LAMK Lahden ammattikorkeakoulu
Lahti University of Applied Sciences

Improving public transportation through open data and the internet of things: the 6Aika cities and Kathmandu

LAHTI UNIVERSITY OF APPLIED SCIENCES
Degree programme in
Business Information Technology
Bachelor's Thesis
Autumn 2017
Upendra Kunwar

Lahti University of Applied Sciences

Degree Programme in Business Information Technology

KUNWAR, UPENDRA: Improving public transportation through open data and the internet of things: the 6Aika cities and Kathmandu

Bachelor's Thesis in Business Information Technology

43 pages

Autumn 2017

ABSTRACT

This thesis focuses on discussing the Internet of Things (IoT) and open data in developing public transportation in a developing country. More specifically, the aim was to study how six Finnish cities, the so-called 6Aika cities, have applied open data to improve public transportation. Subsequently, the goal was to provide development suggestions for the commissioner of the thesis, a Kathmandu-based bus company, SajhaYatayat.

The theoretical part of the thesis discusses the Internet of Things, open data, and the Internet of things and open data in the context of public transportation.

The obtain development suggestions for SajhaYatayat, a short online questionnaire was emailed to project personnel in the 6Aika cities.As a result, the thesis presents development suggestions for Kathmandu and SajhaYatayat.

Keywords: open data, Internet, Internet of Things, smart transportation, Kathmandu transportation

LIST OF FIGURES

CONTENTS

1 INTRODUCTION

Data plays an important role in our everyday life. Knowingly and unknowingly, we deal with and manipulate data. A good example is when one browses the Internet to check for the next available means of public transportation in an area before leaving home and chooses the best transportation method available.

The data provided by transportation agency's website is provides information such as how long does one has to walk to reach a bus stop, or what is the approximate arrival and destination time of a bus. The raw data itself is useless to end users unless such raw datasets are utilized to create meaningful information, for example a suggestion on what route to take depending upon one's location and the wanted destination.

Many enterprises have created devices that connect to the Internet and exchange data over the Internet to create a cluster of devices and services commonly known as the Internet of Things (IoT) (Meola 2016).

The most common force driving the Internet of Things is the rapid emergence of the use of smart phones. Smartphone prices are decreasing, their computing capabilities are improving, and the cost of broadband Internet is decreasing. This has created an ecosystem where new smart phones are a key part of the Internet of Things (MDOT 2016).The number of Android operating system based smart phones has been rising. According to Google's statistics, 1.5 million Android phones were activated every day in 2016 (MDOT 2016).

The Internet of Things is a network where all kinds of devices that can be connected are connected (i-SCOOP 2017). These can be anything such as a car on the road, power stations, doors at shopping malls, refrigerators and so on. Moreover, various handheld devices, for example smart watches, have sensors that collect data of our everyday lives such as the number of hours slept or the calories burned during a day.

Many governments and other organizations publish financial, health and transportation data in the public domain. Such data can be useful to increase the effectiveness of the Internet of Things. One example of this could be when a bus knows how many people to expect at a certain time of the day based on the open data available about the number of employees in a particular area. This information can be used to improve transportation services and their reliability.

Both government and private sector organizations active participation has been a driving force for new generation of smart devices that improve health, transportation and finance. For example, Huawei predicted that the global Internet of Things investments will increase from 700 billion dollars in 2015 to 800 billion dollars in 2016 (Hernandez2016). The new trend will be towards task-based and goal-oriented Internet of Things technologies such as self-managing buildings and driver less vehicles. The future of public transportation using the Internet of Things will enable smart cities to improve public transportation so that the number of customers is expected to increase (Intel 2014). This in return will produce a positive effect on our environment. Using the Internet of Things in transportation provides good opportunities to create eco-friendlier public transportation systems.

2 RESEARCH APPROACH

Helsinki is an example of a city that is well prepared for the idea of a smart city. One example is its highly functional public transportation system that makes the life of its residents easier. The transportation habits of the residents of the region can be analyzed almost in real time. This has the benefit of improving the transportation where necessary while upgrading the services. The other important step that Helsinki Regional Transport Authority (HSL) has taken into make its data sets open. Openness has been realized as an important factor for innovation (Hastrup 2014, 6).

In addition to Helsinki, five Finnish cities – Espoo, Oulu, Tampere, Turku and Vantaa – have plans to develop into smart cities. Taking part in the so-called 6Aika project, these cities are committed not only to opening up their data but also to encouraging its commercial use (6Aika 2017).

On the other hand, especially in many developing countries, big cities are far behind. For example, Kathmandu in Nepal, despite having a population of 1.3 million and most of its residents relying on public transportation, has not been able to successfully use the Internet to organize the city's transportation system. The main problem is timetable information. People do not have an idea at what time a bus leaves for their destination.

By focusing on the 6Aika cities as a case example, this study examines what steps should be taken, so that Kathmandu would be ready to apply the Internet of things and open data in order to develop and improve its public transportation system in the future. More specifically, by sending a questionnaire to representatives of the 6Aika cities project, the study aims to map best practices and find out what information technology infrastructure improvements the transport agencies of the 6Aika cities have done in order to provide smart transportation systems. The findings are then compared with Kathmandu, and the study explains what lessons Kathmandu could learn from the 6Aika cities.

.

2.1 Research question and sub questions

As noted, the study focuses on the Internet of Things and the use of open data in improving public transportation in Kathmandu. The study aims to provide ideas to solve public transportation system problems in Kathmandu by means of gathering ideas from the 6Aika cities that use the Internet of Things and open data to improve their public transportation.

The thesis focuses on answering two research questions:

- How has open data and the internet of things been used in the 6Aika cities to develop/improve public transportation?
- How to improve the public transportation system in Kathmandu through open data and the internet of things?

2.2 Research method and data collection

There are two commonly used research methods, quantitative and qualitative methods. Qualitative research methods focus on exploring and understanding the research problem, for example, opinions from different research subjects are gathered to present findings as in the case of this thesis where several people are being sent a questionnaire and their opinions and thoughts on the questions are studied to present conclusions. (Mapping Research Methods 2017.)Quantitative research methods, on the other hand, focus on numeric variables, and finding and presenting quantifiable data and statistics.

Thus, this thesis project applies a qualitative research method to gather information through an online questionnaire. The research questionnaire will be sent to a person responsible for the 6Aika project in each 6Aika city: Espoo, Helsinki, Oulu, Tampere, Turku and Vantaa. The aim of the questionnaire is to gather general information from the decision makers' perspective about the role of the IoT and open data in providing more efficient public transportation. The findings will be analyzed in order to

present development suggestions for Kathmandu and particularly Sajha Yatayat, a Kathmandu-based bus company.

2.3 Thesis structure

This thesis is divided into seven main sections: introduction, research approach, Internet of things and Open data in public transportation, utilizing internet of things and open data in 6Aika cities public transportation, research data, results and suggestions for Kathmandu and a concluding section.

The introductory section briefly introduces the thesis topic. It briefly discusses key concepts such as the Internet of Things, open data and the usefulness of open data in public transportation. The chapter on research approach briefly introduces the6Aika project, the research approach and the research questions. The chapter on the Internet of Things and open data discusses and defines the concept of the Internet of Things as well as open data and their usefulness in public transportation systems. Chapter 4, Utilizing open data and the internet of things in public transportation in the 6Aika cities, discusses how the 6Aika cities are using the Internet of Things and Open data to improve their public transportation systems. Chapter 5, Research data, presents the findings of the questionnaire sent to the representatives of the 6Aika project. Chapter 6 provides suggestions for Kathmandu based on questionnaire responses. Finally, chapter 7 concludes the thesis. Figure1, below describes the thesis structure.

