority of the user. Both free and premium app development business models are viable for the planned app. Since, most of the users are willing to pay for the app.

4.3 Building solution (MVP)

Lean software development is an incremental process, which aims on building small working batches at a time. MVP is the first version of the product that provide the core functionality and it is the fastest way to start the Build-Measure-Loop. IMVU and Dropbox software companies are some of the successful companies who used the lean startup methodology. (Reis, 2011). Similar to developing MVP, Matsudaira (2015) proposed the concept of building version one fast and building version two right. Building the first version fast, will reduce the risk of wasting resources. Launching the core product fast, helps to assess if the product is viable or not. Developing version two takes more

time because extra features will be added to the first version of the product. Lean software development will increase customer satisfaction because customers will have the core product at hand fast.(Matsudaira, 2015).

The figure below is a good example that clarify the concept of MVP. The figure compares the process of manufacturing a car. The author of the figure uses car as a metaphor for incremental software development. The first product developed step by step but it doesn't have any value until the final product completed. But, in the second product, user can receive valuable product in every step until the final product is ready. It similar with software development, it is possible to provide basic functional product first and add the required functionalities while the basic product is in use.

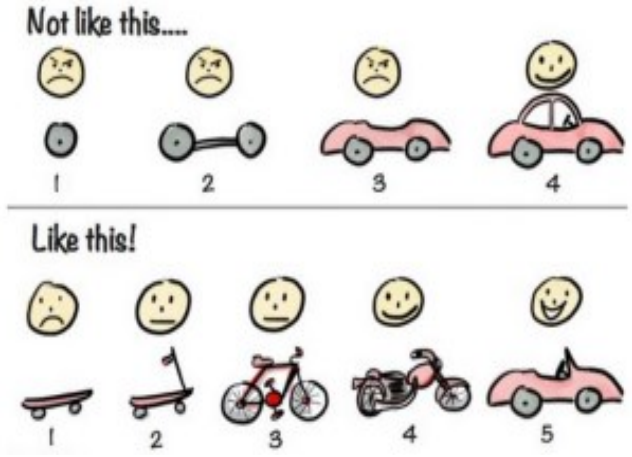

Figure 8. Minimum viable product development (Kniberg, 2014).

MVP of Addis Light Train developed fast and it's called pilot app. The purpose of developing the pilot app fast is to gain fast feedback from the user and to understand its value. The solution validation interview indicates that user's core value is managing their time properly. Therefore, as a first iteration, the basic train timetable app developed. The development of cross-platform mobile applications gained popularity in the current app market. Henceforth, different closed and open source software development environments (IDE) provide supporting tools for developing hybrid mobile applications. Among these IDEs, eclipse, NetBeans and visual studio are the best examples. Due to its easy installation and integration capability visual studio tools for apache Cordova selected to develop the pilot hybrid mobile app. Visual studio installer installs third party components for the intended Cordova project. The most common third party components installed by visual studio are apache ant, java JDK 7, android SDK. These components are required to build and run android project. Node.js component serves to integrate the Apache Cordova Command Line Interface (CLI) and the Apache ripple simulator. Ripple is a cross-platform mobile app emulator that run on the browser. Git CLI component helps to add Cordova plugins manually. (Microsoft, 2015)

Adobe PhoneGap/Cordova is evolving every time, different changes and technologies introduced. First CLI was the only option to create a PhoneGap application. Then the PhoneGap community introduced the PhoneGap desktop and mobile app. The hybrid app can be created easily on desktop and access the changes from the mobile phone. The desktop application and the mobile application are connected through IP address which is running on the desktop. The Desktop and the mobile should be in the same networks.

Visual studio Cordova project includes different folders in the workspace automatically. The folder includes, merges, res and www hierarchically. The merges folder contains HTML, JavaScript, CSS folders to specific platform and overwriting any files with the same name. The res folder contains platform icons and splash screens. The project change taking place in the www folder which contain the HTML, JavaScript, CSS and images. New scripts and style pages can be added in this folder. There are also other files included under the www folder.Config.xml file used to set the app version and to add Cordova plugins to the project. The figure below shows the hierarchical setting of Addis light Train Cordova project in visual studio development environment.

