

MENDEL UNIVERSITY IN BRNO
FACULTY OF REGIONAL DEVELOPMENT
AND INTERNATIONAL STUDIES

Smart villages

Smart mobility in regional cities in the Czech Republic

Bachelor Thesis

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In Brno, 14.12.

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Abstrakt

Bakalářská práce na téma Chytrá mobilita v krajských městech v České republice se zabývá implementací projektů v cílové oblasti chytrá mobilita. Hlavním cílem práce je identifikovat, systematicky třídit a kategorizovat inteligentní projekty v regionálních městech České republiky, které byly zaměřeny na implementaci inteligentní mobility. V teoretické části práce je koncept chytrého města vypracován komplexně pomocí literární rešerše. Potřebné informace pro bakalářku byly získány rešerší veřejně dostupných materiálů v tištěné a elektronické podobě o dané problematice a jednak byly získány primární informace o problematice, a to prostřednictvím řízených rozhovorů se zástupci měst.

Klíčová slova

Chytré město, mobilita, strategické dokumenty, elektromobilita, veřejná doprava, inteligentní dopravní systém, chytré parkování, aplikace pro dopravu, car and bike sharing

Abstract

The Bachelor thesis on the topic Smart mobility in regional cities in the Czech Republic is focused on implementation of concepts Smart city in the target area of smart mobility. The aim of the thesis is to identify, systematically sort; and to categorize those smart projects in regional cities of the Czech Republic, which have been focused on implementation of smart mobility. In the theoretical part of the thesis, the concept of a smart city is elaborated complexly with the help of literary review. The second part of the thesis is a practical part where I concentrated more detail the mobility in thirteen regional cities in the Czech Republic. Required information for the bachelor thesis was acquired by the review of publicly accessible material in both printed and electronic form concerning given issue and the primary information of the issue was obtained through structured interviews with the representatives of the cities.

Keywords

Smart city, mobility, strategic documents, electromobility, public transport, intelligent transport system, smart parking, applications in transport, car and bike sharing

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1. INTRODUCTION

My Bachelor thesis focuses on analyzing the current level of involvement of regional cities in the implementation of smart city, specifically smart mobility. The reason why I decided to analyze the situation in the regional cities of the Czech Republic was that I was very interested in the topic Smart City. Also, the situation of smart mobility is not sufficiently mapped in the Czech Republic. And the second reason that encouraged to work on this thesis was my participation in the project called „Analysis of the current level of involvement of the Czech Republic in the concept of smart city and smart region in relation to new trends, including proposals for measures“. It was announced by the Government of the Czech Republic through the funds of the Czech Technology Agency. This project was solved at The Faculty of Regional Development and International Studies (FRRMS). Thanks to my participation in research team of the project I deepened my previous interest in Smart City concept and also my knowledge. I identified myself with the solution and decided to find out problems, requirements and obstacles during implementation the Smart concept in district and regional cities. That all helped me to find a goal for my bachelor thesis so that the solution would at least partially contribute to the implementation of the smart concept for the Czech City. I found that most cities have a problem with area of mobility. Cities try to find good solution to help in terms of increasing transport and increase pollution. That's why I decided to focus on Smart mobility in the Czech Republic closely and proceed with my ideas and questions. It could be very useful for cities and could help them with implementing of their projects.

Regional cities of the Czech Republic have been interested in the concept of Smart City for several years. Thanks to the project, I have visited all the regions, the regional cities and district cities of the Czech Republic and I discovered that some Czech cities had already been very successful in implementing Smart city concept. On the other hand, in the Czech Republic there are also cities which are just beginning with the implementation of smart solutions. One of the key elements of smart city is sharing good and bad experience. It is useful for improvement of life in the cities of the Czech Republic. It was registered that during visiting regional cities in the Czech Republic reoccurring problem seemed to be low awareness of the Smart city and Smart mobility concepts.

The primary objective of the cities is the support of the smart city project processing information of digital and communication technologies (such as ICT). Accordingly, it is possible to improve the quality of lifestyle and local services in the city and get deeper into the public's awareness about the environment. And last but not least, reducing the city's expenses and consequently, saving the money for the public's well-being.

2. THE AIM AND THE METHODOLOGY OF WORK

The main objective of the thesis is to identify, systematically sort; and categorize those smart projects in regional cities of the Czech Republic. The ones that have been or will be focused on implementation of smart mobility. For successful fulfilment of this objective it is inevitable to reach following secondary objectives:

- to characterise concepts of mobility development in regional cities of the Czech Republic;
- to create categories of partial areas of the target area “smart mobility“;
- to make classification analysis of smart projects in area of smart mobility.

For characterization of the concept of mobility development in individual regional cities of the Czech Republic was firstly done the introductory literature review, focused on strategic documents and publicly available resources both in printed and electronic form. Proposed characterised concepts of mobility development were discussed with and verified by representatives of individual regional cities.

For categorisation of partial areas of the target area of smart city concept, namely smart mobility, was at first done literature review of authors and resources dealing with different approaches to the fragmentation of smart mobility. In further step, the descriptive analysis was carried out of those projects in regional cities, which were either focused on smart mobility or those project, where smart mobility was included into more extensive projects. Partial areas were created after mapping of all realized projects, those projects which have been under the process of implementation and those projects which had been planed by cities for future realizations.

After identification of categories of partial areas of smart mobility, the classification analysis of all projects, which were in regional cities directly or indirectly focused on smart mobility was accomplished. The projects were further divided into three tables on Realized Projects, Projects under implementation, Planned project.

Generally, the methods of induction, deduction and synthesis have been used in the whole thesis.

Besides literature review, the data were obtained during structured interviews with representatives of the individual regional cities.

Thanks to the execution of classification analysis of the projects of the smart mobility and providing the cities with unified information about partial areas of smart mobility accordingly. For regional cities, it is crucial to find out who has implemented a similar project to be able to get inspired by examples of good practice and to learn from mistakes.

3. LITERATURE REVIEW

In this chapter, you are presented a comprehensive view of smart city and smart mobility. The different descriptions of the general definition of the smart city concept, target areas of smart city, smart mobility segments, analysis of the implementation of smart city and last but not least methods of ranking of smart city.

3.1. Defitions of the concept of smart city

For smart city there is no united definition, there are many insights into how we can understand the concept of smart city. The definition is constantly evolving because it is still a new concept. Is very broad and everyone can imagine something different. All cities are special with their own historical way of development, their own characteristics and their culture. The cities, which are tagged "Smart", have many different features of the smart concept. The development of the Smart City concept is created by a complex combination of economic, social and technological factors, policy, and arrangements of the government. Therefore the implementation of the Smart City concept can succeed in different way depending on each city's particular policies, objectives, scope and funding. (Manville et al., 2014).

A lot of definitions of Smart city concept focuses on the role of ICT. „*A smart city is a place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses*” (Boratynski, 2018).

On the other hand data-driven definition from a large company such as IBM defines a smart city as a city that best utilizes all linked information which are available today with the aim to better understand and monitor its activity and choose the best option using limited resources accordingly. (IBM, 2009). Authors such as R. Hamilton and P. Hartswick followed this definition. Further with this definition are closely associated with: C. Harrison, B. Eckman, R. Hamilton, P. Hartswick, J. Kalagnanam, J. Paraszczak, P. Williams (2010), are interested in smart city like municipal area which use operational data. For example traffic jam, public safety and power consumption statistics in order to optimize the operation of urban services.

The Smart cities are cities that are perceived by the European Commission as places, which are more efficient networks there and more efficient traditional services.

For an instance, use of telecommunication and digital technologies as an advantage for residents and businesses. The European Union is investing in ICT research to support this vision. Also the European Union is investing into enhancing the quality of life of inhabitants, developing and innovative policies. The cities should be more sustainable from the perspective of Europe's 20-20-20 objectives (Boratynski, 2018).

Smart city definition according to the Ministry for Regional Development of the Czech Republic does not place much emphasis on ICT, yet perceives the concept of smart city as a whole and does not perceive it only for individual parts of smart city. They say the whole concept unifies a long-term numerical and qualitative development strategy, which cultivates the social, political and spatial environment of the city in order to improve the quality of life or attractiveness and reduce negative environmental impacts. (Bárta, 2015).

Likewise, the authors G. Cristian LazaroIU and M. Roscia (2012), look at the smart city concept in a comprehensive way. They say that smart city should be represented by a company of average technology size which should be connected, comfortable, sustainable, attractive and secure. The factors that are decisive are the landscape requirements and the solutions to local problems.

Last but not least the completely different idea about the Smart city concept is presented by the Manchester Digital Development agency, which defines the concept on the basis of smart citizens. Development agency say that the Smart city is the city where inhabitants have all the information which they need to make informed choices about their job opportunities, lifestyle and travel choice. (Yaidoo, 2017).

3.2. Target areas of the smart city

The concept of Smart Cities is not sufficiently specified in strategic documents in the Czech Republic (Grega, 2018). The Smart Cities sub-segments are conceptually solved in sub-documents such as the State Environmental Policy, the State Energy Policy, Action

Plan for the Digital Market Development, (Digital Czech 2), the National Action Plan of clean mobility or the Transport Sectoral Strategy (Ministerstvo pro místní rozvoj, 2018).

The team of the smart city concept has been assembled in the Czech Republic by the cooperation of the Center for Investments, Development and Innovation, the Regional Investment and Development Agency of the Hradec Králové Region. They focused areas such as Transport, Energy, Environment, Public spaces and living, Public administration and services (Chytrý region, 2017).