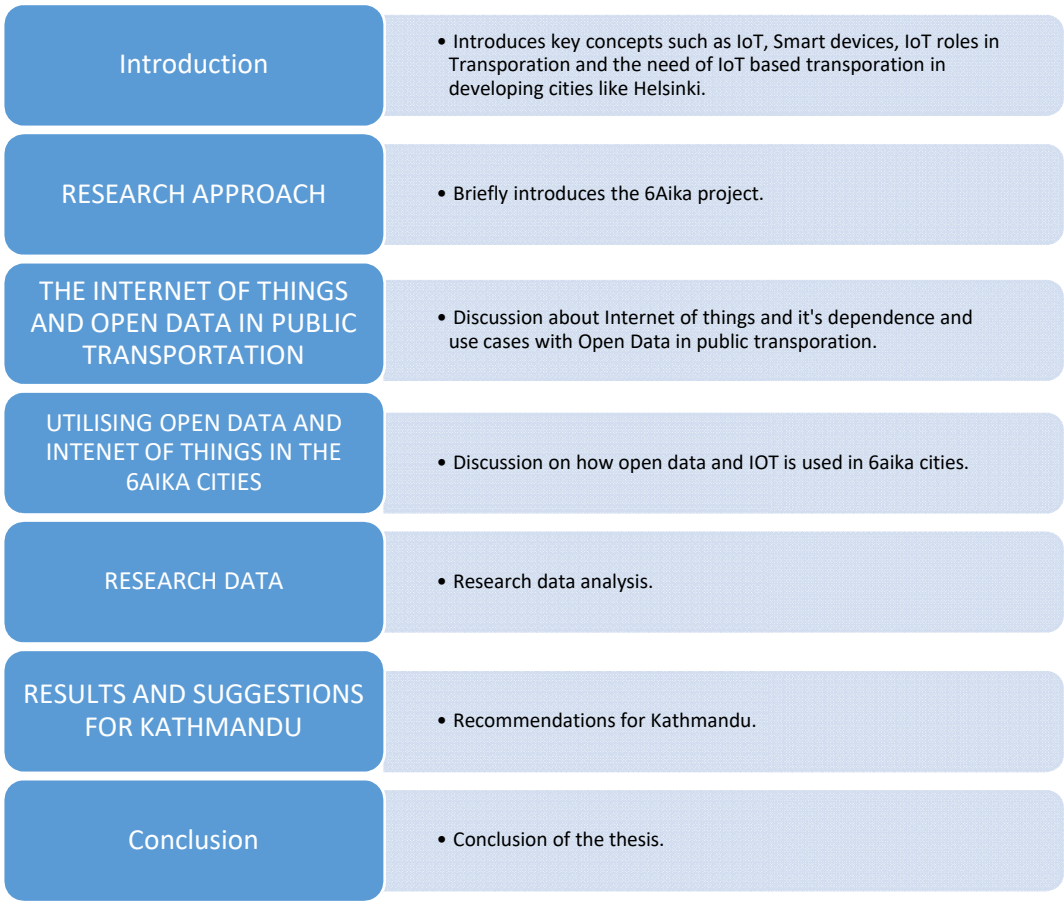

Figure 1 - Thesis structure

3 THE INTERNET OF THINGS AND OPEN DATA IN PUBLIC TRANSPORTATION

The Internet has come a long way to revolutionize our ways of life. When it was invented, it served the purpose of connecting different documents that resided in various machines in a large network. Today, however, we are facing new challenges and opportunities. The challenge is to make sense of the data that is distributed in these documents and create meaningful information out of the data. Open data, by definition, is the data available in public domain under open source licenses and can be used by anyone (Open Data Handbook 2017).

The fall in the price of mobile devices and mobile data has led to an era where handheld devices can be easily connected to the Internet. These devices produce important data that can be utilized to improve the way we work and live. For example, a car is parked in a parking lot can detect when the owner is coming and starts to heat the engine on a cold day, or using a smart device, a bus passenger can see on route map where the next available bus is and what time the user can expect the bus to arrive. (European Data Portal 2015, 12.)

Steps are now being made towards linked data where each piece of data can be correctly connected to another relevant piece of data on the Internet. With linked data, data is linked instead of documents, and IoT devices can use this data for decision-making. One particular scenario where this would be useful is public transportation. For example, it would be useful for a smart bus to have information on how many passengers to expect along its route. It could gather this information through data shared by commuters.

3.1 The Internet of things

The Internet of Things (IoT) is a dynamic global network infrastructure that has the ability to self-configure based on standard and interoperable communications protocols, which could include the combination of existing

internet protocols such as TCP/IP. The main feature of such network is that each entity, physical or virtual, will have an identity and interfaces to communicate with the outside world. Major players such as Google, Microsoft and Amazon are investing heavily to utilize the potential of machine-to-machine communication to conduct business. (Friess&Vermesan 2016, 15-26)

In IoT, every device is connected to the Internet. This is both an opportunity and a challenge. For enterprises and individuals developing IoT platforms that use the gathered data, the opportunities are nearly unlimited. The challenge is security because an average user is not aware how, when and where his or her devices are connected and what they might be doing.

Nest thermostat, DHL's logistic management and Samsung's Smart Things Hub are examples of IoT. Connectivity and the services that the connected devices provide are the two main things in the Internet of Things. The devices in the network are independent entities capable of making their own decisions 24/7 and acting to draw inferences based on the data they receive. These devices can also instruct other devices to complete a given task. The figure below shows some of the key entities involved in IoT.

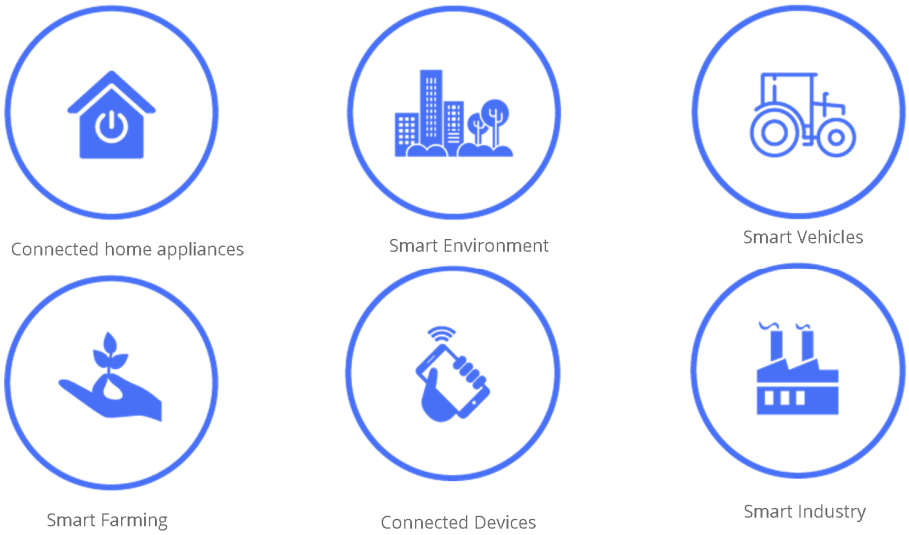

Figure 2 - Internet of things devices (Keltontech 2017)

As shown in the above figure, different entities that we interact in our daily lives form parts of the Internet of Things. When run in harmony, these entities can contribute to the global IoT ecosystem.

Connected home appliances such as a refrigerator has information when an item stored in it is going to expire or how much cooling is required based on the contents of the refrigerator. In addition, connected cars are another key IoT entity. Connectivity in cars can bring additional value to car users such as safety and entertainment. They will also provide essential information about road usage; car failure notification etc. (Weinswig 2015). Similarly, a connected public transportation system can provide real time information to commuters.

Wearable devices and smart phones are also a key entity in the IoT network. They can provide important data about an individual, for example health data, financial data and data on daily habits. These devices can be used to provide information to the individual in the case of an emergency, for instance. Figure 3 below shows forecasts by CISCO on the number of connected devices by 2020.

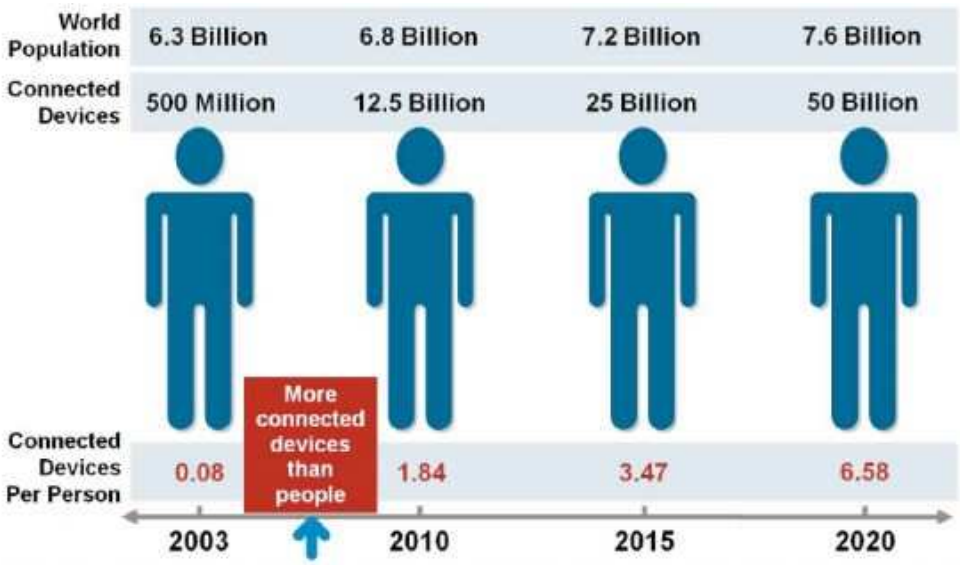

Figure 3 - Connecctted devices by 2020 (Evans 2011, 3)

Transportation is one of the top three industries where investment and spending in IoT infrastructures has been rapidly increasing as is shown in figure 4.