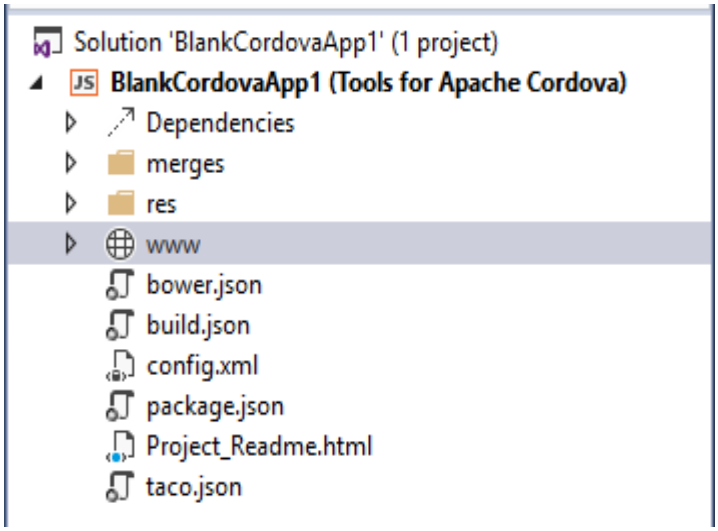

Figure 9. Addis Light Train project

Addis Light Train pilot app is intended to help the users of the new light train in Addis Ababa, Ethiopia. The pilot app provides the basic functionality such as searching departure station, destination station and departure time from the dropdown menu. If user didn't choose time from the dropdown the device time will be used to search the next timetable. Users can be aware of how long the journey takes. The search result shows the next train departure time.

Ripple is the most common debugger tool used in the development of the pilot app. In addition, the app is tested in Windows phone 8.1 720P 4.7 inch and Android tablet Kitkat emulators. However, due to device incompatibility the app couldn't be able to test on iOS emulators and devices. Users can share the app in the social media like Facebook, twitter and Google plus.

Due to time and infrastructure constraints implementation and releasing the app is out of the thesis scope. However, different ideas and recommendation are presented for future work, based on literature review and user evaluation results. The figure below is a screenshot of Samsung galaxy s3 Google chrome emulator that shows about and front page of the pilot app. When users navigate to the hamburger menu, they will find "about" and "help" links. When about link hits the purpose of the app is explained briefly.