Smart Entrepreneurial Lab in a group of 5 following members M. Poel, W. Winden, W. Schrama, I. Oskam, M. Osieck (2018) created areas of the smart city for Amsterdam. The most important areas of the Smart city concept for Amstrdam are Digital city, Energy, Mobility, Circular city, Governance and Education, Citizens and living.

Another interesting country that can be seen as an example of good practice is Brussels. A smart city manager for the Brussels Capital Region is C. Vanderborcht. Brussels has the same number of target areas of smart city like Smart city Hradec Kralove. The categorization of the smart concept in Brussels is Safe, Mobile, Social, Service, Infrastructure (Brussels Smart City 2018)

Unlike the three cities of Hradec Kralove, Brussels and Amsterdam, Smart City Sweden focuses more on organic in the target area. Also Smart City Sweden, which is managed by the IVL Swedish Environmental Research Institute divided the concept of Smart city into more target areas than Hradec Králové, Brussels and Amsterdam. The categorization in Sweeden is Air quality, Biogas, Bio energy, Smart mobility, Waste to energy, Waste management, Smart grids, Water (Smart City Sweden, 2018).

On the contrary, a city that has one of the most defined target areas in the smart city concept is Wien. Overall, it has 10 smart target areas Education, Digital, Energy, Building, Health, Innovation, Mobility, Social Affairs, Location, Environment. The same structure has also German (Urban Innovation Vienna, 2018)

3.3. Smart Mobility segments

After mapping the general main areas of smart city. I will focus on one of the areas which have all the mentioned cities in the previous chapter. Because the mobility area is also divided into other areas. Smart mobility can be explained as a system mainly supported by ICT together with logistics systems and integrated transport systems. As regards the safety and interconnection of transport systems so we identify transport services such as cars, buses, metros, trams, trains, cycles and pedestrians in situations using one or more type of transport. Smart mobility prefers non-motorised options because it is more clean. An important part of Smart Mobility is real-time information that is accessible to citizens. The advantage is improve commuting efficiency, save time and costs or reduce CO2 emission. The same situation is for network transport managers who, thanks to the information, provide feedback to citizens or improve services. On the other hand, citizens using the mobility system can also provide their own data in real time or contribute to long-term planning (Manville et al., 2014).

For example, for Czech Republic, the team of the Center for Investments, Development and Innovation, the Regional Investment and Development Agency of the Hradec Králové Region divided mobility in the next 5 areas. Electromobility, Intelligent transport systems, Smart parking, Bikesharing, Smart public transport (Chytrý region, 2017)

Compared to Hradec, the city of Vienn has created target areas for smart mobility in only four areas. This may be interesting, because in the previous chapter, Vienna has the most targeted areas in the Smart city concept. Public transport wlkng and cycling, E-mobility, Commercial traffic, Commuter trafic (Urban Innovation Vienna, 2018)

Peprah, Amponsah, Oduro were interested in the system of smart mobility and its implications for Ghanaian cities. The goal of the studies was to show how the smart mobility concept can be applied through a system view. It was found that Ghanaian cities are not mobility smart. It means that cities are inefficient in the concept of smart mobility. They should focus on information mobility, people mobility and information logistic mobility (Peprah et al., 2018)

Compared to the very low involvement in the Smart Mobility concept in Africa, T.N.Manders, A.J.Wieczorek, G.P.J.Verbongse are focused on „Understanding smart mobility experiments in the Dutch automobility system: Who is involved and what do

they promise?“ Netherlands has extensive experience with smart mobility experiments. Two areas of mobility have been created and they are a mobility services niche and an automated mobility niche. For the Netherlands, it is more common that intelligent mobility experiments focus more on automobile's immediate problems than on societal challenges (Manders et al., 2018).

3.4. Analysis of the implementation of Smart city

Leonidas Anthopoulos (2017) was interested in the Smart Utopia VS smart reality: Learning by experience from 10 smart city cases. His concept is very interesting because he questions the ideas of the current smart city environment with respect to a "smart utopia" figure. Or he was interested in exploring the ten smart cities with the use of a multi-methods approach. He also compares 10 cases practical proofs with theoretical knowledge. And last but not least He shows the future smart city pursuant to the examined cases' schedule.

Contrary to the theory of the Smart Utopia VS smart reality were G. F. Camboi, P. Antônio, Z. Nathália and A. Pufal who perceived the issue of smart city more complexly and realistic. In their study, they introduced the elements which make a city smarter, based on interviews with experts and the literature. They also focused on city leaders Amsterdam, Barcelona, Lisbon, Vienna and their Smart City projects. They defined that all smart city has 4 dimensions - techno-economic, environ-urban, socio-institutional and governance all of these dimensions has driving elements. They also focused on complex elaboration of smart projects in the strategic plan which is important for every city which wants to be smarter (Camboim at al., 2018).

David Peña, Andrei Tchernykh, Sergio Nesmachnow, Renzo Massobrio, Alexander Feoktistov, Igor Bychkov (2017) are interested about Multiobjective Vehicle-type Scheduling in Urban Public Transport with the aim to improve the Intelligent Transport Systems.

Ricardo Faria, Lina Brito, Karolina Baras, José Silva (2017) they interested about smart mobility especially in Intelligent Transportation and Real Time Traffic Management Systems.

3.5. Methods of ranking of smart city

Boyd Cohen try to evaluate smart cities. Since 2012 he was ranking them. He wants to understand six key elements of a smart city. Due to generally public accessible data were early ranking done. Several regional evaluations have been published. These publications connected secondary data and primary data. As „secondary data“ we understand publicly available data and the meaning of the „primary data“ is, that this data was collected from suitable cities worldwide (Boyd, 2014).

As mentioned, there are six Smart City Wheel components. These six components have an assigned set of indicators. These indicators are set for every component separately. Indicators create proxy for measurement. This measurement is for each part of the wheel. The model has 18 total sub-parts and an average of 3.5 indicators per sub-part. Thanks to data from 11 cities, so these data were changed to a mathematical formula named Z-score. The Data can be compared in dissimilar units. For example, the percentage of tons of Greenhouse Gass emissions etc. The maximum points are 15 (for each of the six components). The highest executive city has assigned 15 points. The maximum is 90 points. If the city gets it, it leads to each of the six components (Boyd, 2014).

The survey will be re-evaluated. In the future, it is expected that large and small similar cities will be compared from around the world. This will make it easier sharing knowledge between the private sector and groups of citizens. (Boyd, 2014)

On the other hand Author Rudolf Giffinger and his team created Smart cities Ranking of European medium-sized cities. According to their research, cities are ranked according to different social, economic and geographical characteristics. The target area is to discover the best and the worst places. Based on that city often use city-rankings. This helps increase their profile and improve their situation in the competition of cities (Giffingr et al., 2014).

The methodology is a way of collecting and processing data and also limiting the selection of cities that are subject for evaluation. Restrictions can be, for example, defining a target for European cities, on the basis of their population size, further

according to their meaning in matters of global importance or perceptual significance for their target audience. The European cities were selected for research. The cities had to comply one of the different criteria (Giffingr et al., 2014).

An important role in deciding on the choice of cities was also the collection of data. The collection of data is mostly on available project resources. Data collection is different. Sometimes some data for rankings were processed by land research or more often way was by interviews. Another method was acquired by desk research, analyzing primary and secondary data (Giffingr et al., 2014).

The key point of the whole methodology is the use of weighting. Generally it is essential to weight factors and indicators thanks to their influence or importance for evaluation purposes. If the target groups are clearly defined, it is practicable to assess the weight of the interviewing factors (Giffingr et al., 2014).

4. PRACTICAL PART

Practical part is divided into two subchapters. In the first part, mobility concept in thirteen regional cities in the Czech Republic is characterised. The information was obtained both from publically available strategic documents and other relevant documents both in electronic and printed form, and from structured discussions with representatives of individual regional cities. In the second part of this chapter, I focused on mapping of smart mobility projects, which were realised, are under the process of realization, respectively are planned for future. These smart mobility projects are categorized and sorted into identified partial areas of smart mobility.

4.1. Analysis of smart mobility in regional cities in the Czech Republic

This chapter will characterise mobility concepts in individual regional cities in the Czech Republic.

4.1.1. Mobility in regional city Brno

Brno has a very detailed strategic document. Mobility planning must be intertwined with spatial planning. For Brno it is important to manage the intersection dynamically as part of the intelligent traffic management system in the city. The regional city Brno suffers mainly from the high number of cars passing through the center of Brno. Because it creates high air pollution and noise. Therefore, the city of Brno decided to plan a vision for the future (2050). With help of a broad database, Brno is able to respond flexibly to mobility trends not only in transport, but also in demography and economics. Brno wants to support the environment in terms of mobility and wants to reduce the number of cars passing through the city. The main objectives are to improve public, cycling and pedestrian traffic. Increase the integration of sustainable types of transport, accelerate public transport and to increase the number of households that do not own a car. Thanks to these goals, citizens in the city should live better in the future. Traffic jams will

decrease and traveling will be faster, the number of road accidents will reduce, reduced greenhouse gas emissions and decreased intensity of transport etc.