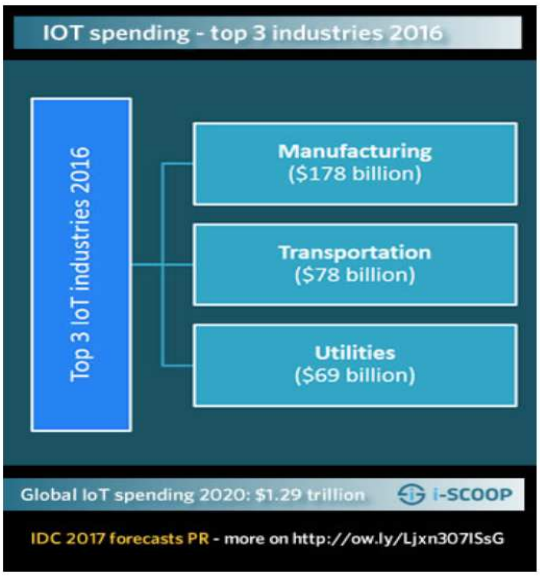

Figure 4 - Internet of Things spending by 2020 (i-Scoop 2016)

3.2 Open data

Data comes in various forms, and there are various protocols to transfer it in different forms. Open data is the data that can be freely used, re-used or redistributed. The core principles of open data are listed below:

- Availability and Access: Data must be readily available in a easy and modifiable form such as XML, JSON
- Re-use and Redistribution: Data must not restrict you for sharing or redistributing it with other parties as well intermixing with other datasets to find other relationship of the data.
- Universal Participation: All the parties must be able to participate in the use of the data. Any restriction on the use of data for example only for medical use or use for certain field voids the principal of open data thus by limiting the data. (Open Data Handbook 2017.)

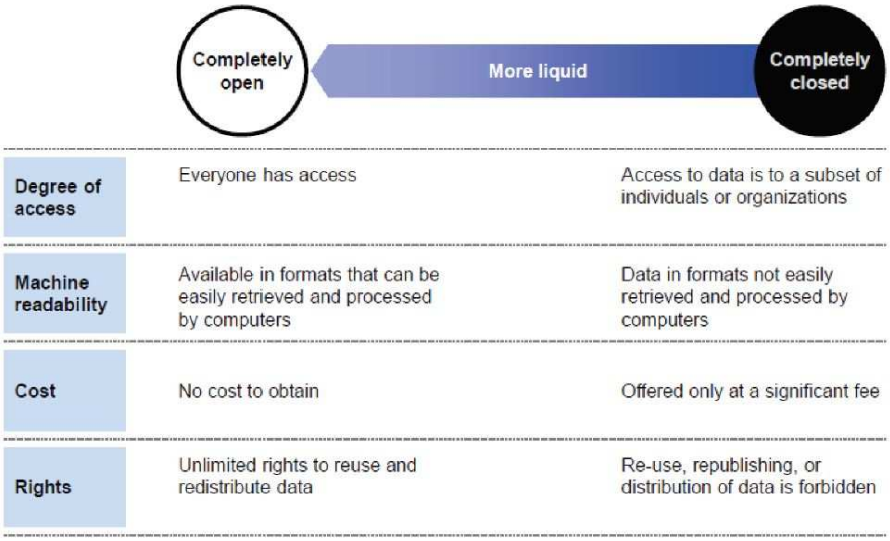

Figure 5 - Classification of data as open and closed (Mariocube, 2017)

For data to be considered open, it should adhere to the above principles. In addition, interoperability is an important factor to determine the quality of open data. At present, both governments and enterprises are taking an active role to publish their data as open data. This is an important step

towards transparency and increased innovativeness. New and innovative ways to use a data can be realized by large groups of people when they have access to the data. For example, there are at least sixty transportation guide applications available for different platforms just for checking public transportation routes in Helsinki. The applications are based on open data published by Helsinki Region Transport Authority. One particular application shows buses in real-time on a map, and commuters can track where the bus they are expecting to take is going at a certain time of the day.

3.3 The internet of things and open data in public transportation

Open data and the Internet of Things can be used to improve public transportation in cities. One example is public transportation in London. There, commuters' data is anonymzed and used to produce a map that gives an accurate picture of where people are travelling to or how long each person spent in a journey in a given day, given month and a year.

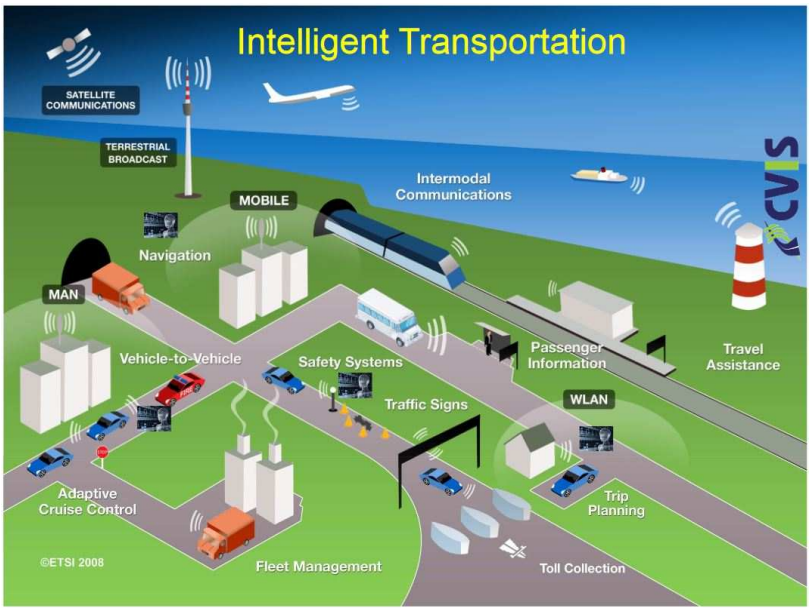

Figure 6 - Internet of Things and Transportation (Bonomi 2013, 15)

As shown in the above figure, connectivity adds intelligence to transportation. Each device can become a node in the network and contribute its part by sharing data. Such shared data, when combined with available open data sets, can be used to produce new findings. One example could be based on the open data available about air quality in a given place and the data collected from vehicles. Based on this, it would be possible to predict the amount of carbon emissions in a particular area at a particular time of the day and the cause for any deviations. (Bonomi 2013.)

TomTom is a navigation device company, and Vodaphone is a telecommunications company. The two companies decided to co-operate, and Vodaphone provided TomTom phone IDs that can be used to track user movement. This information was then used by TomTom, which helped understanding traffic patterns better and give customers better real-time traffic information. This was all possible because of machine to machine communication and internet of things. (Vodaphone2013.)

Moscow's transit authority used open data to decide whether additional investments in its railway network was needed or alternative services such as buses would meet the demand. The transit authority ended up restructuring its bus service. This allowed more flexibility for future population growth in Moscow. Moreover, the transit authority not only saved 1 billion dollars in infrastructure costs but the restructured bus service was able to save three minutes per trip during the rush hours which equals to 10 hours of travel time per year per individual. (TCRP 2015, 34.)

Similarly, when the state of New Jersey opened its public transportation data, third parties were able to analyze the data and help better understand the underutilized railway routes. The analysis also lead to express trains avoid stopping at certain times of the day at certain stops due to very little or no passengers getting off at those stops. (TCRP 2015, 2.)