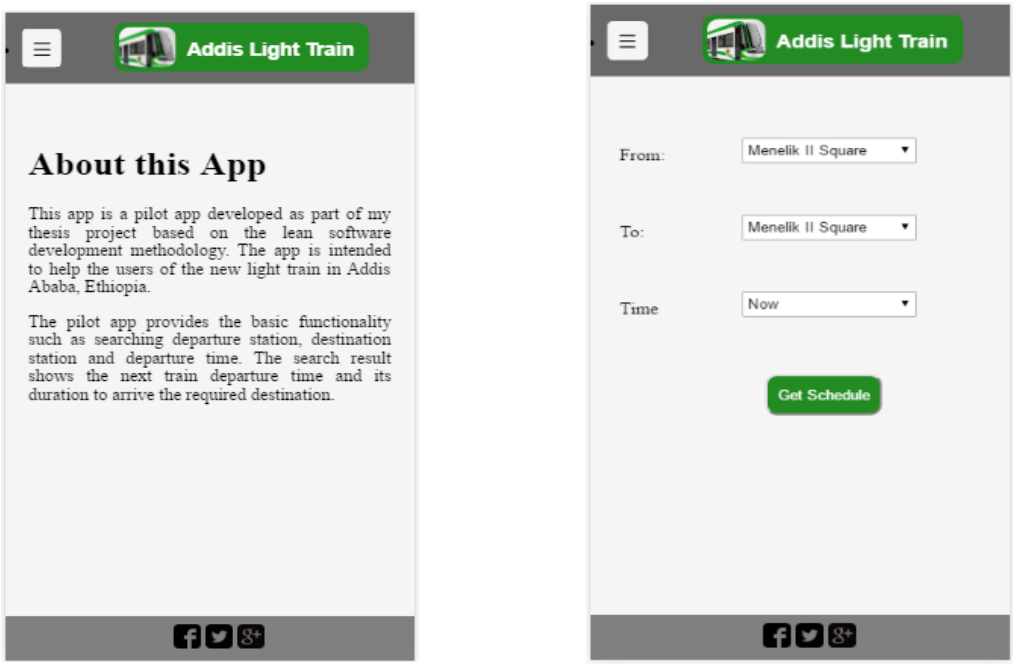

Figure 10. Addis Light Train pilot app

The snip code below shows the JavaScript code that gates the user input from the index.html document. The origin, destination and time are the inputs given by the user and it matches the stored value in the array and displays the output in the div element.

```
var p;

p = new Schedule.ScheduleService();

var element = document.getElementById("searchButton");

element.onclick = function () {

    var origin = document.getElementById("origin").value;

    var destination = document.getElementById("destination").value;

    var time = document.getElementById("time").value;

    p.getSchedule(origin, destination, time);

};
```

Figure 11 shows the help page and the search result. For example the user wants to travel from “Abinet” to “Mexico Square” and didn’t choose time from drop down menu. The result is shows the next train arrival time at 14:25, the journey takes 7 minutes and the train passes through 3 stations. In case users encounter difficulty to use the app, the help page guidance how to search the timetable.

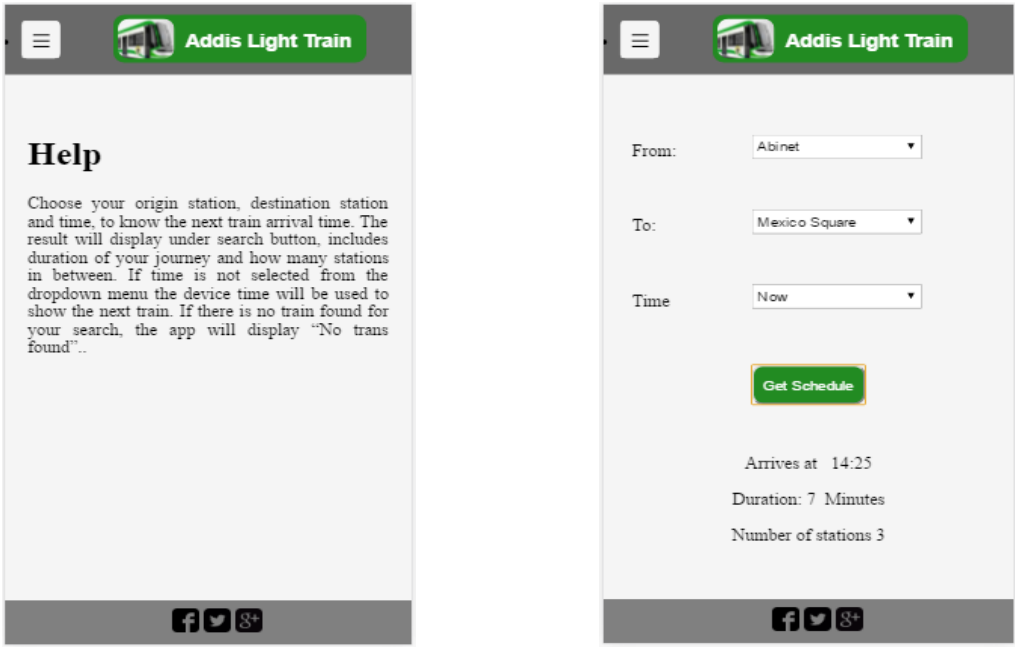

Figure 11. Help and search result

The following function gets searched timetable and returns the next train arrival time.

```
getSearchableHour = function () {

    var time = document.getElementById("time").value;

    if (time === "not selected") {

        return new Date().getHours();

    }

    else return time;

}
```

The following code gets user device time, if the user didn't choose time from the dropdown menu. If there is no train timetable found for that certain time the screen will display a text "No Trains".

```
  ScheduleService.prototype.getSearchableHour = function (time) {

            if (time === "not selected") {

                return new Date().getHours();

            }

            else return parseInt(time);

        }
```

5. Evaluations

In this chapter, the pilot app will be tested and evaluate with a small group of users. As it is discussed in chapter three, the aim of evaluation in DSR is to examine DSR output and information system theories. Evaluation proves if the new designed technology or artifact achieves the desired outcome.