The first large SMART project to reduce the number of cars in the center has been a project called a parking system. Parking works as a resident parking but smart technology is also installed. Residential parking is the basis for different application types for example parking systems with payment terminals, red traffic detection, vehicle weighing, speed measurement, zone detection with limited entry, etc. Everything will be connected with the Brno Municipal Police, which will collect all the data from the roads with the help of the smart camera system and the installation of optical networks. The whole project is positive for the environment, reducing transport, reducing the unnecessary search for a parking space, also reduce energy consumption and reduce emissions. The Regional City of Brno established a Co-financing Fund for European projects. The budget measure has been approved for project implementation, all costs will be paid within the project. Financial resources for operating costs are included in the budget of the Transport Department of the City of Brno (Petlach, 2017).

Brno wants the future as a city where citizens will live a quality life without cars. The city is trying to support as much as possible public transport, cycling and pedestrian transport. The Brno City Transport Company introduced smart stops in 2014. These stops improve passengers traveling in public transport. Information from smart stops can also be used by blind passengers. The stops are equipped with a camera and speaker so the dispatcher can control the problems. Smart stops inform about arrivals and departures of public transport on electronic boards.

Brno has created a project to support public transport called BRNO ID. You will be able to use all non-transferable unlimited tickets on the card. For the convenience of citizens exists an e-shop where you can solve everything online from the comfort of your home.

Brno is the first city in the Czech Republic which started to use the gas generated during cleaning of waste water. Energy will be used to drive for CNG public transport. Project called BioCNG for cities is in testing until December 2018. The transport company of the City of Brno chose for testing a bus with drive CNG (compressed natural

gas). In the future, this project should help to using own resources to drive public transport (Šindelář, 2018).

Brno also supports bikesharing. There are two bikesharing providers since 2017. Bikes that anyone can borrow after using online registration and use them for transportation in Brno. Brno wants to improve the infrastructure in the future and to attract more citizens to use bicycles.

New development stage of mass passenger transport for the future is project Hyperloop. The City of Brno is participating along with the South Moravian Region in a feasibility study of the Vienn – Bratislava – Brno - Prague road. Hyperloop reducing transport time. The Brno Mayor Petr Vokřál and Dirk Ahlborn CEO of Hyperloop Transportation Technologies signed a cooperation document. The aim is to involve Brno companies, research centers and other subjects in creating this visionary way of transport (Smart City Brno)

The city of Brno has high proportion of tram and trolleybus transport. A disadvantage is that the large number of pillars, wires and cabling that compromise the attractiveness of the city's historic centre. In the future, Brno would like to introduce new tram that would use a battery-power drive on some stretches of its route in order to facilitate its passage through the historic centre without the overhead traction line and also ensure safe transport in emergency situations.

4.1.2. Mobility in České Budějovice

The city plans to support the public transport because the city sees great transport potential, which will be supported by many investments to the future. It is important to increase the attractiveness of public transport for new potential passengers. Nowadays, public transport capacities are lower and the capacity of public transport is smaller. The city will make high-quality, faster and high capacity public transport a number of investment action to support this goal. The investment will be for the purchase of new vehicles for example electric buses or trolleybuses with battery drive but also for the reconstruction of existing vehicles. Investing in the installation of smart light intersections for faster movement across the city thanks to public transport

All Smart Innovations that are planned for the city in the future are mainly created to reduce the number of citizens affected by emissions and traffic noise. This is also related to the energy intensity of transport and proposals for sustainable development. Reducing the noise level caused by road traffic can be reduced by the use of public transport with electric drive. The development of telematic infrastructure is important to reduce the air pollution burden. Replace existing intersection for Smart Driver Information Board and Dynamic intersection Control.

Another project is the introduction of environmentally friendly public transport. Is planned an exchange of existing buses for electric buses and trolleybuses that are equipped with a battery system and part of the rout can use only battery. The city would be very interested in this type of ecological transport but the purchase price is very high. The classic models currently used by the city are much cheaper. Although the city has already built smart stops and the citizens are happy with the use so they will continue to improve these smart stops and install new smart technologies. This also improves travel in České Budějovice (Kyp et al., 2018).

Regarding Smart Cycle Transport in České Budějovice so they plan to build more quality bicycle routes. Bicycle transport is promoted in the development of public transport. The investment should be to build a bicycle tower and also introduce a system of bikesharing and electrobikesharing which increases the potential of cycling in the city.

Also, the city of České Budějovice plans to see the decline of car traffic in the city center in the future. Although the expected decline in individual car transport, it is clear that car transport will not disappear. The management system will need to include intelligent dynamic traffic control at (světelně řízených křižovatkách), which will help to increase traffic flow. Intelligent telematics systems are important for providing timely information to drivers about the current traffic situation. Currently the city supports carsharing which helps reduce private cars (Kyp et al., 2018).

Currently is a big problem the lack of parking spaces in the city. The city plans to build more parking spaces with smart technologies. For example, the driver will get information in time, where he or she can park before driving into the city. Thanks to a special navigation system.

The smart road system one of the newest smart projects implemented in Ceske Budejovice. This is a new smart system that finds out all important traffic information on the roads. Traffic data will be used to control intersections. Strategic detectors are designed to monitor traffic, specifically intensity, traffic flow classification and vehicle speed. In the future, the project will be used to link intelligent traffic situations. The value of the project is 6.1 million Czech crowns. The investor is the city of České Budějovice represented by the City Hall of České Budějovice. The contractor of this project was AŽD Praha, s.r.o.

The investment in transport infrastructure projects is mainly pay by the city of České Budějovice. The city of České Budějovice is trying to use the programs and is actively involved in obtaining investment funds from the European Union. PPP projects are another way to get money for the city but because of some disadvantages of the PPP project so the city does not use much of this type of financing (Kyp et al., 2018).

4.1.3. Mobility in regional city Hradec Králové

Hradec Kralove has created a concept for smart city mobility which represents the situation in the regional city and plans for the future. The biggest reason why the city began with the implementation of smart mobility was to reduce the negative impact on city life. The whole concept is comprehensive because it focuses on the 4 most problematic parts of the city. They indicated reducing the environmental burden of traffic, improving the city's traffic, increase the use of public transport and last but not least thanks to electromobility to improve the quality of the environment (Smart Hradec Králové, 2017).

The current Smart Technologies that the city use are cameras and sensors in traffic. The city also uses the application for passengers and smart stops which show you the exact time of your arrival and departure of buses or trams. Information panels are located for drivers, informing about the availability of free parking spaces. I consider cycling to be the strongest side of the city. They built Biketower in the city for support to reducing the environmental burden of traffic. Thanks to the Polabské nížině in which the town lies, city has ideal conditions for cycling. Project of Smart Biketower is very helpful for many people in regional city and they also create an appliation to support cyclotourism.

SMART Transport Organization has also begun implementation which will be financed largely by the city's capacity to implement the projects. The first major project, organized in the Smart Hradec Kralové program, is called Intelligent Transport System (IDS). The IDS project was launched with a public contract in the period of 1 August 2016 to 31 December 2017 and is divided into four stages. An important objective of the IDS project should be the Traffic Model of the City. The project is processed traffic management functions, traffic information feature, navigation features, parking, supervision function, penalty function, data measurement and processing functions, traffic portal function, features for public transport, passport device features. Estimated cost price without value added tax is 248,5 million Czech crowns. The whole IDS project is prepared as the basis for further SMART development in the city (SMART LIVING and SMART MOBILITY). During the realization was found that parking will not be implemented in this project and navigation functions will be solved only partially. The reason is complicated situation with interconnectedness the IPS system and the IDS parking project. The big problem with parking is that they still do not know whether parking will be developed by themselves or in the form of PPP projects or offered to commercially operation (Smart Hradec Králové, 2017).

An important part of the SMART concept is urban public transport. The city wants to make citizens more use of public transport. With the help of smart technology to improve the quality and efficiency of public transport including citizens access to the free Internet on trams and buses or in the stops.

Last but not least electromobility topic in a regional city Hradec Králové. In order to improve the environment, the city began to use electric cars. Because the city is not licensed to sell electrical energy so the city will allow power suppliers to build a network of recharging stations in the city's car parks under commercial conditions.

4.1.4. Mobility in Jihlava

Mobility plans in Jihlava want to connect transport with the environment and create a city that is pleasant for life. It is important to set priorities and examine the broader impacts of smart technology considered on the future of the city. The city also seeks to participate with citizens in the implementation of smart innovations in transport.

Mobility in the city was divided into different types of transport in the past. The city wants to change the whole view of urban mobility and therefore the city created a proposal for sustainable urban mobility in Jihlava. Where mobility is solved as a complex plan which means the interconnection of all kinds of transport in the city. The mobility plan includes car, public, bicycle, pedestrian and supply transport (Dvořák, 2018).

Implementation of Smart Solutions in Mobility is at the beginning in Jihlava. Jihlava has a good infrastructure to use public transport. Citizens have a positive relationship using public transport and actively use public transport. That's why the city decided to invest money in the smart public transport project.

The newest realized project is Smart stops. This is a modernization of old stops for an intelligent transport system. Through electronic panels built into stops, which is connected with the dispatching of the transport company Jihlava a.s. Passengers will be informed of the current time of departure on electronic boards. Increasing numbers of citizens using public transport this smart technology will increase comfort their transportation. The project is also linked to a web application where passengers can find an online departure from their mobile phone. The value of the project is 6.1 million Czech crowns. The grant was granted by the Ministry for Regional Development. The contractor of this project was company Ing. Ivo Herman, CSc.

