Czech Technical University in Prague
Faculty of Transportation Sciences
Department of Transport Telematics

ETIS - Application for Evaluation of Ticketing and Information Systems

Master thesis

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Programme: Intelligent Transport Systems
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Declaration

I hereby declare I have written this master thesis independently and quoted all the sources of information used in accordance with methodological instructions on ethical principles for writing an academic thesis. Moreover, I state that this thesis has neither been submitted nor accepted for any other degree.

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Guides for elaboration

During the elaboration of the master's thesis follow the outline below:

- Design and create web-based system for collecting, storing and analysing information about public transport ticketing and information systems.
- Fill the system with data of at least 20 cities or integrated transport systems.
- Compare collected data and create analysis of public transport systems quality.
- Suggest how to improve one of compared public transport systems according to analysis results.

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I confirm assumption of master's thesis assignment.

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Abstract

This work summarize what information about public transport systems is available, what information is collected among public transport organizers and how they use it. It describes Prague Integrated Transport System (PID) and information systems for passengers that are used at stops and on board of PID vehicles. It also describes the tariff of PID. Further there is also a brief excursion to information systems used around the world. Second half is about ETIS web application, where everyone connected somehow to any public transport system can enter information about the system he knows. It also offers anyone to make comparison on desired parameters easily and find which transport systems around the world have the same point of view on tariff, price policy or by operating in comparable scale.

Keywords: ETIS, public transport systems, tariff, ticketing, Prague Integrated Transport, web application, comparison, analysis.

Abstrakt

Tato práce nabízí přehled o informačních systémech ve veřejné dopravě a o datech, která organizátoři veřejné dopravy sbírají a jak je využívají. V této práci také najdete popis Pražské integrované dopravy (PID) a přehled informačních systémů pro cestující, které se v PID používají na zastávkách a ve vozidlech. Také zde najdete popis tarifu Pražské integrované dopravy a rychlý přehled informačních systémů, které se používají ve světě. Druhá část práce popisuje webovou aplikaci ETIS, pomocí které může kdokoli jakkoli napojený na veřejnou dopravu vkládat informace o informačních systémech a tarifu v systému, který sám zná. Aplikace také nabízí snadné vytvoření porovnání vybraných parametrů a umožňuje tak vytvořit si analýzu a zjistit, které systémy veřejné dopravy jsou si podobné, ať už co do tarifu, cenové politiky nebo do velikosti.

Klíčová slova: ETIS, veřejná hromadná doprava, tarif, jízdné, Pražská integrovaná doprava, webová aplikace, porovnání, analýzy.

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At this place I would like to thank to all people that supported me in recent years. Mainly to my family and friends.

This work would not be possible if I had not that much opportunities to travel and to visit so many countries not only across the Europe but even to visit such a different country as is India. It inspired me a lot and provided me with great amount of experiences and also photos that I used in thesis to outline the differences I mention in text and also the need for unified system. I would also like to thank all my friends that helped me to believe in myself as well as to understand how important is to respect others.

It is also very important to mention the possibilities of visiting specialized public transport conferences that I (as a technician of presentations) was given not only by university, but also by a specialized association for transport telematics. I had the opportunity to learn a lot about the state-of-the-art technologies in public transport and so I was able to use it to write this thesis.

Another thanks also goes to my colleagues at Horská Network Administration Office for letting me work on the thesis while managing my duties. I'm very glad for it.

Special thanks goes to my friend Zdeněk Michl, who read the thesis many times during its creation and was always available to help even without asking. He also managed to enter lots of data into ETIS system as well as asked his friends to also do so. That was crucial to allow ETIS users make valuable analysis, especially in German speaking countries. I would like to also than him for forcing me to work to last hours and make the thesis as good as possible.

Final thanks goes to my supervisors for some feedback and for letting me to work individually without complaints.

List of Figures

List of Acronyms

AE Airport Express. 55

AJAX Asynchronous JavaScript and XML. x, 38, 39

aka also known as. xv, 4, 26

API Application Programming Interface. x, 24, 40–42, 45, 46, 49, 50, 58, 59

CIESIN the Center for International Earth Science Information Network at Columbia University. 42

CSS Cascading Style Sheets. x, 37–39

CTU the Czech Technical University in Prague. x, 15, 25, 36, 43

DPP The Prague Public Transit Co. Inc.. x, 5, 8, 15, 17, 25, 55

FTS Faculty of Transportation Sciences. x, 15, 25, 36, 43

Gbps Gigabits per second. 36

GDP Gross Domestic Product. 40, 42, 46

GPS the Global Positioning System. 21

GPW the Gridded Population of the World collection. 41, 42

HTML HyperText Markup Language. x, 37, 38

HTTP Hypertext Transfer Protocol. 36

HTTPS Hypertext Transfer Protocol Secure. 37

JS JavaScript. x, 37–39

LCD Liquid Crystal Display. x, 16, 25

LDAP Lightweight Directory Access Protocol. 43

NREN National Research and Education Networks. 37

PHP Hypertext Preprocessor. x, 38, 39

PID Prague Integrated Transport. ix, xiv, 4, 6–17, 55, 56, 59, 60

PT public transport. x, xi, xv, xvi, 1, 4, 21, 22, 24, 26–32, 35, 36, 39–41, 44–46, 48–53, 55–62

RFID Radio Frequency Identification. 32

SMS short message service. 12, 31, 55, 60

SSL Secure Sockets Layer. 36

TCS Trusted Certificate Service. 36

TLS Transport Layer Security. 36

WWW World Wide Web. 33, 59

Contents

1

Introduction

"Successful city is the one where rich uses public transport, not the one where poor drives cars."

— Enrique Peñalosa, *mayor of the city of Bogotá*

For more than hundred years PT serves people around the world. It started as a shared service for passengers to get them from villages to towns to markets and back. During the industrial revolution construction of railways has been started to make easier transport of goods and passengers across whole countries.

Also first city transports started its services with horse powered wagons on regular lines. Just few years later, horse powered wagons were replaced by steam powered vehicles, but also just for a while. New discoveries enabled electric tram lines and buses. At the time, they were mostly intended to generate money for its shareholders. Later, lot of them were overtaken by municipalities or government institutions and transformed into a service for citizens.

In the later nineteen and in the beginning of twentieth century, some of these services started to group into transport systems, mostly around larger cities to create the transport network effect for the first time in the history of public transport. These systems started to offer integrated services as we know them today. They created network effect with transfer options between different means of transport and a single ticket for whole systems of public transport attracted more and more passengers. It was in the same time the car revolution started and cars become an affordable standard for more and more people consuming more and more space in cities and in rural areas. Also with more cars in streets air pollution in already polluted cities was rising. This aspect is changing the point of view on public transport also in today's world. Government institutions and municipalities are trying to attract people back to the public transport and meanwhile transfer cities into the modern space for people to live in, reverting the process of change of city's streets to one big parking place. But it costs a lot of convincing to get people from theirs comfortable, easy

to ride and fast cars back to the the public transport. Only for the small part of citizens it is enough to know that they protect environment and make their city better place for living for themselves and others. To change the point of the view of majority of people, there is a need of easy ticketing and information system for passengers so they can travel as easily as if they drive cars. Complicated tariff, confusing line routing or unreliable service are typical reasons for people to choose car rather than public transport.