5.1 Evaluation method

There are different kinds of evaluation methods. Among them, five of them summered as observation method, analytical method, experimental methods, testing methods and descriptive methods. It is necessary to analyze and choose the appropriate method which fits the designed artifact. Venable, Pries-Heje, & Baskerville (2012) proposed evaluation framework which includes a DSR evaluation strategy selection framework, a DSR evaluation method framework and a four-step method for DSR Evaluation research design. The proposed framework is easy to identify which evaluation strategies and methods are appropriate for a certain evaluation in DSR.

The proposed framework includes three parts: A DSR evaluation strategy selection framework starts with understanding the context of DSR evaluation and the selection criteria. The first step, in DSR evaluation research design, is analyzing the context of the evaluation. The context of evaluation includes nature of the artifact, purpose of the evaluation, constraints in the research environment other rigorous factors of the evaluation. The second step is comparing the contextual factor of the evaluation with DSR evaluation selection criteria. The third step is choosing the right evaluation method from the DSR evaluation strategy selection framework. The fourth step is designing the DSR evaluation in detail. (Venable, Pries-Heje, & Baskerville, 2012.)

The pilot app is a demo to show how train timetable can be designed and develop for a developing country. Since the app is not implemented or published in the app stores it is challenging to evaluate its efficiency and utility of the app in the actual market. The appropriate evaluation method for this study is testing evaluation method. Heuristics evaluation used to evaluate the usability of the pilot app. Heuristics evaluation is the most common evaluation guideline practice in human computer interaction study field. The pilot app tested with small user group aimed at demonstrating the functionality of the MVP. Moreover, the persuasive feature of the application evaluated based on persuasive system design principles.

5.2 Heuristics evaluation

Heuristic evaluation is a low cost usability evaluation method. Today, different heuristics evaluation methods are introduced for different purposes. For example Enrico, Silvia & Stephen (2006) introduced heuristics for a mobile computing and Kuparinen, Silvennoinen & Isomäki (2013) introduced usability heuristics for mobile map applications. Most of the improved versions of heuristics are based on the Nielsen’s general heuristics evaluation. Since, there is no specific heuristics found for train schedule mobile application, Jakob Nielsen's (1995) heuristics used to evaluate the pilot app.

The table below shows the evaluation of Addis Light Train pilot app. The first column defines the ten heuristics guidelines and the second column states the evaluation result.

The third column ranks the severity of the problem based on Nielsen's severity ranking rate as it is referred in table 3. Since it is a mobile application it is necessary to test at least in one real device. Testing the app on real device helps to understand how the mobile app looks and feels on the actual device. To test the app on real device PhoneGap desktop application and LG android mobile phone used. First, the android phone and the laptop connected through Wi-Fi hotspot and then the IP address found on the PhoneGap desktop app entered on the mobile PhoneGap app. After the connection placed, Addis Light mobile app appears on the mobile device screen.

Table 2. Nielsen's Heuristics Evaluation (Nielsen, 1995).

Nielsens's Heuristics Evaluation	**Evaluation Result**	**Rating**
Visibility of system status: The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.	Issues found: Addis light train application gives feedback when the search button touched or clicked with reasonable time. The app fails to provide date selection input. The social media found on the footer page doesn't work on actual device.	3
Match between system and the real world: The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.	There is no system-oriented terms used in the app. Only natural and familiar terms are used.	0
User control and freedom: Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.	There is no back button found on the interface which gets back the user to the previous search	1
Consistency and standards: Users should not have to wonder whether different words, situations, or actions mean the same thing	The interface is consistence the header and the footer are the same in every time of use.	0
Error prevention: Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a	The Hamburger menu list stays open when it clicked for the second time.	1

confirmation option before they commit to the action		
Recognition rather than recall: Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.	It will be nice if the interface provides search history for not rembring the	
Flexibility and efficiency of use: Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.	There is no map feature provide. which increases the efficiency and flexibility of the app.	1
Aesthetic and minimalist design: Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.	The app interface is simple design. However, the search result doesn't show clearly. It would be easier for the user to see their result in bigger size and more in detail.	3
Help users recognize, diagnose, and recover from errors: Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.	The interface doesn't offer error prevention message. For example when users origin and destination are the same, there should be an alert message which tells the user the origin and destination are the same.	2
Help and documentation: Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.	When the left corner of the app hits, the help link will be open. But the explanation is not concrete enough.	1