Older projects include the Jihlava Card. This is a chip card that replaced plastic passes for time fares. New check-in system based on the use of an electronic wallet which speeds up travel by public transport. The value of the project is 20 million Czech crowns and 16 million Czech crowns have been paid from EU funds. The contractor of this project was company Mikroelektronika, spol. s r.o.

For automobile traffic a great advantage is a functioning road I / 38. As a result, transit traffic is driven outside from the city and does not burden the city's environment. But big problems are with free parking spaces in the city. That is why they are planning to construct parking spaces where smart technologies will be installed in the future.

Unfortunately, the city is not very well in terms of pedestrian and bicycle traffic. Bikesharing is not supported by the city. They are not built any Biketower and for the future, there are no plans yet to support this issue.

They also do not use electromobility but buses for an ecological CNG drive.

4.1.5. Mobility in Karlovy Vary

Karlovy Vary in the field of transport safety is the safest regional city in the Czech Republic. Thanks to the fact that Karlovy Vary is a spa city is introduced a regulated transport mode. This means that it limits entry and parking in the center of Karlovy Vary. The biggest problems are with the lack of parking space. The city would like to solve this by creating a complex parking system using intelligent solutions such as park and ride. It is a combined car transport connected with public transport. The city's priority is to build more intelligent parking spaces and intelligent parking buildigs close to public transport and train stations. There was a cooperation between the Transport Company in Karlovy Vary and the Center for Transport Research, vv.i. The subject of their cooperation is to create a feasibility study of a smart parking system for parking areas managed by a transport company. The investor of the whole project will be the city of Karlovy Vary.

Another infrastructure that the city would like to support is alternative transport cyclotourism. Which would help to cleaner mobility in the spa city. Due to hilly conditions, the number of cycling routes is lower than in other regions of the Czech Republic. Bike and ride transpor is another form of of interconnection cycling to public transport. For this kind of service, it is most important to build bicycle parking called Biketower and the development of smart navigation and information systems. In the future, the city will improve the conditions for cyclists and therefore create a job position of the cycling coordinator.

Due to hilly conditions, the city has no trolleybus and tram transport. Instead of this traffic, the city uses buses. Karlovy Vary Transportation Company, a.s. built smart stops to improve passenger comfort. Smart stop give passengers information on the current arrival of buses on electronic boards. The passengers are also warning to the locks in transport. The value of the project is 1,769,346.94 Czech Crowns which have been paid

from Investment plan for the development of the territory. The contractor of this project was company Largos, spol. s r.o. Other technical improvements to public transport services will be smart dispatching, installation of cameras into the interior of buses and installation USB connectors for charging the phones (Dopravní podnik Karlovy Vary, 2018).

Karlovy Vary has started to cooperate with Mastercard on non-cash payment in public transport. Citizens use an electronic wallet which is a special chip card so passengers can pay cashless.

Public transport application is also created and passengers help with find the closest stop and the fastest bus connection.

The city uses special public transport which is track lift. The track lift is part of public transport. Track lift is a good solution to limiting growth of car transport. But track lift needs modernization and building smart transport systems. Two track lifts are used in the city. The first track lift connects the spa area with the residential area and the second track lift connects the spa area with the lookout tower Diana. This transport is not optimal due to the hilly landscape layout and small cabin capacity. The solution can be to build lifts and increasing the number of track lift. This would help with calm down the traffic situation and transport more citizens and tourists. Karlovy Vary uses buses with CNG drive for more ecological friendly environment.

4.1.6. Mobility in Liberec

The problem of mobility in the city of Liberec is that all target mobility groups worked independently in the city. The target groups are automobile transport, public transport, cyclotourism and pedestrians. The city of Liberec wants to connect all these groups and create a whole that will communicate with each other. And that's why Liberec is connected with the city Jablonec nad Nisou and they created a project called Sustainable mobility plan Liberec - Jablonec nad Nisou (SUMF). This project should help to accept request for subsidies for transport projects after 31.12.2017 from OPD and IROP. The total budget for the preparation of the document is 3 448 500 Czech Crowns and financed

from budget of statutory cities Liberec and Jablonec nad Nisou (1: 1), (Rittenauer et al., 2017).

Some smart projects are realized in Liberec, for example contactless card payment in public transport. The contactless payment should be on all buses. Passangers will be simplified travel by public transpor. The value of the project is 10,000,000 Czech Crowns and financed from budget of The transport company of Liberec and Jablonec (Král, 2014).

In the city was not parking system and missed smart sensors monitoring the occupancy of parking spaces. It was not possible to respond to the traffic situation. It was reason why they created project parking information and navigation systém. They solved problems with the help of the project and installed the smart sensors, installed of intelligent traffic signs, monitor and evaluate traffic data in real time and optimized parking in the city center. The value of the project is 7 935 994 Czech Crowns and financed from Operational Program Transport.

One of the last realized project is Road meteorology. There was no traffic sign in the city to inform the driver about the condition of the road. Due to the location of the city is a higher accident rate influence bad meteorological conditions. Therefore, it is important for the city to build a mapping system of meteorological conditions. They installed twelve road meteorological stations with smart road sensors. Drivers will give current information on road conditions and the accident will be reduced on the road. The meteorological data will be to improve winter maintenance on city traffic. The value of the project is 10 190 012 Czech Crowns and financed from Operational Program Transport (Rittenauer et al., 2018).

In terms of public transport, The Sustainable Mobility Plan is a planned realization project of smart stops. It is necessary to modernize public transport information systems and creating an on-line telematics system about departure of public transport. Electrical information boards will be installed at stops. The project realization is planned for 2020. Assumed price is 10 000 000 Czech Crowns.

In connection with smart public transport will be created smart application. Citizens will be able to buy tickets for public transport and check the position of the publick transport. The project realization is planned for 2020. The new telematics system will increase citizens' interest in public transport.

Purchase of three electric buses and the position of the charging station includes modernization of rolling – stock (vozového parku). The main objective is to reduce the negative impact on the environment and transport. The project realization is planned for 2023. Assumed price is 30 000 000 Czech Crowns (Rittenauer et al., 2018).

Support for cyclotourism including bikesharing is also important for the city. The city plans to install bicycle parking boxes. Bikesharing is introduced in trial mode. After completion of trial mode the project will be evaluated and then implemented during the years 2018-2023. Assumed price is 3 361 000 Czech Crowns (Rittenauer et al., 2018).

To solve the problem with a low number of parking spaces, the city will build a parking space with a capacity of 450 seats, 30 bike places and 4 places for charging electric bikes. The building will be close to the bus station so it is expected to increase the citizens using the smart park and ride systém. The project realization is planned for 2019-2020. Assumed price is 74 000 000 000 Czech Crowns (Rittenauer et al., 2018).

4.1.7. Mobility in Olomouc

The main objective is to promote sustainable transport and remove barriers in key network infrastructures. Olomouc starts with implementation and plans for the future development of the city. Olomouc has created a strategic plan for city development by 2023. Olomouc wants to reduce car traffic to the future so will support ecological drives, carsharing, publick transport and also walking and cycling. Thanks to good infrastructure they want to develop ways for electric bike and bike sharing. This will ensure good crossing through the city and citizens will start to make more use of cycle traffic. To reduce traffic jam plan to use intelligent traffic management.

The first intelligent project that the city implemented was the smart stops in 2006. Olomouc was the first city to introduce smart stops. A total of 51 electronic boards that showed departures public transport. The city also purchased 3 new trams at that time. Other trams was modernized and equipped with digital panels. The value of the project is 210 000 000 Czech Crowns and financed from the sources of the European Union. In public transport, it is also possible to pay for time tickets electronically. Passengers for

payment use a contactless card. Citizens are very satisfied with this service because it is more comfortable and time-saving.

Smart parking in Olomouc is connected with the smart application. Facilitates and speed up the lives citizens.

Project Carsharing function in Olomou from 2017 it offers 2 cars. Carsharing is aimed at drivers who do not need a car daily.

Bikesharing contributes to a healthy environment and is cheaper than public transport. This should support greater interest in non-motorized transport in the city. The project was implemented in the city in 2017.

4.1.8. Mobility in regional city Ostrava

Ostrava is inspired by successful projects realized in European. Ostrava's history is very characteristic and different from other Czech and European cities. The environment is the most important to the future so Ostrava is most interested in pure mobility. Ostrava develops and uses innovative smart technology friendly to nature and the environment. Ostrava is also trying to support public transport, bikesharing and pedestrian. (Magistrát města Ostravy, 2017)

Ostrava's biggest problem that city has one of the most polluted air in the Czech Republic. Smart mobility could greatly help to improve pollution. Intelligent transport systems in Ostrava is divided into four parts. The main objective is to ensure safer and more efficient transport with less traffic jam on the roads and lower ecological loads.