In globalised world, information services are getting standardized interfaces for users worldwide - computer users are working with the same Windows interface from America to China, no matter language differences. The same principal applies for smartphone users - Android and iOS interfaces don't change much around the world. Also websites have the same interfaces - Facebook and Google are the same no matter user is American, Czech or Japanese. United interfaces are also in cars. There is no difference whether you drive in the USA, in Italy or in Thailand (except for driving side). Most of the signs, symbols and arrangement of the elements inside of cars are identical across the world. This unifying principal should be applied also in the public transport. When transport organizers will use united information systems (or even better just one system all across the world), easy to understand tariff and trip planning application, it will help a lot to promote the public transport to the public as it will reduce the fear of getting lost and being late. And here comes the ETIS, the Evaluation of Ticketing a Information Systems web application. It aims to help public transport organizers with communication with each other, with sharing of innovations, tariff policies and prices ranges, maps and all other stuff that influences lives of millions passengers every day. I believe that united public transport interfaces will help to attract more people back to the public transport in overcrowded cities all across the world of 21st century.

It will save hundreds of thousands of working hours and tremendous amount of public money if all or at least most of the large public transport system organizers will use only one unified global information system for passengers. There is no need to have different information systems for passengers in every single city. That is extremely inefficient. Can you even imagine that there are completely different versions of operating systems like Windows on computers in every city? That you came to the computer in Brno or Paris and you don't know where to find the internet browser, how to open the word processor and how to print a document. I cannot imagine that for truth to be told. Yet in public transport systems, those that helped us to become global specie, we have different environments and tariffs for every larger city. As was already mentioned, united public transport information systems will help passengers from different cities to easily adapt to a new place they visit and ultimately to promote the public transport as a better transportation option that is easy to use. It will be also very nice to have one

smartphone application for most of the larger cities so there will be no need to download new application at the airport of new city you just landed in. Also it will be very nice not to deal with different credit or ticketing system (not to have many accounts) and just to easily find a connection and purchase a ticket within one application anywhere across the world.

2

Prague Integrated Transport System

"Motorist is not an enemy of the public transport, he is a potential customer."
– Miroslav Vyka, *president of the Federation of Passengers of the PT*

PID is a system of public transport that operates in Prague and nearby region of Central Bohemia. It offers its customers regular lines of most transport means. With a single ticket passengers can travel using metro lines, trams, buses, local trains, ferries and funicular to Petřín. PID is center oriented system with circle outer zones around the city. PID tariff consist of the inner city zone (4 zones merged together) and 7 outlaying zones in suburban area and Central Bohemia region.

2.1 City Transport in Prague

As most of the citizens and even often very surprised tourists says: "Traveling in Prague using public transport is super easy." And that is what makes Prague one of the most successful cities when it comes to users of public transport to drivers ratio which is about 57:43 [1]. PID is an open transport system, that means anyone can get on any public transport vehicle without even showing a ticket. Tickets are controlled only randomly on board by ticket inspection officers. Most of the transported passengers in Prague uses rail vehicles as metro takes nearly 40% of all passengers and tram lines takes more than 30% [2]. It is very positive to the city's environment as metro and trams are powered by an electric network and doesn't produce any direct emissions in the city.

2.1.1 Metro

Metro (aka underground or subway) is a train system mostly hidden in underground tunnels. In Prague it consists of three lines (A, B and C) with three interchanging stations. No line is combined with any other line and have completely separated tunnels.

Each line have its own color so it is very easy to identify its entrance and determine which line it is. All lines length in total are 65,1 km [3] long, it have 61 stations, 730 carriages and its share on all transported passengers in Prague was 39% in 2015 [2]. It started its operation in 1974 and now it is the most popular and the fastest mean of public transport in Prague.
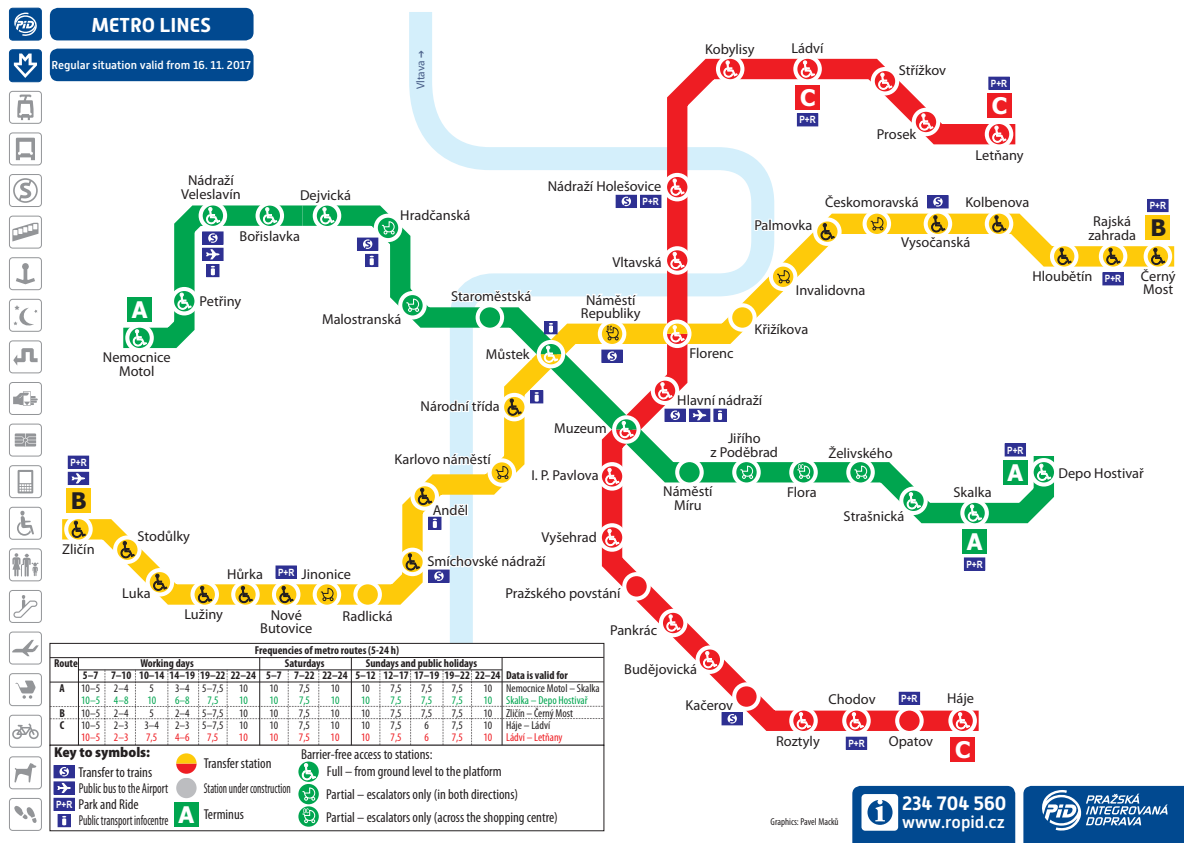
Figure 2.1: Scheme of metro lines in Prague as of 2017-11-16 [4]