Severity rating consists of three factors: frequency, impacts and persistence. It is necessary to analyze these three factors, how often the problem occurs, how difficult it is to recover and can user's gates familiar after they know the problem once. Severity rating will be useful to assign the available resources. (Nielsen, 1995).

Table 3. Severity Ratings for Usability (Nielsen, 1995).

Rate	Description
0	I don't agree that this is a usability problem at all
1	Cosmetic problem only: need not be fixed unless extra time is available on project
2	Minor usability problem: fixing this should be given low priority
3	Major usability problem: important to fix, so should be given high priority
4	Usability catastrophe: imperative to fix this before product can be released

In addition Nielsen's heuristics, Oinas-Kukkonen & Harjumaa's (2009) persuasive system design guidelines are used as heuristics to evaluate the persuasive features of the application. The aim of evaluating the persuasive feature is to understand to what extent the persuasive feature applied in the current version of the app. The evaluation result will be useful to plan for the next iteration persuasive features. From the primary task support category, reduction principle is used strongly by reducing complexity and by providing meaningful content. Tailoring could be applied for the next iteration of Addis Light train app by providing different language options to address different user groups need. From dialog support category, liking principle supported in the design of the app. The user interface of the app has the train's color theme and the logo of the app designed with the actual train image to make it more persuasive. Reminder principle could be one persuasive feature that can be added to the next iteration by adding alarm function. The alarm function will be useful to remind users about their search. System creditability support principles are not found in the current version of the app. However, trustworthiness and authority principles could be added in the future iteration. Trustworthiness can be achieved by providing accurate train schedule information and authority can be achieved by referring the Ethiopian railways company. Since the app doesn't provide any social interactivity, none of the social support principles supported. But, Facebook, Twitter, and GooglePlus social media links provided in the footer of the page to allow sharing the app for friends.

5.3 User testing

User testing conducted with few user groups to get actual user feedback. Five test users were chosen and given to try the pilot app. The challenge of distributing the pilot app limited the number of the test users. The users have chosen based on their past experience of using the new train system in Ethiopia. The pilot app demonstrated for the user as an MVP. The users asked to try the application and give feedback about the application use. The opinion and feedback of the test users are summarized below into three parts: usability, functionalities, and bugs.

Usability issues: The simplicity of the user interface appreciated by the users. Users found the visual appearance of the search result is too small and they found unnecessary space when users scrolling down.

Functionality feedback: Map and date functionality are the most required functionalities that the user needs to see in the next iteration of the app. Feedback option is another functionality suggested by a user. Users also suggested that it would be more convenient to view at least three consecutive search result rather than only one result. Moreover, the user would like to see a live schedule and updates in the future.

Bugs found: Users found placing a new search required to refresh the page every time. They also found that the hamburger menu navigation failed to close when it hits again.

6. Discussion

In this chapter, the process of designing and developing of the pilot app discussed and its result compares with previous studies.

Mobile applications and services have brought tremendous social and economic benefits. However, there is a lack of mobile application and services development and usage in Ethiopia. Mobile banking is one of the recent mobile application and services which is adopted with few national and private banks. As it is understood from the problem and solution validation interviews, users are willing to adopt new technologies in Ethiopia. However, ICT infrastructure and economy limit the user to try and adopt new technologies.