4 UTILISING OPEN DATA AND THE INTERNET OF THINGS IN THE 6AIKA CITIES

The 6Aika project includes six participating cities: Espoo, Helsinki, Oulu Tampere, Turku and Vantaa. These are the six largest cities in Finland, and approximately 30% of the Finnish population lives in these cities. These six cities have joined forces to tackle problems together. The aim is to create smarter and more viable cities as well as new business and jobs. (6Aika 2017.)

Figure 7 - 6aika smart cities (6aika 2017)

4.1 The 6Aika cities as Smart cities

The Six City Strategy commonly known as 6Aika has three focus areas: open innovation platforms, open data and interfaces and open participation. (6Aika 2017.) These are also close to the core values of the open data initiative, which emphasizes the availability, usability and open distribution of data (Open Data Handbook 2017).

The first focus area of the 6Aika project is realized as the cities involved in the project open up their data storages and makes data as accessible as possible. Such openness and collaboration is useful for, for instance, creating electronic services to manage energy, logistics and traffic. One particular example is the driverless smart vehicle imitative by the city of Helsinki. Opening data helps promote new business ideas and create new jobs. The second focus area of the project is open participation and customer ship, which are useful for creating services in collaboration with the actual users of those services. For example, commuters can participate and experiment a new transportation system, the related technology, and their impact on different demographics, for example the elderly, disabled and children. The third focus area is open innovation platforms in order to create tools to solve public service problems by providing platforms for them. (6aika 2017.)

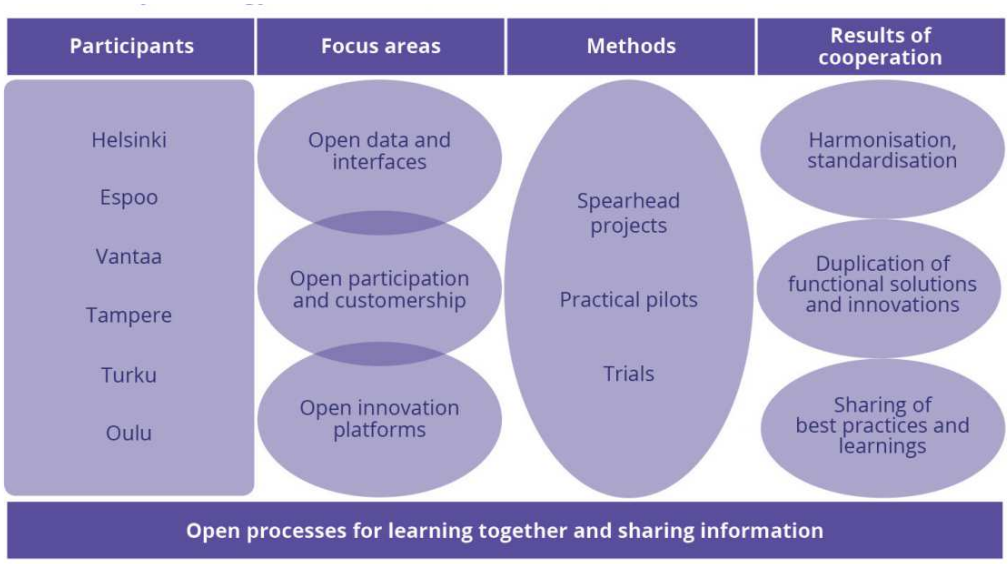

Figure 8 - 6aika cci ities initiative structure (6aika 2017)

The 6Aika project is a good example of how cities can collaborate in order to create smart cities. The two following sections discuss the six cities in more detail.

4.2 The metropolitan area: Helsinki, Espoo, Vantaa

Helsinki is the capital city of Finland with a population of 630,000. It is the most rapidly growing city in Finland. Regarding public transportation, Helsinki's transportation infrastructure has been made to apply the Internet of Things. Helsinki Transportation Agency opened its data to public in 2009. The city's public transportation is fitted with GPS devices that send real-time data to servers, and this data is also openly available for developers.

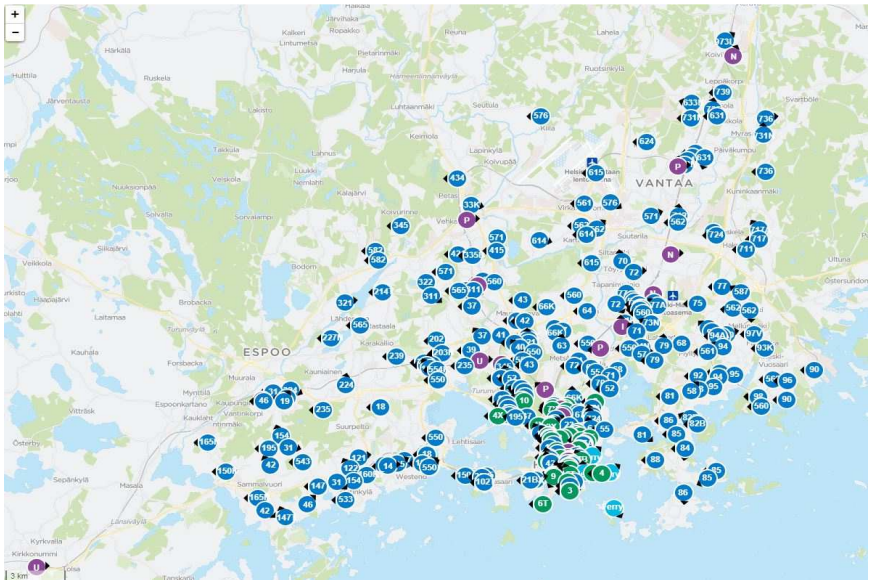

Figure 9 - Helsinki transport system on a Sunday evening

GTFS-Real-time (or GTFS-RT) is a standard for transportation agencies to provide real-time updates about their fleet. This standard includes three genres of feeds: trip alert, vehicle positioning and service alert. Helsinki Transportation Agency provides all the three kinds of feeds to public as open data.

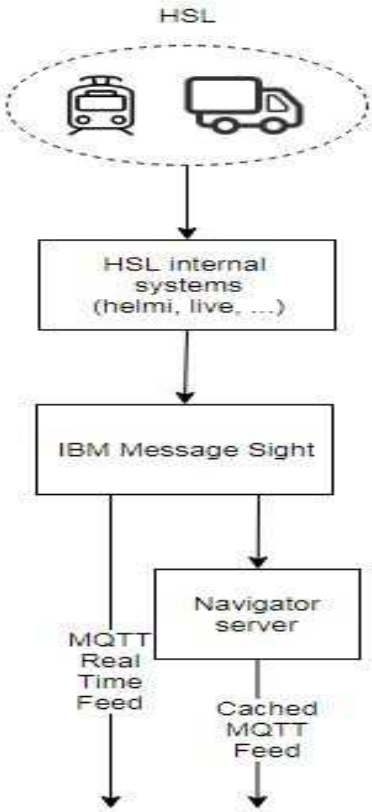

Figure 10 - Real-time data processing by HSL (Digitransit 2017)

As shown in Figure 10, the real-time data collected from a vehicle is received by HSL's internal system. It is then processed by other entities and distributed to public as open data as an MQTT real time feed.

Espoo is the neighboring city to Helsinki with a population of 270,000. Espoo is a key innovation and technology hub in Finland because it was once the home of the telecommunications giant, Nokia Corporation. Espoo follows a strategy called Espoo story for developing services and infrastructure and improving service productivity (6Aika 2017). Like Espoo, Vantaa is a neighbouring city to Helsinki with a population of 215,000. The main international airport in Finland, Helsinki-Vantaa Airport, is located in Vantaa.

These three cities are being served by the Helsinki Region Transport Authority (HSL). HSL provides various means of public transportation such as rails, buses, trams and ferries in the greater Helsinki area. In the 6Aika initiative, these cities plan to act as a hub for the development of open

innovation platforms. Such platforms can help businesses find new opportunities and develop their existing services. The transportation system managed by HSL is a good example. Public transportation datasets are open, and there are several applications available for finding the right mode of transportation from any part of the greater Helsinki area. Reittiopas is the main source of transportation information that can be used by the public to find the right mode of transportation. The transportation service has been organized so that it covers all the parts of the greater Helsinki area. However, there are still areas that are difficult to access for tourists. The 6Aika project aims to develop an easy access to those areas for tourists as well as the residents of the Helsinki metropolitan area. (6Aika 2017.)