2.1.2 Tram Lines

In Prague there are 25 regular tram lines as of November 2017 (in operation during day hours). Two of them are operated by historical tram vehicles intended mainly for tourists. In 2015 there were 30 lines with 500.4 km length operated by 869 trams (some of them operated mostly in couples) [2]. Share on all transported passengers was 30.6% in 2015. Trams in Prague have great historical tradition as the first tram service started in 1875. It was powered by horses. First electric tram was opened in 1891 as a private company. In 1907 the City of Prague bought all other companies and since that all tram lines in Prague are operated by city owned company, the DPP [5].
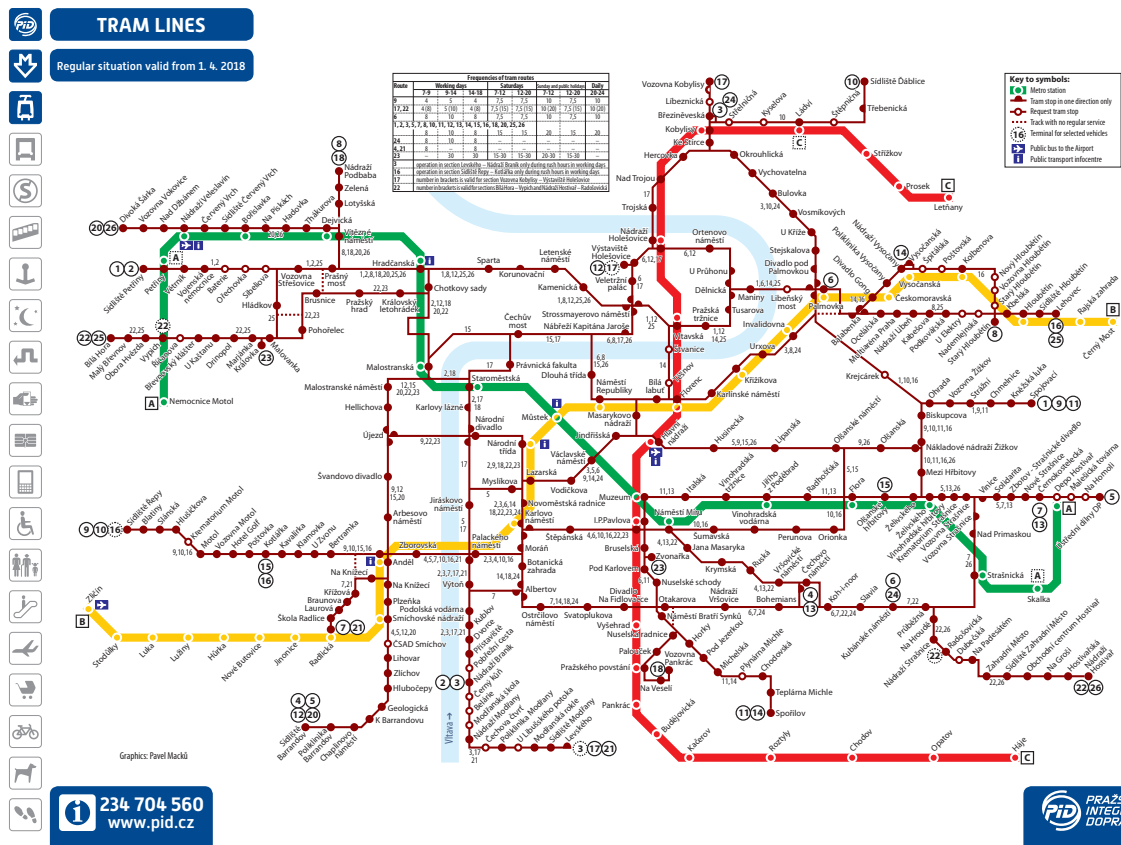
Figure 2.2: Scheme of tram lines in Prague as of 2018-04-01 [6]

2.1.3   Buses

There are 121 regular bus lines in Prague urban area and 20 special school lines (operates only during morning or afternoon hours). Due to the high tram and metro lines density in the central Prague, most of the bus lines operates outside of the city center. They are mostly run as a gathering service to metro stations and in big settlement areas without tram lines. Rest of buses are in operation in less inhabited areas. Unfortunately there is no railway or metro built to the Prague airport yet, therefore also airport lines are operated by buses. Airport lines and the zoo line (during weekends) are the most busy bus lines in the PID network. There is a plan to use bi-articulated buses on those lines and bi-articulated buses were tested on airport line in recent year [7]. Unfortunately there are some issues using them as there is a need of special permission for that long vehicles in the Czech Republic (and it is valid only for few months at maximum).

2.1.4   Trains

Since 1992 trains are part of the PID as the "S" lines and so PID tickets are valid in trains in urban and suburban area. Trains are also the last mean of transport where you can use either an integrated ticket or a ticket of the railways company (mostly the

Czech Railways Company - the national train carrier, but there is also one other small company KŽC Doprava with single regular line and two season touristic lines operated with historical vehicles). Unfortunately there is only limited number of train tracks in the city (as you can see on 2.3 - the white area is the city zone of Prague) and therefore trains are used only by quite limited number of passengers in the city. Yet train popularity for traveling into suburban areas is rapidly increasing in recent years.
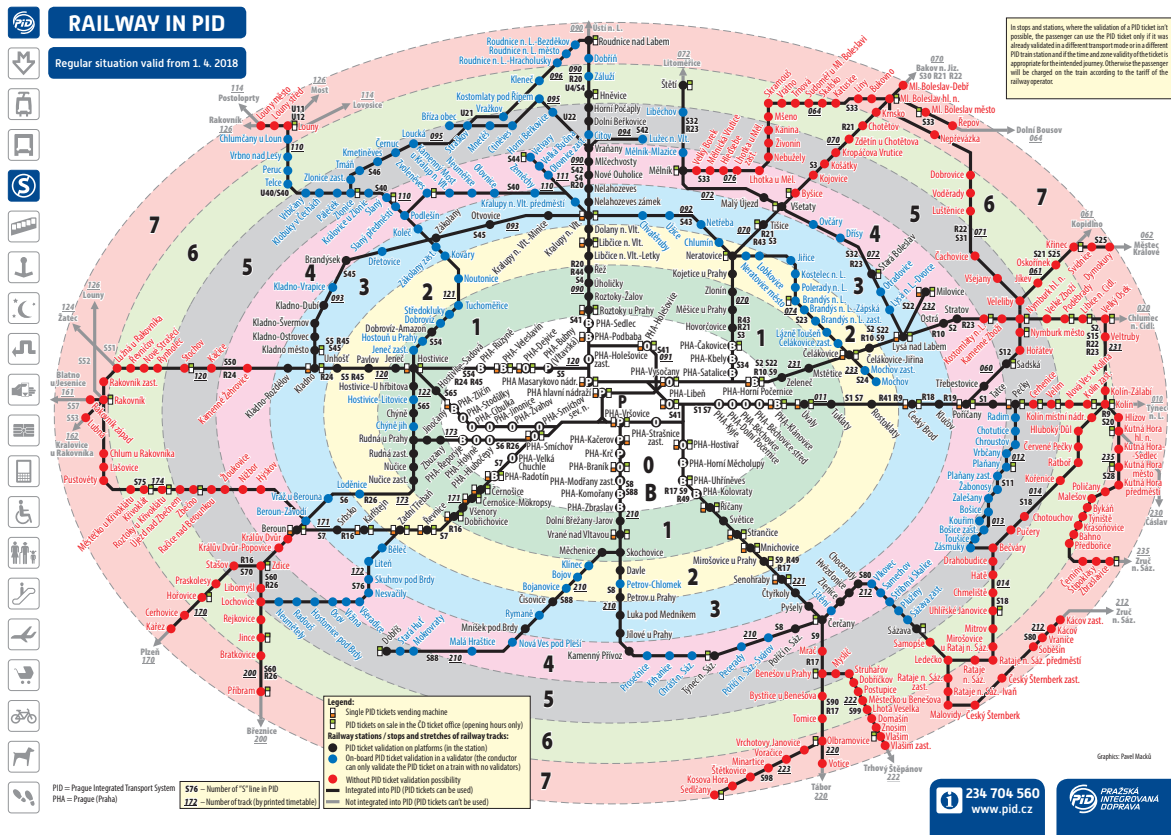
Figure 2.3: Scheme of train lines in PID urban and suburban area as of 2018-04-01 [8]

2.1.5 Ferries

Ferries are the newest mean of transport in the PID. There were first two lines introduced in 2005. Ferries started to be very popular mainly during weekends amongst families that walks around the Vltava river with children and amongst cyclists as main cyclist routes in Prague are built around the river. Now there are seven ferry lines in operation in the PID system, all of them in the city zone of Prague (line P4 is on the border of the city zone of Prague and first outer zone, so tickets for city zone and first outer zone are accepted). Because of its season character, five lines are operated in the April to October period, two lines are in operation during whole year.