Support for public transport is the first part of the intelligent transport system solved in cooperation with Ostrava Communications. It is concerned with more effective city management, ensuring fluidity transport. Public transport that is more environmentally friendly. In public transport it will be replaced light signaling controllers, building a transport center, establishment of a traffic light switchboard, transport modeling software, installation of strategic detectors. The estimated total cost of the project is 143 143 thousand Czech crownds. It is financed from Regional operational programmes and by the city 's budget. (Gacka, 2017)

Smart stops is the second topic of Intelligent transport systems. The project is divided into two stages. The first stage is the city bought and installed information panels for passengers. Panels give information on arrivals and departures. Thanks to GPS navigation, they can provide information at the current time. The second stage the Ostrava transport company provides on-board computers and intelligent dispatch management for public transport. The estimated total cost is 137 144 thousand Czech Crowns. (Gacka, 2017)

In the past, Ostrava had problems with parking in the city center. This situation has decided to solve in time and the first intelligent parking systems appeared in the city center in 2010. Collecting information on the availability of car parks and parking in the city center. Displaying information on the number of free parking spaces. The total cost of the project is 34 million Czech Crowns. The project was financed by Social media optimization and the developer of the project which was Saab Czech, s.r.o. In this case they use smart application for find free parking place called Park it. (Magistrát města Ostravy, 2010)

In Ostrava, it is also possible to use bikesharing from company REKOLA since May 2018. It also connected with application where you can find also maps of bicycle path in Ostrava. Citizens accepted bikesharing positively. (Gacka, 2018)

The project Silent speed was realized in 2017. It is a Czech technology to reduce noise and vibration from tram rails. They use ecological material from recycled synthetic and technical textiles. This measure should improve the environment and to reduce noise with large concentration of buildings. In the future all tram rails should be created from ecological materials. The estimated cost of the project is about one billion Czech crowns and is financed 85% by the European Union. (Statutární město Ostrava, 2017)

4.1.9. Mobility in Pardubice

The city is particularly interested in the use of intelligent and information technologies for motor and non-motorized transport. Thanks to support biketourism (non-motorized traffic) the city will reduce the car transport. The city hopes to increase the share of electromobility and increase the share of environmental protection.

The city cooperates with the Czech electricity and gas supplier ČEZ due to electromobility in city. ČEZ will build a charging station on six locations in Pardubice. These are mainly parking spaces. The eBUS project will be financed from EU funds from the grant program HORIZON 2020. Owners of electric cars will also be supported. The advantages that the city plans to offer are for example discounts on parking prices in selected locations for electromobility or dedicated parking places in the center. In the city's budget is approved 2,600 ths. Czech Crowns and subsidies 800 ths. Czech crowns. It is approved to support electromobility for 2018. (Chvojka, 2017)

Old parking spaces will be modernized smart parking. Implementation will mainly use monitoring of free or full parking spaces and citizens will receive information on their smart parking applications on mobile phones. This is facilitating transport in the city. Smart parking sensors will be used for the project.

The Biketower project is a realized project which help citizens for the safe storage of bicycles. The city built the building on the site with the highest concentration of citizens and where is good access to public transport. The value of the project is 11 million Czech crowns. (Chvojka, 2017)

The car sharing project is realized in the private sector by CAR4WAY in Pardubice. Drivers pay the cost of using the car and mileage. The Company pays the cost of operating the car, including fuel, repair and insurance costs. The city does not pay for the project only provides the area for operation.

The city also installs smart cameras that inform the driver about current traffic on the road. Project is connected with mobile phone. The advantage is that citizens will be able to choose public transport instead of stay in heavy traffic jam. The value of the project is 11 million Czech crowns. (Chvojka, 2017)

4.1.10. Mobilita in Plzeň

Plzeň has a Mobility Plan by 2025. They want to link public transport with cycling, car transport, pedestrian and always choose the most appropriate kind of transport. Helps active smart organization of the transport system. Smart innovations are located in the most frequented places in the city.

As to car transport to speed up the traffic, the city participates in the construction of the circuits. Thanks to that, so many cars will not pass through the city. To support the traffic situation was created smart project which called intelligent traffic visualization. This project is connected with smart application which shows the current condition on the road. That means ongoing closures and traffic intensities. Plzeň get accurate traffic data, preview of real time traffic jam, map where it is possible to plan closures in real time etc. The project is 100% financed by HORIZON 2020. (Mott MacDonald CZ, 2016)

Public transport is the most used in Plzeň. Public transport is most often combined with pedestrian. Because of the public transport is more than 5 years ago. Most smart technology is mainly implemented in public transport. Replace existing trolleybuses for battery trolleybuses. Battery trolleybuses are more comfortable for passengers, less noisy and are more environmentally friendly. The city is very satisfied with the trolleybuses and plans to replace all trolleybuses for battery trolleybuses to the future. Smart cameras in public transport provide greater security for passengers and drivers. Smart payment by contactless card in public transport. It has been working well since the year 2015. Smart stops are also introduced here for comfortable travel. Passengers see current information on public transport and the current departure of public transport. (Mott MacDonald CZ, 2016)

Plzeň card smart payment system for public transport. In 2010, the city began to use smart dynamic dispatching in public transport and still updating it. The system which is for the management, monitoring and evaluation of public transport. Passengers are very satisfied with this service because they receive online date information. The card should be extended to cycle and parking functions to the future.

In cycling, the city wants to build bicycle paths called greenway along the rivers. Also support bikesharing to the future. For walking around the city they want to improve conditions for short distances. The city will build the P + R parking with connection to the tram and railway station.

4.1.11. Mobility in Prague

Prague is the leader in implementing the Smart city project in the Czech Republic. But Prague also solve the most problems related to mobility in the city. The constantly increasing number of cars in the city center leads to air pollution, excessive noise and traffic jam. Suburban locations are constantly expanding in last 10 years and citizens prefer car transport rather than public transport. The problem of lower use of public transport is connected with the slow implementation of the P + R parking system and in the past, public transport lacked smart mobile applications and smart traffic information panels at stops. (Primátorka hl. města Prahy, 2017)

Prague used smart strategic documents. Mobility in Prague focuses primarily based on the acquisition data from traffic, public transport will be self governing, citizens will have all actual information in their smart applications on mobile phone, stop the increase of cars and to use electric cars and electric public transport. (Primátorka hl. města Prahy, 2017)

Prague considers the most important implementation of smart strategic projects to improve city life and to create a healthy environment. Smartest projects are created for smart public transport and electromobility. But for most of these smart projects, Prague work with city companies. For example, a digital taxi terminal payment project which allowed non-cash payment to passengers. They can pay by credit card and for passengers it is more comfortable. The whole project is 100% financed by Mastercard, which implemented the project. Non-contact payment is also introduced in trams. But here the whole project is financed by the Prague Transport Company. (Smart Prague, 2017)

New project called multi-channel check in system has been introduced into public transport. This is an uniform electronic check-in of passengers. The project is connected with the application for the purchase of tickets. Passengers buy a ticket faster and more comfortably than in a conventional way. The multi-channel check-in system the city financed the whole project from own city budget. The city paid approximately 500 million Czech crowns for 10 years.

Nowadays, the city wants to improve travel for the blind citizens so the city implement LCD monitors in trams. LCD monitors have bluetooth and it can be connected with smartphone. Blind can hear voice guidance from smartphone and travel is easier. The whole project is financed by the Prague Transport Company. As a result of the tram

accident, anti-collision systems for trams and accidental cameras will be installed in the future. These smart innovations will provide greater security. The project of Intelligent Public Transport Management for buses and trams. Drivers will receive actual information on passenger transport. And last but not least Airport express Ebus project. In the future, they want to support electromobility even in public transport. For bigger support ecologically friendly environment. Electric bus will drive from the main railway station to the airport. The expected cost of the project is 150 million Czech crowns from European funds.

Prague supports electromobility. For example, in the form of renting and selling electric bike and electric cars. The public infrastructure is operated for charging electric cars. The cost of the project is 30 million Czech Crowns. The transport company has decided to support electromobility and will start using electric cars as a service car. The whole project will be funded by the Prague Transport Company.

Smart innovations are also implemented in traffic management in the city. Project information system on driving times. The drivers are informed about the actual state on the road. Data sensors are installed on the roads. The cost of the project is 190 million Czech Crowns. And it will be financed from the Operational Program Transport and from the city budget.

To improve the city's traffic and reduce the emission burden was created project called development of traffic-based management. Thanks to adding appropriate detectors using existing infrastructure, obtained data will be quality and it will be possible to propose alternative routes. The cost of the project is 100 milion Czech Crowns. And it will be financed from the Operational Program Transport and from the city budget. Project of smart city multifunctional elements in Prague-Šeberov was created to support electromobility in the district Prague-Šeberov. The cost of the project is 947 200 Czech Crowns and it will be financed from the city budget and district Prague-Šeberov.

System for guidance on free parking spaces, drivers will make it easier to find a free parking space and reduce the time spent in the car. The cost of the project is 150 milion Czech Crowns and it will be financed from the Operational Program Transport and from the city budget. Because of the high frequency of cars in the Prague 5 and drivers often can not find free parking places. It was created project called Monitoring the parking

situation and security of data analysis district Prague 5. Drivers can find information about parking on a website or on their smartphone. Data is collected from telecommunication networks. The cost of the project is 5 million Czech Crowns and it will be financed from the city budget and district Prague 5. Other parking project for the future is System for automatized entry and exit car from parking. Drivers will appreciate faster check-in from parking and this will support more citizens to use park and ride parking which is connected with public transport. The value of the project is 700 000 Czech Crowns and it will be financed only from city budget.

Artificial Intelligence should help with traffic management in the project Development of intelligent management. The project should serve both to manage the actual traffic situation and after time to manage the whole city.