4.3 The other 6Aika cities: Oulu, Tampere, Turku

In addition to Helsinki, Espoo and Vantaa, the other cities in the 6Aika project are Oulu, Tampere, and Turku. These cities are opening up real-time traffic data according to the open data principles. The aim is to facilitate the development of intelligent traffic services and to solve transportation problems and also to provide business opportunities. (6Aika 2017.)

Turku has been developing its new journey planner service called Föli that makes it easy to find public transportation routes and examine timetables.

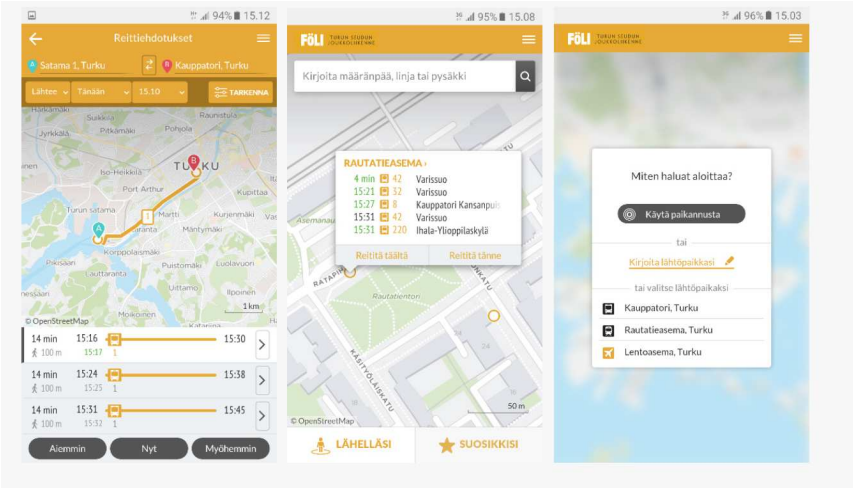

Figure 11 - Föli journey planner application used in Turku (Föli 2017)

The Föli journey planner is based on the open Application Programming Interface (API) and uses the open public transportation data provided by Föli. This service also provides open source data about the routes. Third party application scan use this data for other purposes or for improving the usability of the service. The service works seamlessly on any device. The GPS data provided by a given device is used to show real time traffic and stops in the vicinity. The application can also remember the initial searches and stops of the user. The service utilises the Open Street Map base map. Improving and reforming the Föli journey planner is part Turku's open data actions. The reform will be carried out as part of the spearhead project called Open data and interfaces. (Föli 2017.)

Oulu has a similar journey planner to Föli, which is based on the Digitransit system also used by the city of Helsinki. Figure 12 below shows the journey planner in use at Oulu. The journey planner is user-friendly as well as innovative.

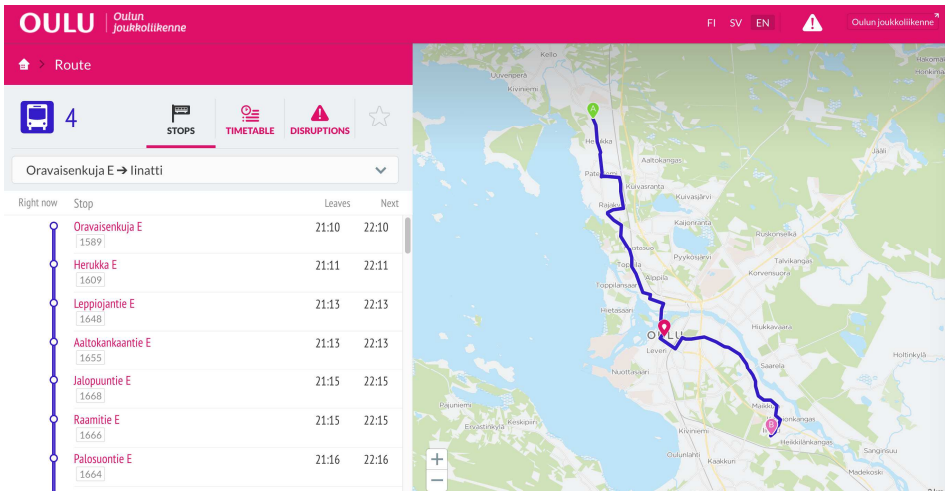

Figure 12 - The journey planner used in Oulu

Tampere also has journey planner system, which is called RepaReittiopas. It helps to search for the best public transportation available between selected locations, and the search can be saved for further use. RepaReittiopas is also good for journey transfers and connections; it plans a walking distance between an origin to the transfer point and up to the final destination.

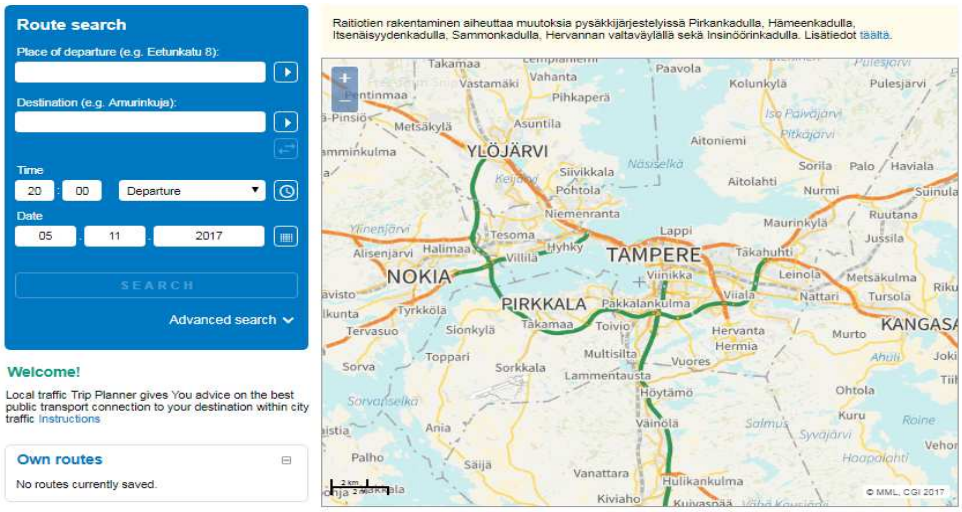

Figure 13 - The journey planner used in Tampere

This is a more reliable and easy way than having printed timetables and public transportation routes. RepaReittiopas shows users the most favorable modes of transportation and connections on the basis of least time taken by estimating the actual travel time. Routes on RepaReittiopas

are shown based on estimated travel time so if the weather conditions are poor and there are disturbances in the transportation system, the journey planner fails to give true information.

5 RESEARCH DATA

The following two sections, 5.1 and 5.2, introduced the research data gathered through an online questionnaire sent to key representatives of the 6Aika project by email. The data was gathered during the summer of 2017. The respondents chose to remain anonymous. The aim of the questionnaire was to gather information on the use of IoT and open data in the 6Aika cities in order to provide development ideas for the city of Kathmandu and of its public transportation operators, SajhaYatayat.

Figure 14 - Passengers trying to get in to an overcrowded microbus in Katmandu without a fixed time table (left) vs. comfortable buses in Helsinki whose movement can be viewed in real-time (right).

5.1 The metropolitan area: Espoo, Helsinki, Vantaa

Questions	Answers from the 6Aika representative
Espoo	
What is the history of using open data/IoT in your city in public transportation?	HSL, which is the main public transportation organization in the Metropolitan area (Helsinki, Espoo, Vantaa), has provided open data and API couple of years ago, e.g. app called Nysse is using that open data.
What were the steps taken to utilize open data/IoT in improving public transport in your city?	HSL is operating also in the City of Espoo.
Was there a pilot project first? If yes, how was it organized?	N/A
How the general public was made aware of the travel planner application?	On the major media´s in the Metropolitan area, social media web´s, Android, Apple and Window´s shops.
How is the developer community currently involved in the use of open data/IoT for public transportation in your city?	Kindly see above, Espoo City´s public transportation is operated by HSL.