2.1.6 Funicular

In Prague, there are two funiculars and one cable car. One funicular is a part of the PID, second is a part of the hotel complex and it is agreed that all passengers can use it for free, no matter staying in the hotel (this funicular will be closed on the January the 1st of 2018 and replaced by new starting operation at the end of March 2018). The cable car is inside the ZOO area and although it is operated by DPP, it is not part of the PID system (as for its touristic character) and therefore all passengers have to buy dedicated single ride tickets.

Figure 2.4: Funicular railway to the Petrin hill and boat called Josefina on ferry line P3 from Veslarsky ostrov to Lihovar. Passengers can travel with PID tickets only. Photos taken by author.

2.2 Transport in Suburban Areas of Prague and the Central Bohemia Region

Outer zones of the PID system are established in the suburban area of Prague and also in the most of the Central Bohemia region. There are plans to cover entire Central Bohemia region by the PID transport system by the end of the year 2018 in the name of the principal "two districts, one ticket, one timetable, one tariff, one network". As there is a law limitation, each district (Prague and Central Bohemia region) must have its own transport organizer (Ropid in Prague and IDSK in Central Bohemia region, for easier cooperation, they are both located in the same building). Therefore there will be one transport system with one tariff managed by two organizers. In Prague and the Central Bohemia region lives in total one quarter of the population of the Czech Republic. In Prague, there is a public transport to drivers ratio 57:43, in the Central Bohemia region 20:80 [1]. Mission for next years is therefore to increase number of users of public transport

in the Central Bohemia region.

2.2.1 Trains

Trains are very important part of the suburban public transport and since their integration into the PID system (in 1992 in Prague, in 1996 in suburban areas and the Central Bohemia region) their usage is rising. [9] Most important lines are on main railway lines as service there is operated by fastest and highest capacity trains. They create most of the transport performance of railways in Prague suburban area because only there the travel time difference between trains and cars is acceptable for most citizens. The Prague municipal authority is aware of rising numbers of cars in city streets and is trying to reduce them also by creating better railway infrastructure. They also moved some railway stations to more suitable places for passengers by creating better and easier connection between local buses, tram lines, metro and trains.
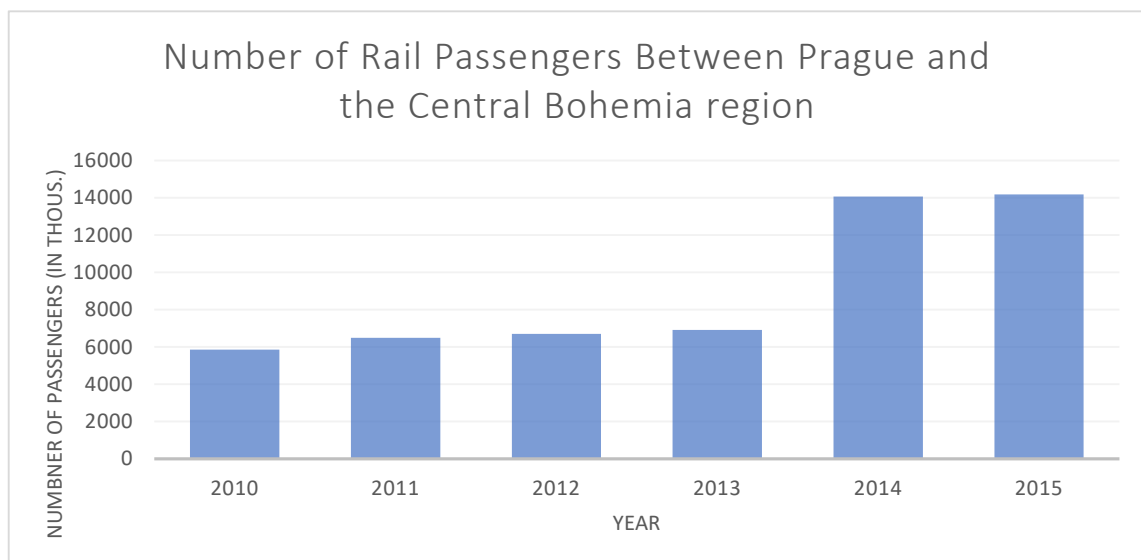
Figure 2.5: Numbers of train passengers between Prague and the Central Bohemia Region in years [3]

2.2.2 Buses

Buses are the most important transport mean in Prague suburban area and Central Bohemia district apart from trains as there is no other infrastructure but roads. Most bus lines are part of the PID system but as integration is not completed yet, there are still some private lines between Prague and regional towns.
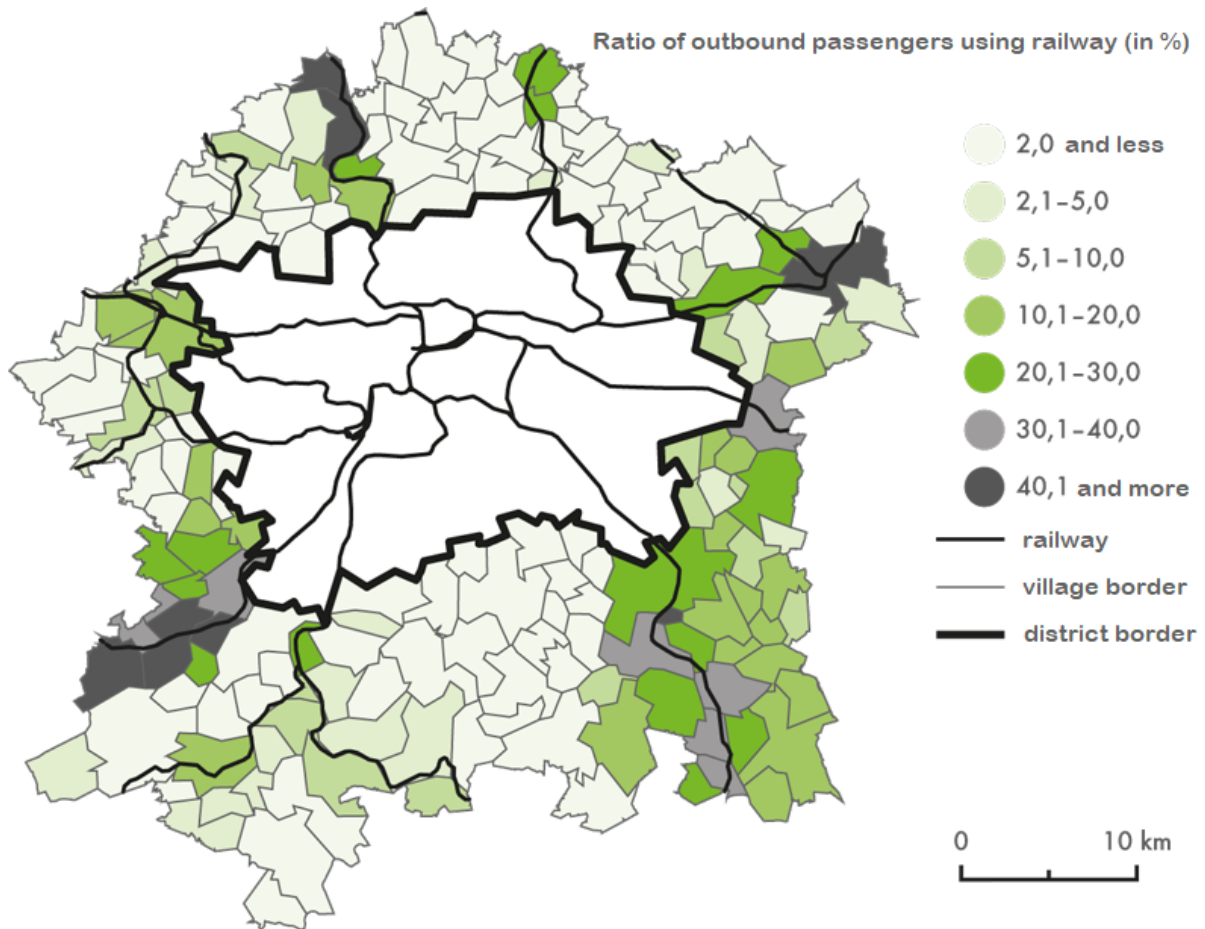
Figure 2.6: Ratio of outbound passengers that use railways in Prague suburban area [3]