From 2019, Prague would like to participate in the implementation of the E-carsharing project. The target user group is mainly citizens using public transport and tourists who visit the city. The city hopes that more than half of the population will use the alternative mode of transport to the future. In mobility, this is the first PPP project on which Prague cooperates. The value of the project is 190 million Czech Crowns and the supplier costs about 700 million Czech Crowns.

4.1.12. Mobility in Ustí nad Labem

The city Ustí nad Labem lies at the strategic point of three important transports. These include road, railway and water transport. An important highway is the highway D8 which connects Prague and Draždany. In the past, the newly built roads were mainly connected the city center and resident areas. Thanks to this, nowadays the city center is heavily loaded with car transport, public transport and railway transport. Consequently, another big problem is parking in the city center. The solution can be to build new parking spaces (building) and improve public transport. The city will build better pedestrian and bicycle traffic in the city center. And it will connect non-motorized traffic with public transport. This reduces the interconnection of public transport with car transport. The part of the city is Lake Milada has a high potential for transport for the city in the future. The city will support creation of transport infrastructure.

Ústí nad Labem wants to reduce the number of cars in the city center, so it will support the most pedestrian, cycling and public transport. The main objective is to make more comfortable public transport for citizens and ensure greater security and passengers to give more online information (Oddělení strategického rozvoje, 2015).

One of the realized projects to support public transport is the project called Smart stops. The system provides passengers online information departures of public transport. The total cost of the project is 5 487 119 Czech Crowns. Financed from Regional operational programs, subsidies of the Ústecký kraj and from the city budget (Oddělení strategického rozvoje, 2015).

New smart project which will give passengers more comfort is called Electronic passenger check-in system. Fully functional should be from the beginning of 2019. Thanks to the new system, you can pay the tickets by credit card or mobile phone. The advantage is also for transport company which will get more accurate information on the number of passengers who use public transport. The transport company will only rent Electronic passenger check-in system.

4.1.13. Mobility in Zlín

Zlín has problems with mobility in the city and also with the technical infrastructure. In Zlín is a poor realization in sustainable transport systems. For example, problems are unfinished road constructio, poor state of roads and poor interconnection of the different type of transport. Thanks to the constantly expanding residential localities so public transport has to be modernized and also expanded. The city uses buses and trolleybuses. Combination of two public transports is in some cases complicated and increases transport costs. The city would like to make more efficient public transport and more environmentally friendly. Zlin wants to expand trolleybus transport and replace bus transport in selected locations. The city will primarily support multimodal public transport and the expansion of electromobility in transport (Statutární město Zlín, 2014).

Public transport will be supported parking system Park&Ride (P+R) and Kiss&Ride (K+R). The stops will more secure and barrier-free to make it more comfortable for passangers. Public transport uses a classic paper ticket in Zlin. But smart telematic

systems are deployed in the form of electronic ticketing systems. Passengers will be able to pay with contactless cards. Public transport will be more attractive and more enjoyable. The estimated cost of the project is 5.1 million Czech crowns (Statutární město Zlín, 2014).

In terms of cyclotourism and pedestrian, city wants to create more safe cycle paths and improve sidewalks. And building integrated cyclo infrastructure. For example, better lighting cycle paths and sidewalks or the introduction application of intelligent transport systems (Statutární město Zlín, 2014).

The city uses dynamic traffic management. Semaphores that prefer public transport to speed up traffic or or sectional speed measurement. However, the potential for smart innovation is not fully exploited. But the city would like to more develop smart technology in transport. So they created the Project Telematics System in the first and second stages. The first stage is building a BTT detection network to monitor the traffic situation, detectors installed in 20 locations. This is connected with smart traffic applications. The second stage is that the drivers receive information on arrivals to the center according to current traffic situation on smart electric board. The total cost of the project is I. stage: 1.7 million Czech crowns and 2nd stage: 5.5 million Czech crowns. The project is financed by the city 's budget and State Fund for Transport Infrastructure.

The city is also interested in electromobility and implemented testing project of electromobility in 2018. The project to acquire vehicles with alternative propulsion in the rooling stock of the City of Zlín Municipality. They bought 2 electric cars. Small truck for the maintenance of urban greenery and car for the transport of persons for the purpose of performing public administration. The value of the project is 1.7 million Czech crowns. The project is financed by own resources and National Environment Program.

Public buses and trolleybuses for CNG drive will be included in public transport. Because of the more ecological friendly environment. Smart dispatcher management of public transport will be also supported with using smart technology. For example, current route changes. Crossroads will use intelligent transport systems to speed up traffic.

Parking system is also improvin in the city center. There is used of modern technologies and intelligent traffic management systems. The new parking system will provide online data on the number of free parking spaces, register registration marks of

card and drivers can pay by credit card. Also they created smart application for cashless payments.

4.2. Partial areas of smart mobility

In the second part of practical part are explained partial mobility areas. These are Electromobility, Public transport, Intelligent transport system, Parking, Car and Bike sharing and Application in transport.

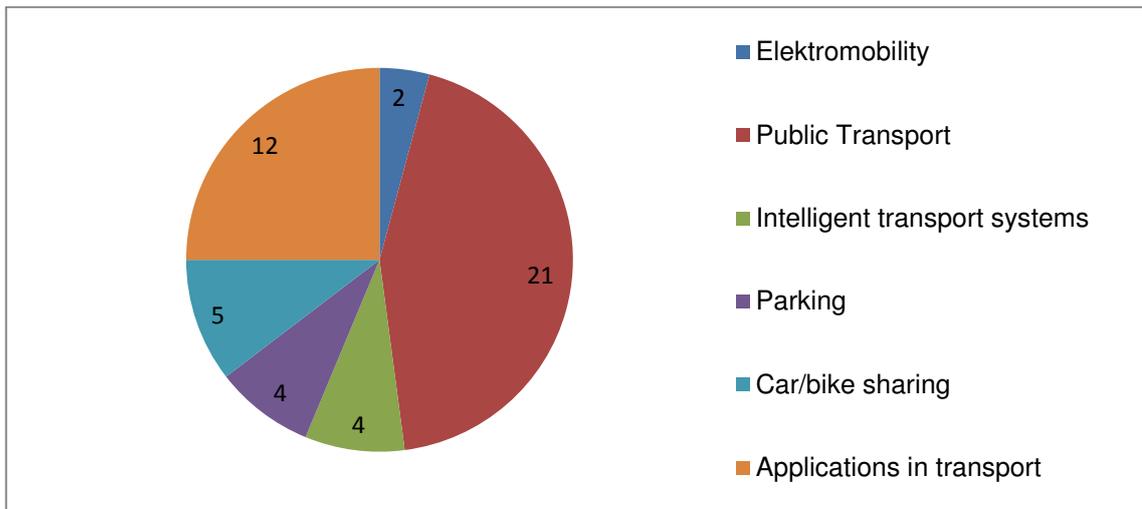
All mobility projects were both classified into defined partial mobility areas, and sorted into groups of those, where regional cities started with implementation of Smart mobility projects in the past, those where regional cities are starting right with the implementation of these projects now and the projects have not been completed yet, and finally of those, which at the moment are at the phase of planning. Three tables were created, e.g. Realised projects, Projects under implementation, Planned projects. For better clarity I also created graphs which show numerical frequency of a partial mobility area solved in particular smart mobility projects. This frequency is identified for realised projects, projects under implementation and for planned projects.

Table no 1. Realised Smart mobility projects

Regional city	Partial areas of smart mobility					
	Elektromobility	Public Transport	Intelligent transport systems	Parking	Car/bike sharing	Applications in transport
Brno		Brno ID; Smart stops			Bikesharing	Sejf
České Budějovice		Smart stop	Smart road system			Sejf
Hradec Králové	Ecological public transport			Biketower		Sejf
Jihlava		Jihlava Card; Smart stops; Sensors in public transport				
Karlovy Vary		Chip card Karlovy Vary; Smart stops				SMS parking; Application for public transport
Liberec		Contactless payment	Road meteorology	Parking information; navigation		Sejf
Olomouc		Contactless payment; smart stops			Carsharing Bikesharing	
Ostrava		Silent speed			Bikesharing	Park it
Pardubice				Biketower	Carshaing	Sejf
Pízen	Battery trolleybuses	Pízen Card; Dynamic dispatching; Cameras in public transport; Contactless payment; Smart stops	Visualization of traffic intensity			My PMDP
Prague		Multichannel check-in system for public transport; Contactless payment in a taxi; Smart stops				Sejf
Usti nad Labem		Smart stops				Sejf
Zlin			Telematics System(I. and II. Stages)			Sejf

Source: The data come from Grega, (2018), were processed by the author.

Graph no. 1. Structure of realised Smart mobility projects



Source: The data comes from Grega, (2018), were processed by the author.