How vital is an active developer community in a project such as this?	To my knowledge very vital
How is the system currently maintained?	By HSL
Could you give some recommendations for starting a project to apply open data/IoT in public transportation?	N/A
Helsinki	
What is the history of using open data/IoT in your city in public transportation?	First actual open data service launched in 2009. Before that, some developers used screen scraping techniques or we gave them some data on a case by case basis. First there was only static routing and timetable data available. Today we offer real-time data (including GPS locations up to once per second for more than 1000 vehicles) and other data sources like geo information, statistics etc. More info here: https://www.hsl.fi/avoindata http://dev.hsl.fi/
What were the steps taken to utilize open data/IoT in improving public transport in your city?	We have gradually improved our APIs, their documentation and the range of data. We have promoted our open data via our own developer events as well as via participation in several national developer events like Apps4Finland, Open Finland Challenge, MyData2016, Slush/Ultrahack. We are currently sharing to third-party developers the same open data and APIs as we use in our own services. Finally, the new journey planner as well as the prototypes that lead to it are published as open source code, so others can learn from it and even copy it as a basis for their own projects.
Was there a pilot project first? If yes, how was it organized?	Not really when we first opened our data: we just opened the old journey planner API to everyone. Before the new journey planner project (Digitransit) began, there was a pilot

	project called HSL Navigator that implemented and validated the use of technologies such as GTFS, OpenTripPlanner, HTML5, OpenStreetMap, LeafletJS, Websockets and MQTT for real-time APIs.
How the general public was made aware of the travel planner application?	We continuously advertise all our services, including the journey planner.
How is the developer community currently involved in the use of open data/IoT for public transportation in your city?	There are some 60 apps or services, made by third-party developers using HSL's open data. So, there is quite a big community of developers. We get some feedback and development ideas. Contributions to development could be more active but on the other hand, we do not have enough resources to activate developers and take care of many pull requests. We have Facebook and Twitter channels for communication and we try to be responsive. We participate in and organize developer events. Our journey planner development is quite transparent; everyone can see what's on the roadmap. https://digitransit.atlassian.net/secure/RapidBoard.jspa?rapidView=7&projectKey=DT&view=planning.nodetail https://digitransit.atlassian.net/secure/RapidBoard.jspa?projectKey=DT&rapidView=7 Everyone can get the code, make pull request or give feedback in GitHub https://github.com/HSLdevcom/digitransit-ui
How vital is an active developer community in a project such as this?	It used to be much more vital when smart phone evolution was faster and a public authority could not keep up cost-effectively. The developer community provided the apps and (at the time) novel user interfaces such as ReittiGPS, Andropas and the various apps for Symbian, Jolla, Blackberry, SailfishOS etc. But now, as a result of the Digitransit project, we now have our own official user interface that works well on most smartphones. Even as it's not so vital anymore, it has huge benefits such as providing the best user experience for vision-impaired travelers (Blindsquare), and HSL doesn't cover all the specific devices and use

	cases such as smartwatches. We hope the mobility-as-a-service (MaaS) concept will revolutionize the competitiveness of public transport against car ownership, and MaaS startups are becoming an important part of the developer community for HSL and the ecosystem.
How is the system currently maintained?	HSL has a combined development and operations (devops) team that maintains and improves the software as well as several deployments under Digitransit.fi including reittiopas.fi and opas.matka.fi. The team is funded via an agreement between HSL, Finnish Transport Agency and Waltti.
Could you give some recommendations for starting a project to apply open data/IoT in public transportation?	Be bold and publish your work in the open. Take advantage of and participate in existing open-source projects. Explain to others the benefits of openness including your and others' success stories.
Vantaa	
What is the history of using open data/IoT in your city in public transportation?	Metropolitan area (Helsinki, Espoo, Vantaa) has a common public transportation system (hsl.fi). They use open data/IoT in transportation vehicles.
What were the steps taken to utilize open data/IoT in improving public transport in city?	All improvement is done thru HSL (www.hsl.fi). See also Helsinki region info share open data (hri.fi).
Was there a pilot project first? If yes, how was it organized?	Long time ago a pilot project was done and every year the most important features
How the general public was made aware of the travel planner application?	Social media, radio, local magazines, billboards and viral marketing by users.
How is the developer community currently involved in	See www.hsl.fi open data section for more information and community.

the use of open data/IoT for public transportation in your city?	
How vital is an active developer community in a project such as this?	Very vital
How is the system currently maintained?	Main application reittiopas.fi is maintained by HSL and all other applications are in community
Could you give some recommendations for starting a project to apply open data/IoT in public transportation?	Test few things first, give information to public well in advance and listen users before, during and after the tests.

5.2 The other 6Aika cities: Oulu, Tampere, Turku

Questions	Answers from the 6Aika representative
Oulu	
What is the history of using open data/IoT in your city in public transportation?	Open data makes it possible for third parties to publish public transport information in their products and services. Also, City of Oulu uses its own produces public transport data.
What were the steps taken to utilize open data/IoT in improving public transport in your city?	(Real-time) passenger information is accepted to be very important. Since the data has been available we have to make it open to the public through our own services (RTIS) for customers and through API's for developers.
Was there a pilot project first? If yes, how was it organized?	From 2007 (?) there has been a pilot publishing public transport data through open data resources on city own displays. The pilot failed due to too complex organization of too many actors.

How the general public was made aware of the travel planner application?	Oulunliikenne -project has a yearly budget for advertising.
How is the developer community currently involved in the use of open data/IoT for public transportation in your city?	Static open data can be found on the city's internet site. For real-time public transport data, the producer of the data complies to whitelisting IP-addresses. On a yearly base, we get about 15 requests for using real-time data. We don't track static data use.
How vital is an active developer community in a project such as this?	I am not very often in straight contact with the dev community and therefore I cannot answer to that.
How is the system currently maintained?	Public transport open data is updates and uploaded to a server after every data change. The producer of the real-time data deals with the whitelisting of the IP's.
Could you give some recommendations for starting a project to apply open data/IoT in public transportation?	GTFS archives enable using ticket information. This might be of growing importance in the near future. At the moment, we don't have ticket information embedded into GTFS.
Tampere	
What is the history of using open data/IoT in your city in public transportation?	We have opened the data of public transport some years ago and anyone, willing to use it, have been able to utilize the data, e.g. some private companies and individuals have built mobile applications for public use (some of the are free) for tracking of buses etc. Some other applications have also appeared based on open data; for example, tracking of condition of the roads etc.
What were the steps taken to utilize open data/IoT in improving public transport in your city?	We started an Open Data -Project about 7 years ago and currently we have a bigger Project (6 biggest cities of Finland working together) called Open Data and interfaces.

How the general public was made aware of the travel planner application?	The applications were reported and discussed in social media but to some extent in the paper media (news - local newspapers) also.
How is the developer community currently involved in the use of open data/IoT for public transportation in your city?	Because the data is open it could be utilized by any member of development community. This should also be asked from the Project manager od Open Data -Project
How vital is an active developer community in a project such as this?	it is very necessary and useful, very vital also
How is the system currently maintained?	We have several developer communities dealing with open data: we have several open innovation platforms where open interfaces and open data is being developed. Open innovation platforms are facilitated and maintained usually by public actors.
Could you give some recommendations for starting a project to apply open data/IoT in public transportation?	Start to take small steps: depends on the current local situation. E.g. if you have public transportation start to put gps-systems in them (also tracking devices). Start also to put the data from the tracking devices openly in standardized form (create open interfaces) openly in some information cloud made available to everyone. Take care of the privacy though.
Turku	
What is the history of using open data/IoT in your city in public transportation?	Public transportation Open API has been published updated 2015! A lot of applications have been developed using this API. IoT has been used mainly in order to collect data, e.g. air quality, urban noise. But we have a

	possibility to use it also in public transportation in order to show exactly where our buses are at the moment.
What were the steps taken to utilize open data/IoT in improving public transport in your city?	First, we opened data and then created API, IoT data has been available shortly and now its quality has been improved at last spring.
Was there a pilot project first? If yes, how was it organized?	No
How the general public was made aware of the travel planner application?	By different events and informing about it in our city website.
How is the developer community currently involved in the use of open data/IoT for public transportation in your city?	In Turku, we have opened GI data for some time, and now we are running an open data project until 31.12.2017. After that opening data and API's will be a part of city services.
How vital is an active developer community in a project such as this?	Most vital. A new technology needs to be marketed and people need to be informed of its possibilities, the more active one is the better new ideas are adapted in organization!
How is the systemcurrently maintained?	If you mean open data system, it is maintained together with Regional Council of Southwest Finland, we aim to have also a regional impact in our project.