2.2.3 Local public transport in regional centers

As long as the integration of the Central Bohemia region is not completed yet, some of the local public transport lines in regional centers are managed by local town hall authorities and are not integrated into the PID yet. But there are towns like Kladno, where integration is completed and passengers already benefits from it. Especially in Kladno. There was a big problem with failures from the local transport company, resulting in missing connections and late or early departures (even without any notice). Since integration into the PID system on the end of August 2017, all connections are under the detail monitoring from the PID dispatching and sanctions for each failed connection were applied to the local transport company. It heavily improved quality of service for passengers by way higher reliability. Also the PID information services are now available to passengers and therefore passengers can now find even the real time bus location and information about delay online on the PID website or in the PID INFO smartphone application (available for Android and iOS users, free of charge).

2.3 Prague Integrated Transport Tariff

PID is divided into Prague area zone and suburban areas and the Central Bohemia region. In the city of Prague PID is considered as an open system and so there is no need of showing ticket when getting on the vehicle of public transport in most cases. Passengers shows theirs tickets only during random ticket inspections on the board of vehicles or at metro stations. Ferries are the only exception as there is a regular ticket check because of the usage statistics collection . In suburban areas and the Central Bohemia region the PID is considered as a closed system and therefore tickets are inspected when getting on the bus (by the driver). In trains in the PID system ticket inspection is always done by conductors of the railway company no matter if traveling in Prague zone or in suburban area. Tariff of the PID is divided into eleven zones. Four of them are in the city of Prague. Zone P for the Prague city transport is doubled (considered as double zone). Then there are also zones zero and B as terminal zones for suburban public transport. In suburban areas and in the Central Bohemian region are outer zones starting with number one to number seven. Outer zones are made as circles around Prague where number of zone represents its distance. Farther away of the Prague bigger the number is.

Figure 2.7: Overview of PID zones in the city of Prague and suburban areas and Central Bohemia region as of 2018-04-01. [10]

2.3.1 Tariff in the city zone of Prague

To travel around Prague passengers can use short-term tickets that are available in four variants: 30 minutes for 24 CZK (0.94 EUR, as of 2017-11-24), 90 minutes for 32 CZK (1.26 EUR, as of 2017-11-24), 24 hours for 110 CZK (4.32 EUR, as of 2017-11-24) and 72 hours for 310 CZK (12.18 EUR, as of 2017-11-24). For residents and long-term visitors are available long-term season tickets that are issued to one person (either with chip card or a PID pass) and so are not transferable. Transferable tickets are also available for specific use of business customers with higher prices than regular long-term tickets. Regular tickets have five variants: one month for 550 CZK (21.60 EUR, as of 2017-11-24), three months for 1 480 CZK (58.13 EUR, as of 2017-11-24), five months for 2 450 CZK (96.23 EUR, as of 2017-11-24) and one special discounted version for one year for 3 650 CZK (143.36 EUR, as of 2017-11-24). As you can see, the price represents 10 CZK for a day with a year ticket and it is available in version for adults only. There is also variant for ten months that is specially designed and available for students only (represents one school year without summer). Student (19 to 26 years), junior (15 to 19 years) and senior tickets are available for the half of the regular adult price (for short-term and also for long-term).

2.3.2 Tariff in suburban areas and in the Central Bohemia region

To travel in suburban areas and in the Central Bohemia region there is a set of short-term tickets with different time validity while also valid for the specific zone range. The cheapest ticket is valid for 15 minutes and 2 zones (cannot be used in urban area of Prague as it is considered as 4 zones merged together) while longest tickets are available for 5 hours and 24 hours with 11 zones validity (which means they are valid for entire PID network). Detail short-term tickets list is on the figure 2.8. Long-term tickets list is on the figure 2.9.

2.4 Ticket Sale

Ticket sale in the PID network is provided by vending machines on stops and in special cases also on board, local newsagents, specially designed public transport ticket shops and information points, by the driver in suburban area and by train company ticket offices at railway stations (in the testing regime in selected train stations only, since May 2017)[12]. Passengers can also buy tickets using their phones by sending specific premium short message service (SMS). Multi channel ticketing (including smartphone applications,

Number of zones	Validity (time)	Adult (*)	Child (*)
2 zones	15 min.	12 CZK	6 CZK
2 zones	30 min.	18 CZK	9 CZK
3 zones	60 min.	24 CZK	12 CZK
4 zones	90 min.	32 CZK	16 CZK
5 zones	2 hrs.	40 CZK	20 CZK
6 zones	2,5 hrs.	46 CZK	23 CZK
7 zones	3 hrs.	54 CZK	27 CZK
8 zones	3,5 hrs.	62 CZK	31 CZK
9 zones	4 hrs.	68 CZK	34 CZK
10 zones	4,5 hrs.	76 CZK	38 CZK
11 zones	5 hrs.	84 CZK	42 CZK
11 zones	24 hrs.	160 CZK	80 CZK

Figure 2.8: Short-term tickets available for suburban travel in PID. [11]

e-shop and on board vending machines) is scheduled to start on July 1st, 2018.

2.4.1 Ticket sale in the city zone of Prague

In the city zone of Prague short-term tickets are mostly sold by vending machines which are available at all metro stations and some tram or bus stops with higher traffic of passengers. They are also available at all funicular stations. At tram line no. 18 there are also available vending machines on the board of all trams which accepts contactless payment cards only. It is nice additional option to buy a ticket when no classic vending machine is available, yet currently not much used due to its limited availability (just one tram line in entire network). Other option where to buy a ticket in central Prague are some newsagents, special transport ticket offices that are mostly located at metro stations and are primary meant to sell long-term tickets to Prague citizens, public transport information points that are available at the Vaclav Havel Airport Prague, at the Prague main train station, in the city hall of Prague and at important metro stations. In buses is also

Validity	Adult (*)		Child (*)	
Number of zones	Monthly	Quarterly	Monthly	Quarterly
1 zone	300 CZK	760 CZK	150 CZK	380 CZK
2 zones	460 CZK	1 200 CZK	230 CZK	600 CZK
3 zones	700 CZK	1 800 CZK	350 CZK	900 CZK
4 zones	920 CZK	2 400 CZK	455 CZK	1 190 CZK
5 zones	1 130 CZK	3 000 CZK	565 CZK	1 500 CZK
6 zones	1 350 CZK	3 600 CZK	675 CZK	1 795 CZK
7 zones	1 560 CZK	4 200 CZK	780 CZK	2 100 CZK
8 zones	1 780 CZK	4 800 CZK	890 CZK	2 400 CZK

(*) **Adult /** From 15 to 70 years of age
Child / From 6 to 15 years of age. From 10 years it is necessary to prove the child's age

Figure 2.9: Long-term season tickets available for suburban travel in PID. [11]

a limited option to buy a ticket from the driver (yet it is more expensive and prepared exact amount of cash is required).