The design and development of the train scheduling mobile application aim to improve user's time efficiency. It is common to see long queues of travelers waiting for transportation in Addis Ababa, which is perceived as a major transportation problem. The urban light rail system has decreased the transportation problem to some extent (Worku, 2015). This thesis work proved that there is still higher transportation demand and users still wait for some time until the train arrives. It is observed that users miss the train while they are in the queue to buy a train ticket. It is believed that the developed mobile application will decrease users waiting time. When Internet speed reaches to the desired level, the train schedule could be developed as a centralized way by storing in a database or by using APIs. GPS and maps could be used for more advanced usage. The development of the network infrastructure in Ethiopia concentrated on the capital city while the other rural areas didn't get even the basic network. To develop this idea more in advance there is a need to work with telecom providers. Ethio-telecom and the railway company could work together to arrange ticketing system. Currently, the user buys a trip ticket from kiosks located around the stations. It is observed that users became frustrated to buy the ticket because they are afraid of missing the coming train. Mobile ticketing will minimize long queues and eliminate user's frustrations. The problem identification interview questions identified that smartphone usage is increasing in Ethiopia.

This thesis work combines DSRM, lean startup method, and self-referential persuasion. The lean method integrated with DSR in the design and development phase. There are some similarities between DSR and the lean software development methods, as both methods aim at providing an innovative solution and follows an iterative process. Applying DSR as scientific research will add rigor to the research process and applying lean as a software development method will eliminate waste. Lean startup development helps to make pivot or preserve decision at the early stage of problem identification and product development phase. Ruhi and Akhigbe (2016) suggested a conceptual framework that integrates lean principles to DSR. First, the framework applied lean principles in DSR and then lean iteration Meta-patterns integrated with DSR iteration Meta-patterns, and finally, lean-DSR canvas proposed. The lean-DSR canvas serves as a means of documenting, measuring, and communicating DSR projects (Ruhi & Akhigbe, 2016).

The lean principles guide to improve process and quality in DSR. Lean standardization principles improve model and method creation as it eliminates methods that don't add any value to the artifact. Better instantiation and constructs can be created by using value stream principles as it provides synchronized way of understanding problems and

solutions. Since the build-measurer-learn loop involves algorithms and practices, it will be useful to produce good instantiation and constructs. Validation and engage everyone principles are helpful to provide better constructs, methods, models, and instantiation. Since both principles provide a way of understanding, defining and representing a solution for identified problem. The DSR Meta-pattern used to address relevance and rigor cycle. The relevance cycle starts the DSR activities by defining requirement from the application domain. An application domain includes people, organization, system, and technical systems. The rigor cycle relates the DSR activities with knowledge base and foundations which include scientific theories and methods, experience and expertise. (Hevner, 2007). The problem/solution fit of the lean meta-pattern addresses the relevance cycle and product/market fit addresses the rigor cycle by evaluating how well the specified solution performs in line with problem hypothesis and the value it produces. (Ruhi & Akhigbe, 2016.)

The proposed framework has not been evaluated in an actual research project. Even though the integrated lean-DSR canvas is not applied in this study, the integrated lean and DSR principles and iteration Meta-patterns used in the process of designing and developing the mobile application. The process of applying lean and DSR in this thesis could be used for evaluating the applicability and integrity of lean approach in DSR. Moreover, persuasive system design principles are used as a conceptual framework in this thesis. Applying PSD model principles with DSR and Lean software development methods will be beneficial to add persuasive features to the artifact. The persuasive feature principles are not found in the DSR and lean software development method. The PSD and lean software development method haven't been practiced widely in the Ethiopian context research works. Therefore, using these principles in design and development of an artifact will contribute knowledge for other researchers in the Ethiopian context.

The pilot app is designed and implemented with basic functionality to get early user feedback. Different kinds of literature advocate the lean software development to gain successful business. This thesis assesses the feasibility of this development by applying the intended steps. In lean software development the first useable product release first and add more technical and usability functionalities released later based on users feedback. Enhancing UX at the pilot test application is a waste because it doesn’t add feature based value to the software product. Since the train is a new transportation system and it is under development, it is necessary to test part of the project before releasing the final app. During solution validation interview users were expecting something to see if the promised solution is working well. Based on the interview result another user testing conducted after the MVP is ready. Addis light train app was presented for a small group of users. The users were selected based on their experience of using Addis Light train system. The user feedback received from the test users indicate that the developed app is feasible for the intended purpose. Since, the premium business model chosen for the train timetable app, A/B testing could be used to test the value of the paid and free MVP. A/B testing uses to differentiate which version of the software product performs best in the market. (Chopra, 2010).