Could you give some recommendations for starting a project to apply open data/IoT in public transportation?	It's worthwhile to make a survey of your data and see if there are some regulations to prevent to open it. Otherwise it is just to open it, study suitable licenses and maybe create some kind of open data policy for your organization.
May I mention your name in my thesis?	No

6 RESULTS AND SUGGESTIONS FOR KATHMANDU

The public transportation system in Kathmandu is in dire need of improvements in order to provide a better system for the city's growing population. Despite having a good network of roads in the Kathmandu valley, a systematized public transportation system that people can use to comfortably move in the area is lacking. The primary cause is the lack of organization. The Internet of Things and open data can play a vital role for the better management of a transportation system in Kathmandu. Smart phones are common in Kathmandu, and the availability of a live timetable application with the ability to track the movement of public transportation could be of great benefit for the residents in the area. It could also be used to organize traffic resulting in less chaos in the city.

Making timetable datasets and the Internet of Things, open data could encourage the Nepalese developer community to build applications and services for the transportation system. The core principle followed by the Six City Strategy, making platforms and data open, could be adopted by Kathmandu as well in order to allow the creation of innovative services.

6.1 Public transportation in Kathmandu

There are both public sector transportation service providers and private sector transportation service providers in Kathmandu. The private sector operators include companies such as AagniYatayat and Buddha Transportation Private Limited. Their focus is to provide transportation services for tourists and foreign visitors. The private companies cooperate with big hotels in Kathmandu. The service is better and more efficient than that provided by the public sector operators, but the costs are not affordable for average middle-income residents in Kathmandu. Private sector operators provide a better window on how transportation services could be improved in the city. The thesis was commissioned by SajhaYatayat (Common Transportation), a public sector operator, and it therefore focuses on providing development suggestions particularly for them.

SajhaYatayat (Common Transportation) mainly serves the Kathmandu valley. Its routes cover both Kathmandu and its neighboring cities such as Lalitpur and Bhaktapur. Modernization has been proposed to improve the currently chaotic and unorganized system (Clean Air Network Nepal 2014). Figure 15 below shows the proposed routes for public transportation.

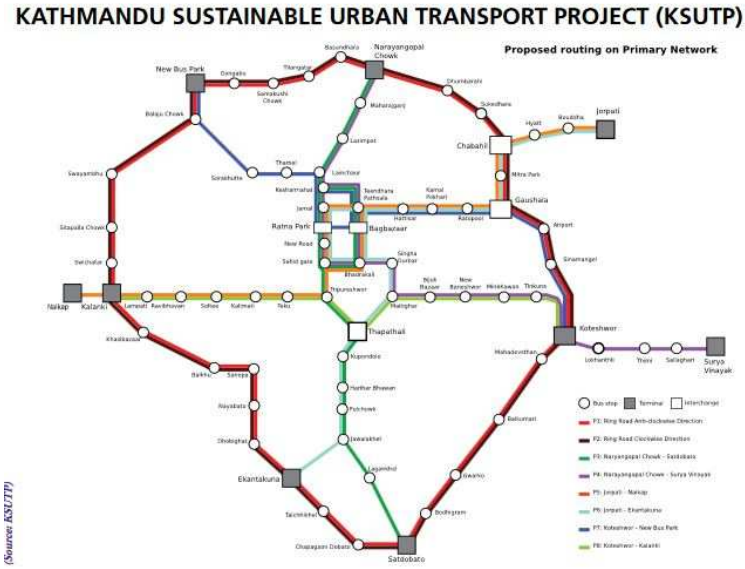

Figure 15 - Proposed public transportation routes in Kathmandu (Urban Mobility in Kathmandu 2013)

The main vehicles used for transportation are Tempos (three-wheeled vehicles powered by LPG gas) with passenger capacity of 13, Microbuses with passenger capacity of 16, Minibuses with passenger capacity of 35, and large buses with passenger capacity of 50. Minibus is the most popular mode of public transportation in Kathmandu and it is often crowed. (Public Transportation in Kathmandu Valley 2014.) Figure 16 below shows the vehicle types, their passenger capacity, the number of routes being operated and the number of operating vehicles. A proposal has been made to phase out tempos and microbuses due to their low capacity.

Types of Public Transport	Passenger Capacity	Number of Operation Route	Number of Operating Vehicles
Tempo	11-13	21	913
Micro Bus	10-16	90	2,036
Minibus	26-35	107	2,036
Large Bus	35-50	4	336
Total		222	5,321

Figure 16 - The number of operating public transport vehicles and their routes within the Kathmandu Valley (Public Transportation in Kathmandu Valley 2014)

Figure 16 below illustrates the modes of transportation in Kathmandu. Public buses are used by about a quarter of the total population in Kathmandu. Using buses is therefore an important mode of transportation, and buses have a significant role in the everyday life in Kathmandu.

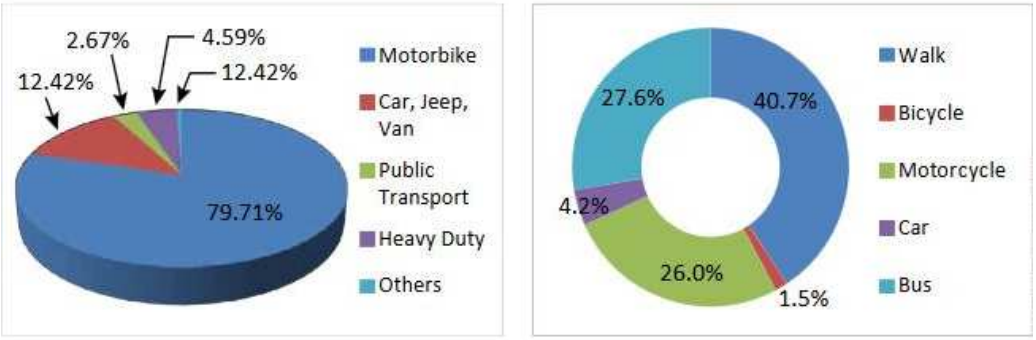

Figure 17 - The composition of registered vehicle fleet in Bagmati Zone (Kathmandu and neighboring municipalities (Public Transportation in Kathmandu Valley 2014)

6.2 Recommendations for Kathmandu and SajhaYatayat

Kathmandu needs an innovative solution to manage the current chaotic transportation system. The below picture illustrates the currently chaotic situation of public transportation in Kathmandu.

Figure 18 - Public transportation chaos in Kathmandu

As shown in Figure 17 above, there are too many vehicles in the street of Kathmandu, including private cars and taxis whose numbers could be decreased by providing a more efficient public transportation system. Motorcycles are the most popular mode of transportation for the middle-class residents of Kathmandu. They are also one of the main causes of traffic chaos in Kathmandu. People use motorcycles instead of public buses because public transportation is not reliable.

It is recommended to provide public transportation route information using standard software and make the route information available to the public. This can be done by publishing the route information on a website. Data could be published as open source data, which could then be used by developers to build applications to find the correct public transportations as in the case of Helsinki or other major cities in Finland.

An initiative to use an electronic card instead of collecting money on a bus could make bus journeys more effective. It is recommended to use an online payment system to load balance in a card. Once such travel cards are being used, they can act as important tools for collecting data about passenger behaviors. A mobile application to find routes can also help identify the most important routes and the number of people searching for these routes. Due to the rise of internet usage in Kathmandu, there is a demand for applications and services that rely on the Internet of Things to provide services such live previews of routes and timetables that are, discussions with public transport service users in Kathmandu reflect a wish for a better public transportation system in the city.

Based on the findings of the questionnaire responses from the 6Aika representatives, openness of data is the key to developing a public transportation system. Open data that provides real-time traffic information can be used in many different ways. For example, Helsinki Regional Transport Authority uses the same data that is also open to public. There is an application called Blindsquare, which helps blind people use the journey planner. Blindsquare is an example of how an active developer

community can help produce services that can serve various kinds of users, which would not have been possible if the data were closed.

Cities in the greater Helsinki area started opening their data gradually, first static data was made open and then slowly real-time data provided by IoT devices attached to public transportation vehicles. Kathmandu could take a similar approach of first publishing timetables in a csv format. Social media was considered a good platform to promote the new services in the greater Helsinki area, so Kathmandu could do the same increase awareness of city's readiness to improve its services. Helsinki Regional Transport Authority also uses Open data technologies such as Open Street Map. Helsinki has not only opened its data but has lead by example to use other open data for its journey planner. This is an important aspect to be considered by cities such Kathmandu that has a limited budget.