2.4.2 Ticket sale in suburban areas and in the Central Bohemia region

In suburban areas of Prague and in the Central Bohemian region there is only limited availability of vending machines. Most of the short-term tickets are therefore sold by bus drivers on board (apart from train tickets mentioned in next chapter).

2.4.3 Ticket sale on trains

On trains in Prague and suburban areas are valid PID tickets and tickets of the railway company. Passengers can buy a ticket of the railway company on board from the conductor or at train station. There are sold also T+R tickets (PID) specially designed to motivate people to use rather train than car to get to the city. T+R is cheaper ticket with one day validity than usual 24 hours ticket. It is required to be sold with train ticket only and its validity is limited to the same day as is the validity of the train ticket.

2.4.4 Ticket sale on board

On board tickets are available in the zone of Prague only in buses from drivers (surcharged tickets) as mentioned before and on ferries (regular PID tickets). On the tram line no. 18 are also sold tickets by special vending machines that accepts contactless payment cards only.[13] In trains are issued tickets from conductors, yet these tickets are only valid for train as they are not PID tickets but tickets of the railway company. SMS tickets are required to be received by passenger before boarding and therefore cannot be considered as on board sale. In suburban areas and Central Bohemia region are tickets sold by bus drivers.

Figure 2.10: Vending machine for on board ticket sale on tram line 18. Only contactless payment cards are accepted. Photo by author.

2.5 Information Systems and Other Ways of Informing Passengers in PID

Even there are more than 20 transport companies in the PID, all of them have to follow the same guidelines for information systems on board. At stop information systems are not unified yet apart from paper timetables that are the same across entire network. DPP is using lot of digital systems at tram stops as they were testing them or were built with a new line or with a reconstruction of selected tracks. But on the 19th September 2017 the city hall council of Prague approved the new Standard of PID Stops document which aims to be the guideline for all new constructions of stops and upgrade of current stops. Its creation lasted for two years and also CTU FTS participated [14].

2.5.1 On board information systems

On board information systems are visual and acoustic. Visual information systems inform passengers about current time, current tariff zone of PID, line number, next stop and destination stop. It also show whether the next stop is a request stop or not. On board acoustic systems tells passengers name of the current stop when arriving in it and the next stop (in some vehicles, eg. metro, informs about the next stop when leaving previous stop). On board acoustic signals also inform passengers about closing doors. Dispatcher can remotely control acoustic signalization in vehicles and inform passengers about some irregularities in PID network operation. He can select specific lines or vehicles to distribute this information to. The newest on board systems also allows remote control functionality on visual systems. Dispatchers can change line destination if necessary to inform passengers on board or when getting on the vehicle when traffic change is in effect. All acoustic signals (with exception for airport line) are only in Czech language, visual information systems sometimes provides information also in English (all metro lines, new trams and buses with LCD panels).
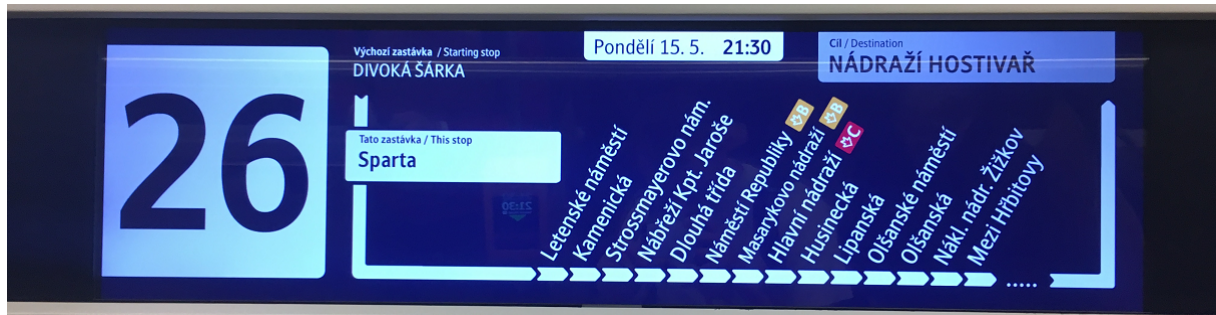
Figure 2.11: Information system for passengers in Prague on tram line 26, tram type 15T For City, photo by author.

2.5.2 At stop information systems

Modern digital on stop information systems are unfortunately quite rare in PID network. There are some experiments with them, mainly on the tram network. They use different technologies and show different information. Some of them are also capable of showing current departures based on the situation in the network and also inform passengers by dispatcher provided information if some traffic change occurs. There is also acoustic system in metro stations that is often used by dispatchers to inform passengers about traffic changes (planned and unplanned).

Figure 2.12: Three different types of information systems at tram stops in Prague, photos by author.

2.5.3 Online (internet) information systems

As the rising number of passengers is equipped with smartphones and internet connection, using smartphone application is now easiest way how to provide information to passengers during planning phase of their trip. When they search for their connection they also find information about necessary ticket even without knowing of tariff zones. They can be also informed about traffic changes before start of their trip and also during trip if we know where they travel. There are two official public transport smartphone applications available. Older and to be deprecated application is "DPP info" by DPP. It provides a lot of information but is sometimes quite unstable. Therefore it is not much popular among passengers in Prague. Even though it can provide online information about planned and unplanned traffic changes in PID network. It also allows users to purchase a ticket (unfortunately only through premium SMS, which is very often not available in corporate tariffs). It provides also information about P+R parking, departures from stops, PID tariff schemes and current status of lifts for handicapped passengers. Second official smartphone application comes from "DPP info" and it is called in similar way: "PID info". It enhances features of the original application and range of usage on entire PID network. Added features are real time departures (counting with delays), better map with more clear positions of stops and positions of vending machines. In future versions it should offer possibility to buy a ticket directly from connection search using PID account. "PID info" is in beta version as it was released in October 2017 (as of November 2017)

[15].