In the developed countries the mobile platform is used for advanced services and applications. For instance, persuasive system applications and behavioral changing support systems are the current evolving mobile technologies Oinas-Kukkonen & Harjumaa, 2009). It is interesting to see when a simple mobile technology or application changes one’s behavior and habit. As it is defined by Oinas-Kukkonen and Harjumaa,

(2009) “Information technology is never neutral”. People’s attitude or behavior could be influenced in one way or another. Addis Light Train app could be a persuasive system indirectly. The app is intended to help users to manage their time and to enhance their punctuality. It changes and improves how people reaches to their destinations. It is necessary to add a more persuasive feature in the next iteration, to make Addis Light Train a system’s self-referential persuasion. Thus, users keep using the train timetable regularly and share it with other users. Reduction and Liking principles are applied in the design and development of the app to fulfill the primary task support and dialog support categories respectively. Reminder and tailoring principles proposed for the next iteration. Alarm functionality will be beneficial to remind users the search result and different language option fulfill different users groups need.

The literature review and interviews supported the choice of hybrid mobile application development. Hybrid apps are the best choice in the case of scarce resources. However, using only JavaScript for HTML programming language lacks advanced capability. Jquery and AngularJS could be used for advanced functionalities. For instance, AnguarJS is applicable to create single page application which could increase the app performance.

7. Conclusion

This chapter includes the implication of the thesis work, limitation, and challenges of the research work and future research recommendation.

The purpose of this thesis was to design and develop a train timetable scheduling app. The pilot mobile app developed for train system in Addis Ababa, Ethiopia. The study was done based on DSRM and lean startup software development methodology. Literature reviews used to examine prior researches in related to this study. Interviews were used to learn user's requirements and value of the application in the market.

Today, the mobile platform is becoming popular for accessing Internet in the developing countries. For this reason mobile based train timetable checking app is feasible for developing countries like Ethiopia. This thesis work has provided an overview of the current state of ICT usage in Ethiopia. The literature and interviews revealed that ICT penetration is at the lowest stage in Ethiopia when it is comparing with the rest of the world. It has already observed that people use a mobile phone to access the internet in Ethiopia. Thus, providing this kind of mobile technologies and an application will be beneficial to increase user satisfaction.

The pivot and preserve decision is not made because the application is not released in the app market. The major limitation of this research is that lack of accurate train schedule information. Since the train system is in the trial phase, Ethiopian Rail Ways Corporation couldn't provide accurate information about the planned schedules. Therefore, Addis Light train pilot app designed with a simulated schedule which will be biased if it is released in app stores. Another limitation of this thesis work is that the app is not tested on different devices and screen orientations to understand its responsiveness. It is expensive and time-consuming to find and setup different devices. Testing the pilot app on IOS platform required IOS developing environment. Since only windows operating system used for developing an app, the pilot app didn't test on IOS emulators.

The result found in this thesis work will give insights for future work. Further researches could be conducted about the available technology of Ethio telecom and with the railways company. Moreover, other transportation companies could adopt and follow the steps provided in the design and development of the pilot.

In conclusion, introducing and developing new mobile applications will contribute to the growth and development of ICT in the developing countries. Thus, telecom companies should open up their doors to work with other ICT companies and individuals to bring more advanced technologies for the users.

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Appendix

Problem validation interview questions:

1. Gender?
2. What kind of mobile platform you are using currently?
    - Apple iOS
    - Android
    - Blackberry OS
    - Windows
    - Other
3. Do you download mobile application from Google play or other mobile application stores?
4. How often you use those mobile apps? And for what purposes?
5. Do you use the new light train? How do you check the train and other public transportation timetables?
6. Do you find waiting the train or bus time consuming?
7. Do you have enough information when there is transportation disruption occurs?
8. Do you know how long it takes your journey before you start traveling?

Solution validation interview questions:

1. Is it clear what the mobile application is about?
2. What do you think you can be able to do with it?
3. Are you interested to try download the app and use it?
4. Are you interested to share it for a friend?
5. What do you think of the process?
6. What could be improved?
7. Would you be willing to spend money to buy the app?