There are also important lessons to be learned from the other 6Aika cities. Oulu acts as a good example of opening data to limited partners but also not restricting other interested parties. In case Kathmandu is not well prepared to handle opening its data to all possible kinds of parties, it can first white list only those parties that are really interested in the data. Oulu Public Transportation Authority uses General Transit Feed Specification, a standard that is being used by transport authorities around the world to release public transportation schedules. Kathmandu could start by using these well-defined and widely used standards. Using standards can help open the interfaces to developer communities and incorporate the data to platforms such as Google maps.

A common approach the 6Aika cities have taken is to encourage businesses and technologies to fulfill the idea of Mobility as a Service (MaaS) and to open up their public transportation data. All 6Aika cities have opened their public transportation data, which has helped create new ecosystems where developers contribute to ongoing projects in order to improve journey planners as well as to fulfill the needs of various user groups. The cities could not have managed this own. As a result,

Kathmandu should start creating a journey planner system based on an open API, standardization, and the Internet of Things.

7 CONCLUSION

This thesis focused on discussing how the Internet of Things (IoT) and open data can be used to develop and improve public transportation systems. Public transportation vehicles can act as IoT nodes and, for instance, help collect data about road conditions, ease of use of the transportation and the efficiency of transportation.

The aim here was to gather ideas from six Finnish cities, the so-called 6Aika cities, on how they have applied open data and the Internet of Things to create smarter public transportation solutions. In addition, the thesis aimed to provide some development suggestions for Kathmandu, Nepal, on how to improve its public transportation based on the lessons learned in the 6Aika cities. Therefore, the aim was to answer the following research questions:

- How has open data and the internet of things been used in the6Aika cities to develop/improve public transportation?
- How to improve the public transportation system in Kathmandu through open data and the internet of things?

Each 6Aika city has made its public transportation data open and each city has a journey planner that helps the city's residents to use public transportation services. As a result, the thesis suggests that similar infrastructure and service developments could be done step by step in Kathmandu in the future. To conclude, open data can play an important role in developing transportation services in developing countries such as Nepal.

7.1 Reliability and validity

The respondents who answered the questionnaire were either directly or indirectly related to the 6Aika project. Some of the technical questions were left unanswered by some respondents, but answers to those questions were readily available on the websites of the transportation

agencies of the corresponding cities. The research data also corresponds to recent developments in transportation systems improvements in the 6Aika cities.

Some of the respondents were project managers without broad knowledge of the technical details on how the open data interfaces are managed and how IoT is used in connection with open data. This lack could have been improved by collecting data from software engineers and software architects who implement these systems. Such approach could have provided with a deeper insight into how open data interfaces are managed technically and into technical difficulties that transport agencies face when they open date for the public.

7.2 Further research

Applying open data and Internet of Things is still a developing industry and its full potential is yet to be realized. Further research could be conducted regarding the question of how open data and the Internet of Things can be used to improve public transportation in developing cities. The research could proceed to present an actual implementation of this concept under developing cities such as Kathmandu.

LIST OF REFERENCES

6Aika.2017. Six Finnish cities join forces to become better and smarter. Aika-strategiatoimisto[accessed 8 October 2017]. Available at: https://6aika.fi/in-english/

Bonomi, F. 2013. The Smart and Connected Vehicle and the Internet of Things. National Institute of Standards and Technology [accessed 6 September 2017] Available at: http://tf.nist.gov/seminars/WSTS/PDFs/10_Cisco_FBonomi_ConnectedVehicles.pdf

Digitransit. 2017.About the API. [accessed 13 October 2017] Available at: https://digitransit.fi/en/developers/services-and-apis/4-realtime-api/1-getting-started/

European Data Portal. 2015. Creating Value Through Open Data [accessed 7 September 2017] Available at: https://www.europeandataportal.eu/sites/default/files/edp_creating_value_through_open_data_0.pdf

Evans, D .2011. The Internet of Things How the Next Evolution of the Internet Is Changing Everything, Cisco [accessed 13 October 2017] Available at: https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf

Friess, P&Vermesan, O. 2016. Digitising the Industry: Internet of Things Connecting the Physical, Digital and Virtual Worlds.European Rsearch Cluster on the Internet of Things [accessed 20 September 2017] Available at:http://www.internet-of-things-research.eu/pdf/Digitising_the_Industry_IoT_IERC_2016_Cluster_eBook_978-87-93379-82-4_P_Web.pdf

Föli.2017. The new Journey planner.Föli service office [accessed 13 October 2017] Available at: http://www.foli.fi/en/new-journey-planner

Weinswig, D. 2015. Connected Cars a Mobile device cruising the Internet of Things. Fung Business Intelligence Center [accessed5 September 2017] Available at: https://www.fbicgroup.com/sites/default/files/Connected%20Cars-%20A%20Key%20Part%20of%20the%20Internet%20of%20Things%20July%2028th.pdf

Hastrup, T. 2014.HSL. HSL Navigator – Fully open journey planning [accessed 10 October 2017] Available at: http://dev.hsl.fi/tmp/itseurope2014-hastrup.pdf

Hernandez, P. 2016.IoT to Cover 100 Billion Connected Devices by 2025. Datamation[accessed 1 September 2017]. Available at: http://www.datamation.com/data-center/iot-to-cover-100-billion-connected-devices-by-2025.html

Huawei. 2016. Things Network Coverage Planning White Paper Bring Everything Connected. Huawei [accessed 9 October 2017] Available at: http://www.huawei.com/minisite/hwmbbf16/insights/paper-en.pdf

Intel. 2014. Smart Cities, Self-Driving Cars and Smart Factories: The Internet of Things “Mash-Up” Post. Intel [accessed 10 October 2017] Available at: http://blogs.intel.com/iot/2014/07/01/smart-cities-self-driving-cars-smart-factories-internet-things-mash-post/

i-SCOOP. 2017. The Internet of Things – essential Internet of Things (IoT) guide. i-Scoop [accessed 9 October 2017] Available at: https://www.i-scoop.eu/internet-of-things-guide/

Keltontech.2017. Internet of Things. Kellontech Solutions Ltd [accessed13 October 2017] Available at: https://www.kelltontech.com/internet-of-things

Mapping Research Methods. 2017. Qualitative Research. University of Jyväskylä[accessed 13 October 2017] Available at: https://koppa.jyu.fi/avoimet/hum/menetelmapolkuja/en/methodmap/strategies/qualitative-research

Mariocube.2017. Open Data Unlocking Innovation and Performance. [accessed 12 October 2017] Available at: https://mariocube.com/open-data-unlocking-innovation-and-performance-with.html

Meola, A. 2016. What is the Internet of Things (IoT)? Business Insider [accessed 9 October 2017] Available at: http://www.businessinsider.com/what-is-the-internet-of-things-definition-2016-8

MDOT. 2016. MDOT: The Google Ecosystem. Michigan Department of Transportation [accessed 9 September 2017]. Available at: https://www.michigan.gov/documents/mdot/Google_101_Intro_518148_7.pdf

Open Data Handbook. 2017. What is Open Data? Open Knowledge International[accessed 6 September 2017]. Available at: http://opendatahandbook.org/guide/en/what-is-open-data/

Public transportation in Kathmandu Valley. 2014. Public Transportation in Kathmandu Valley Restructuring and Reforming the System. Clean Air Network Nepal [accessed 08 October 2017] Availableat: http://www.cen.org.np/uploaded/Public%20Transportation%20in%20KV_Maya%20Factsheet%204.pdf

TCRP. 2015.Open Data: Challenges and Opportunities for Transit Agencies. Transit Cooperative Research Program[accessed 13 September 2017] Available at: http://transops.s3.amazonaws.com/uploaded_files/Open%20Data-Challenges-and-Opportunities-for-Transit-Agencies.pdf

Urban Mobility in Kathmandu. 2013. Urban Mobility in Kathmandu - Status and Trend. Clean Air Network Nepal [accessed 08 October 2017] Available at: http://www.cen.org.np/uploaded/Urban%20Mobility%20Ktm%20MaYA%20Factsheet%201.pdf

Vodaphone. 2013. TomTom and Vodaphone take Jam out of the Traffic - Case study. [accessed 28 September 2017] Available at: http://www.vodafone.com/business/global-enterprise/case-study/tomtom