However most of the passengers in Prague uses for their journeys using public transport IDOS application. IDOS is a public transport planner that allows users to search a public transport connection in whole Czech Republic combining all public transport means and systems together. It also provides information on planned traffic changes, but not about unplanned ones and also don't provides additional information I mentioned when I was describing possibilities of DPP info application. IDOS and "DPP info" applications have the possibility to switch language of the application into English. There is also "Jízdní řády" (formerly known as Pubtran) application that provides information from timetables combining all transport means and systems in the Czech Republic together. It also combines information from maps and provides information even for walking (for short distances between different stops) and therefore shows interesting combinations of possibilities of walking and public transport together. There is also available search from any or current location to any stop, place on the map or address. It can also show the connection on the most popular maps with public transport line routing and precise stop locations using the best smartphone map provider in the Czech Republic called Mapy.cz (as they are from the same company Seznam.cz, which is sometimes called the Czech Google).
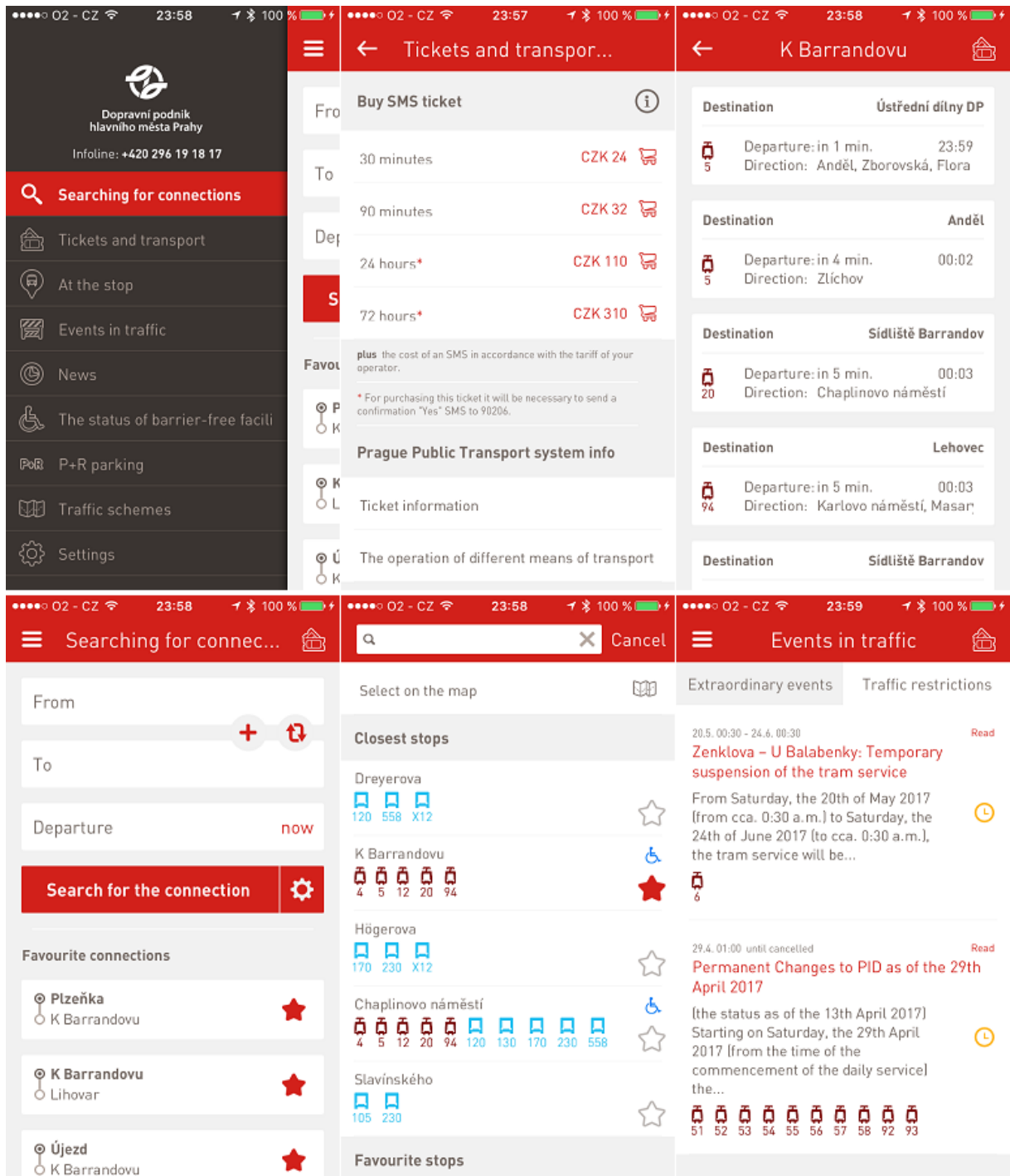
Figure 2.13: User interface and screen examples of DPP info smartphone application. Screenshots captured by author.
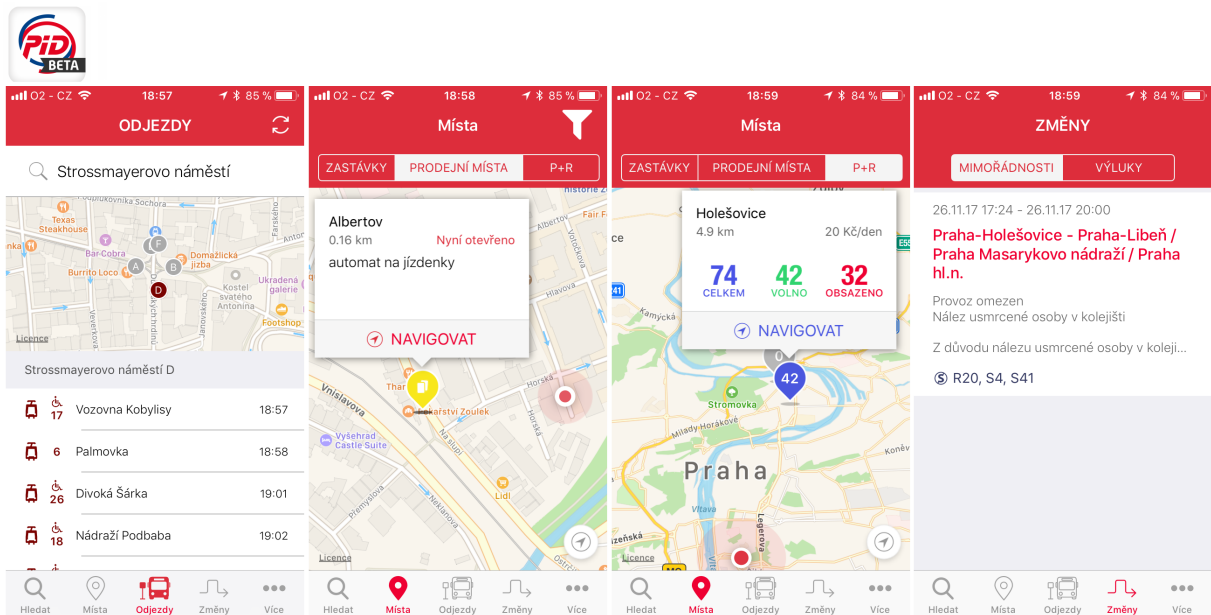
Figure 2.14: User interface and screen examples of PID info smartphone application. Screenshots captured by author.
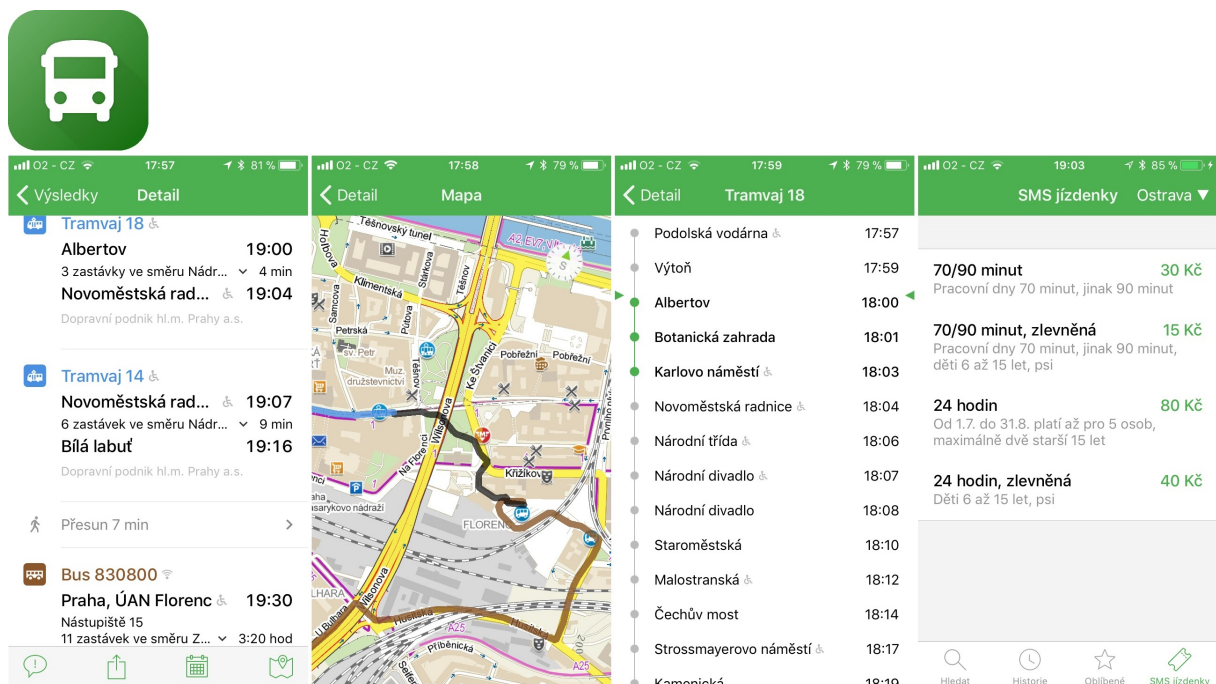
Figure 2.15: Jízdní řády (Pubtran) user interface and screen examples. Screenshots captured by author.