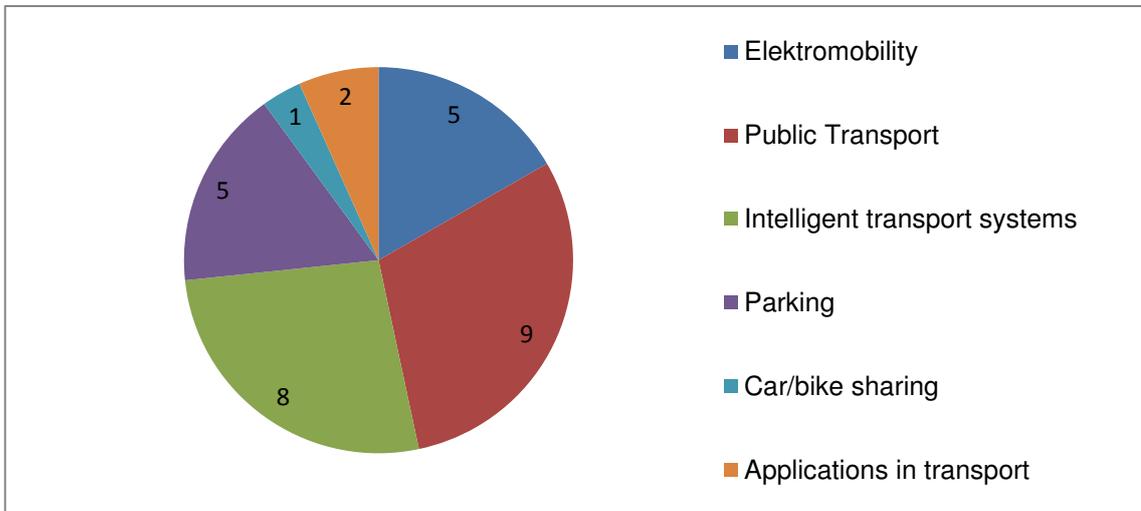
This Graph no. 1 is connected with Table no 1. Realised Smart mobility projects. This graph better shows the frequency of Partial areas of Smart mobility. As you can see the most often, smart projects are implemented in Public transport. Smart applications are the second most often projects, but they have only 12 realized smart projects which is about 9 projects less. Car and bike sharing have 5 realised smart projects and intelligent transport system with parking are in the same position and they have only 4 realised smart projects. Elektromobility has least of the projects.

Table no 2. Smart mobility projects under implementation

Regional city	Partial areas of smart mobility					
	Elektromobility	Public Transport	Intelligent transport systems	Smart Parking	Car/bike sharing	Applications in transport
Brno				Smart parking		
České Budějovice			Transport telematics; Strategic detectors		Car and Bike sharing	
Hradec Králové			IDS project			
Jihlava			Central transport terminal			
Karlovy Vary		Intelligent dispatching				
Liberec						
Olomouc				Smart parking		Applictions for parking
Ostrava		Support for public transport; Smart stops; Onboard computers and intelligent dispatching control; check-in systems				
Pardubice	Development of electromobility public/private transportation		Smart cameras in traffic			
Plzen						
Prague	Charging station for electric vehicles; Electromobiles as DPP bussines cars; Electric buses for public transport	LCD monitors in the trams; Contactless fare payment	Arrival times information system; Development of traffic-dependent management at intersections with traffic lights; Development of an intelligent management traffic lights	Free parking spots guiding system		My Prague-parking
Usti nad Labem		Electronic passenger check-in system		Smart parking		
Zlin	Vehicles with alternative propulsion	Electronic passenger check-in system		Park&Ride		

Source: The data comes from Grega, (2018), were processed by the author.

Graph no. 2. Structure of Smart mobility projects under implementation



Source: The data comes from Grega, (2018), were processed by the author.

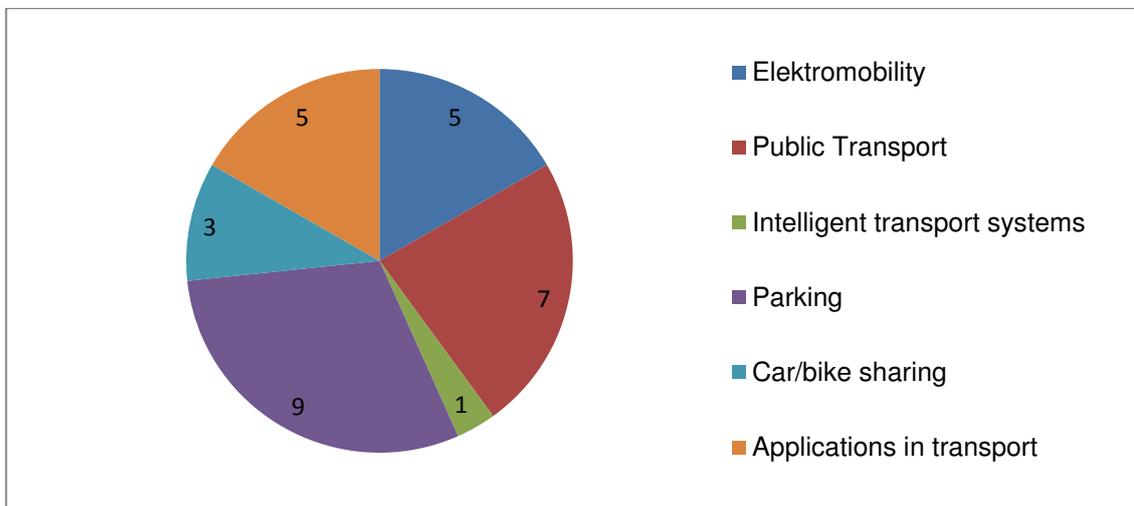
Graph no. 2 is connected with Table no 2. Smart mobility projects under implementation. This graph better shows the frequency of Partial areas of Smart mobility. This time is situation more in balanced. Because public transport has 9 smart projects but is only about one project more than Intelligent transport systems which has 8 smart projects. Elektromobility and Parking smart projects are equal and they have 5 projects. Applications in transport have only 2 projects and last one is car and boke sharing which have 1 smart project under implementation.

Table no 3. Planned Smart mobility projects

Regional city	Partial areas of smart mobility					
	Elektromobility	Public Transport	Intelligent transport systems	Parking	Car/bike sharing	Applications in transport
Brno		Hyperloop, Wireless tram				Virtual Parking Clock
České Budějovice	electric buses trolleybuses		smart light junction	Biketower, Parking system		
Hradec Králové		Internet access		Smart parking		Smart applications-for cycling
Jihlava				Smart parking		
Karlovy Vary				Park and ride		
Liberec	Electric buses	Smart stops		Smart parking		Application for public transport
Olomouc						
Ostrava						
Pardubice				Smart parking	Bikesharing	Application Smart Information - Traffic Situation; Smart parking
Plzen					Bikesharing	
Prague	Project of multifunctional elements in Prague-Šeberov; Airport Express Ebus	Anti-collision system for tram; Tram accident cameras; Intelligent management of the surface city public transport		Monitoring parking situation and ensuring data analysys at Prague 5; System for automated entry and exit from car park	E-CARSHARING	
Usti nad Labem						
Zlin						

Source: The data comes from Grega, (2018), were processed by the author.

Graph no. 3. Structure of planned Smart mobility projects



Source: The data comes from Grega, (2018), were processed by the author.

Last graph no. 3 is connected with Table no 3. Planned Smart mobility projects. This graph better shows the frequency of Partial areas of Smart mobility. The situation is little bit different because first time parking has 9 planned smart projects. Public transport is the second most often projects. Elektromobility and applications in transport are equal position and they have 5 planned smart mobility projects. Last is Car and bike sharing which has only 3 planned smart mobility projects.

4.2.1. Elektromobility

Electromobility is in regional cities typically viewed as a solution for sustainable urban mobility, based on the reduction of individual car traffic in favour of shared and mass modes of transport. Cities are very interested in experience with E-mobility (e-cars) as well as experience in the sharing in general. Projects under implementation have cities like Hradec Králové, and Zlín. They started to use electromobility because they have good infrastructure for implementation and they saw more advantage for the future. The biggest advantage of the use of electromobility in these cities is environment protection which is very important for healthy life in big cities. Hradec Králové use mostly electromobility in public transport because they want to reduce CO₂ emissions, lower

noise in the city and to provide greater comfort for passengers and drivers. With the use of this type of transport there is not a problem with overheating in the summer months and it is easier to operate the transport means. Also electromobility saves money because it is cheaper. The financing of these two electromobility projects was mainly from transport companies. Electromobility project in Zlín was financed from 73% by city budget, 27% from national environmental program. Zlín purchased 2 electric vehicles which are a small truck for maintenance of urban greenery and car for the transport of persons for the purpose of public administration.

Following the example of these cities, which realised mentioned projects in the past, other cities at present joined the electromobility projects. The capital city Prague, Pardubice and again Zlín currently realize projects in electromobility. An important part of the functional city's electromobility is also building recharging infrastructure for electromobility. Prague has already begun to support the development of electromobility by offering rental and sale of electric bicycle and electric cars and they are introducing electric cars as service cars transport company Prague and the introduction of electric buses into public transport. Recharging infrastructure for electric vehicles cost 30 million Czech crowns and the project was funded by 100% station operator. While electromobility in public transport is 100% funded by the city.

For the future, electromobility projects are planned in Prague, České Budějovice and Liberec. Prague will implement project of multifunctional elements in Prague-Šeberov and Airport Express Ebus. They chose to support multifunctional elements in Praha-Šeberov because they had problem with infrastructure. So they want to support more electromobility and increase overall visitor comfort. The project will finance 50% of the city and 50% of Prague – Šeberov. The total amount of the project is 947,200 Czech crowns. The advantage from the implementation of Ebus is that the transport is a less noisy in the city centre, for slower city traffic Ebus use a very low power consumption so we can save more money because these days are prices for fuel very high. Using Ebus also saves the environment which is very important in our life. On the other hand, the biggest problem is the capacity of the whole battery. The battery has a low range approximately 150 – 200 km but when you use for example climatization the range is significantly lower. The planned investment in electric buses will be around 150 000 000 Czech crowns. Subsidies should be from European funds (OPPPR). České Budějovice

and Liberec will implement electromobility into public transport. Specifically, for buses and trolleybuses. From these projects they are expected to saving money on public transpor.

4.2.2. Public Transport

In public transport, we can find a lot of smart technology to improve mobility in the city, as well as more convenient transportation. In most regional cities elektromobility in public transport is the most discussed topic. Which is also reflected in number of those project, which were solved, which have been solved and which are going to be solved. For example, projects under implementatio are solved in more than half of regional cities. The reason why public transport began to be solved in the cities was the high demand of citizens for better technology, simpler and safer public transport which they use every day. Brno, České Budějovice, Jihlava, Karlovy Vary, Liberec, Olomouc, Ostrava, Prague, Plzeň, Ustí nad Labem these cities have realized public transport project. The most often implemented projects of these cities are the projects of smart stops. Smart stops mean that stops show on the electronic board exact arrivals and departures of buses thanks to GPS installed in a buses or trams. Thanks to these electronic board, it is more convenient for passengers to find timetables.

The second biggest issue in this area has been paying for public transport. Nowadays, more and more people pay with credit cards. That is why cities wanted to introduce credit card payments into public transport. Cities or transport companies have also introduced special cards. You can leave your money on the card and subscribe to a public transport ticket.

has also introduced dynamic dispatching secure necessary information from public transport. Their evaluation, interpretation, for the dynamic management of urban public transport. Providing online information for passengers on the current state of public transport. And other project cameras in public transport ensure safety for public transport passengers. This project is also realized by Ostrava and Karlovy Vary.

In the future, Brno intends to introduce the Hyperloop project, which should speed up travel between Brno and Prague. And the second project is Wireless tram. Which is

created to improve the environment. Tram will use battery powered drive. The city center will be without the overhead traction line. They will ensure safe transport. On the other hand, Prague wants to focus mainly on safety in public transport for the future. Prague created two projects Accident cameras in trams and Antikolistic system for trams. Dispatching will be warning about tram traffic situation and they will actually trying to respond to eventually complications. They will take care about the passengers. The second smart system prevents the collision of the tram with other transport in the city. This reduces damage to trams and safety will increase. Last project which Prague created for public transport is Intelligent management of public transport. Thanks to the interconnection of public transport buses and trams, transport capacity will be optimized. The comfort of transport will increase and citizens will use more public transport. Liberec wants to ensure smart stops and Hradec Kralové free internet access in public transport to the future.

4.2.3. Intelligent transport systems

Traffic jams are worse and worse in bigger cities. The average number of cars in each household is growing year after year in the Czech Republic. That's why intelligent traffic management technologies are coming to market and it's trying to make it easier to travel by car across the city. The most common help in transport are smart road system, road meteorology, visualization of traffic intensity, telematics system, central transport terminal, smart cameras in traffic, arrival times information system, development of traffic-dependent management at intersections with traffic lights, development of an intelligent management traffic lights. Thanks to these technologies, traffic becomes smoother, safer and faster.

With continuity to the table no. 1 České Budějovice, Liberec, Plzen and Zlin had realized project in partial areas of smart mobility. In this area, for the city was important smart road system which actually gives information about situation on the road. The similar function has visualization of traffic intensity and telematics system. Project road meteorology give information about road surface.

In the table no. 2 regional cities are more involved in implementation of intelligent transport system. České Budějovice, Hradec Králové, Jihlava, Pardubice a Praha has projects under implementation.

And last but not least, in table no. 3 only České Budějovice has planned project in partial area intelligent transport system. Maybe more cities are interested in this partial area but for now it not published publicly.

4.2.4. Smart Parking

Especially due to the high urbanization in the bigger cities, and increasing scale of commuting, the number of cars in bigger cities is growing. People living in the city do not have parking spaces and the situation is getting worse in the whole Czech Republic. That's why cities have become interested in smart parking technology and are creating projects to promote easier parking in the city.

Most often, the smart parking technology is considered from smart navigation system to free parking spaces, smart parking board which show you actual condition of parking space before than you go into the parking building or it can also be park and ride parking space where you can leave your car close to bus station, tram station or train station. With park and ride parking, you get comfortably into the city center without spending time in the traffic jam and without complicated search for a free parking space.

Liberec was the first city which has realized project of smart parking navigation and information system. Project smart parking in Brno is still under implementation. Brno has introduced residential parking from 2018. But the implementation of smart technology continues in this project.

Smart parking is also available for bicycles. The project is called Biketower and this is the place where you can leave your bike safely and comfortable. Biketower is often built near bus and train stations. The reason is for citizens to take advantage of other travel options. Between the regional cities, only 2 cities already built smart parking Biketower. The reason for this is that people began to use cyclotourism less and they began driving more cars. That's why cities try to return to cycling and more support it nowadays. Pardubice and Hradec Králové have a good infrastructure for cyclotourism. That's why

Biketowers are build in these cities. Cycling has increased in these cities. České Budějovice also planned build Biketower in their citi.

4.2.5. Applications in transport

The projects regarding smart applications in transport realized cities like Brno, České Budějovice, Hradec Králové, Karlovy Vary, Liberec, Olomouc, Ostrava, Pardubice, Plzeň, Praha, Ustí nad Labem, Zlín. Smart applications are most often connected with smart parking, buying public transport tickets, navigation to free parking, carsharing and bikesharing. Smart applications for mobility are used by most cities.

The popular commercial smart application is the application called Safe. It uses 7 regional cities which are Brno, České Budějovice, Liberec, Pardubice, Praha, Ústí nad Labem a Hradec králové. The application knows the transport infrastructure of these cities. Citizens and city visitors can put their money into the application, buy online public transport tickets, and last but not least, pay parking in the city from their smart phones. This application makes life easier for citizens and visitors in the city. Payments are safe and nowadays the big advantage is that you do not have the cash but you pay online from your phone.

Ostrava, Plzeň and Olomouc use otherwise called applications but with a lot of similar uses as application safe. For example, Ostrava and also Prague use application Park it. This application is expanded by navigating to parking places and navigating to electromobile charging stations.

4.2.6. Car and bike sharing

Car and bike sharing together with electromobility is one of the most environmentally friendly ways to travel. That is why cities try to promote it more and more in their territory. Bicycle paths are improved for bigger comfort for cyclists and spreading to the city center. Cities want to connect cyclotourism with public transport. Although bikesharing is for a short time in the Czech Republic is becoming very popular between the citizens of the city.

Bikesharing projects have already been realized in Brno and Ostrava. Pardubice realized project of carsharing, while a project for bikesharing will be realized in the future. Also České Budějovice have projects of carsharing and bikesharing under implementation. For future Prague and Plzeň prepared project for support carsharing and bikesharing.

Also Prague will support project of E-carsharing in the future. They want to have electromobility as one of the types of public transport. This will support cleaner mobility in the city centre. This will help reduce emissions in the air and traffic jam in the center. Because the city hopes that this more attractive form of public transport, convinces more people and tourists will use this type of transport.

5. CONCLUSION

The bachelor thesis solves the question of development of smart solutions in the concept of smart city in regional cities in the Czech Republic, with focus on the segment of smart mobility.

Focus of my thesis was to some extent affected by my experience I got from my participation on the solution of the project “Analysis of the current level of involvement of the Czech Republic in the concept of smart city and smart region in relation to new trends, including proposals for measures”, which was solved at Faculty of Regional Development and International Studies. At first I considered to identify examples of good practice in implementation of smart mobility projects in the Czech Republic, however after discussions with representatives of regions, and all regional and former district cities, which were organized within above mentioned project solution, I found that for the regional cities would be more contributory to describe all projects, which were solved, have been solved or are planned to be solved in future in area of smart mobility, because mobility is by the great majority of regional cities considered as the most important for future implementation of smart concept. Systematic mapping of smart projects aimed on mobility and their more detailed categorization provides representatives of regional cities with the information, who has already solved or is going to solve a particular type of project. Examples of good practice and bad experience are important for successful realization of intended projects.

It may be stated, that all objectives of this thesis were met. Mobility concepts of all regional cities in the Czech Republic were characterized. Smart mobility categories were identified and following classification analysis of smart mobility projects was done. Results obtained for individual regional cities were validated by representatives of these cities.

Before I started mapping of smart mobility projects in regional cities, I assumed to learn what are expenditures of municipalities for smart projects in target areas including smart mobility.

However, I learned, that it is practically impossible to make an analysis of finance spent on implementation of smart concept, and realization of smart projects both finished and actually realized. Reasons are especially following:

- many smart segments, which were realized in the history, were implemented as a part of broad investment activities, where „smart“ part created only a fragment without a possibility to identify its scope;
- many segments, which are today considered as a „smart“ did not wear this label at the time of realization;
- even if an implementation of smart concept was in form of the project, these projects were very often much broader than focused only on smart aspect and budgets of these projects do not enable identification of money spent on implementation of the smart concept;
- cost of implementation of smart concept is not only about investment cost, important and sometimes crucial part of this expenditures create operation cost of smart systems;
- structure of municipality budgets does not allow to make such a classification of cost which would enable to identify cost on implementation of smart concept.

It would be very beneficial if the database which identifies categorized smart mobility projects would be regularly updated and completed by new projects, because authorized person who create smart project needs to know actual information for their self-realization and inspiration.

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