3

Information Systems for Passengers

Information to passengers were historically passed by paper timetables on stops and by printed signs in vehicles that informed about destination and about important stops on the way. Only change was done by driver or conductor at the end stop by changing destination sign on the front windshield. It is still being used in poorer parts of the world like India or China. But as the world of information technology is expanding into all areas of our live, it is no surprise that one of the first penetrated fields was transportation where everything is changing from minute to minute. As the Global Positioning System (GPS) navigations are widely spread among drivers, it was necessary for PT to also adopt state-of-the-art technologies to increase efficiency and precision in informing passengers. Using the most advanced technologies with high level of precision is the only way (non-repressive) to keep high numbers of passengers in public transport and prevent massive car domination with all its negative impacts in cities and also rural areas.

Figure 3.1: Examples of at stop information system at K Barrandovu tram stop in Prague. Photo taken by author.

3.1 On board information systems

On board information systems are a part of the way of informing passengers during their journey. It is very important to keep PT super easy to use and every single element that can help passengers with orientation is to be implemented. Today's passengers wants to be informed in exact moment they need it, not too early, not too late.[16] They also require information whether they want it. So it is important to equip vehicles appropriately. Visual systems are informing passengers whole time and it is only theirs decision when they look for information they know they will find at specific location in vehicle. This information consists of current time (not that important by now, when every passenger have his watch or phone), next stop (or current stop if on board system can provide that information while vehicle is in stop), destination and list of the closest stops. It is also very nice if the system can provide information about estimated arrival, about the possibility of change to another line with estimated or regular departure and when some irregularity occurs it can react to it by showing substitute routing and estimated delay. Design of the on board information units slightly differs throughout the world. Different nations consider different information with different priority. There are also acoustic information systems that reminds passenger of upcoming stop and if possible about irregularities on their way. It can also provide information whether next stop is a request stop.
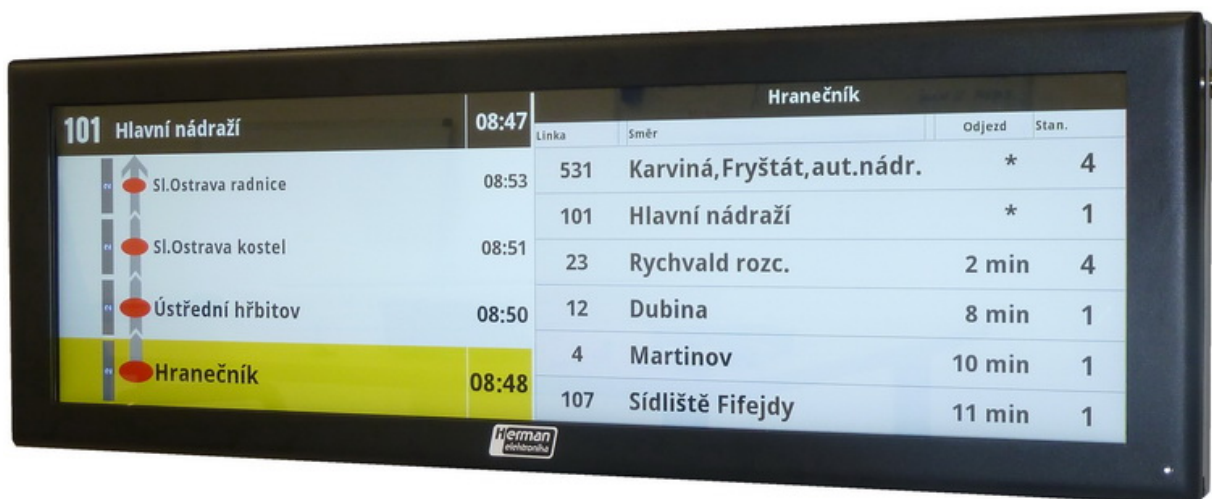
Figure 3.2: Dynamic on board information panel by the Herman elektronika company is showing real time departures from the current stop. Figure from [17].

3.2 At stop information systems

At stop information systems are even more important than those on board. It is for a simple reason: when passenger is on board, he can always receive information from the

Figure 3.3: Examples of on board information systems. From the top: Brno (CZ), Bratislava (SK), Helsinki (NO). Photos taken by author.

driver, the conductor or any other employee of the transport company. When passenger is at stop waiting for connection and some accident occurs, there is no other way to inform passengers at the stop then by at stop information system (apart from passengers equipped with smartphones and internet connection that can receive this information online through smartphone application notifications). If such system is installed at stop its primary function is to inform passengers about upcoming connections and their estimated arrivals. It helps to calm passengers when there is some small delay of their connection. In addition it can inform passengers about cancelled connections and reasons for that or about some routing change because of the accident on their regular route. Passengers can then decide to wait, change their plan or to choose some other connection.

3.3 Online information systems

Online information systems are websites that provides connection search, smartphone applications of the transport companies or public transport systems and social media that can also help with informing passengers in unexpected situations. If we want to keep

Figure 3.4: Examples of at stop information systems. From the left: Trieste (IT), Brno (CZ), Prague (CZ). Photos taken by author.

passengers in PT rather than in cars we have to provide them with smart information exactly when they need it with intuitive interface, fast connection search, smart notifications about theirs journey and in case of traffic change to warn them immediately and provide them with substitute route options so they will not have to care. As we already mentioned PID info application, it can provide passenger with lot of information needed. Yet it still miss smart notifications based on search history or current location (like substitute route warning), even from design point of view it is quite nice and lot of others applications could have inspired from it, it is still in beta version and therefore some errors sometimes occurs, it have nice function of finding connection at current time. It have very useful maps of stops with departures from selected stands and also map of vending machines and P+R parking with real time information about available parking places. In global scale leader on the market is of course Google with Google Maps application with integrated public transport information that works worldwide. But unfortunately it doesn't provide additional information about PT service and irregularities and therefore it is debatable whether to use for regular traveling by PT Google or local applications. If there are local applications that are providing additional information in local language it makes sense to use them as they usually more respects needs of local citizens. It would be quite nice if local authorities make some API for other applications to use (so even Google can provide adapted current situation).

Figure 3.5: Paper timetables at stop in Trieste. Photos taken by author.
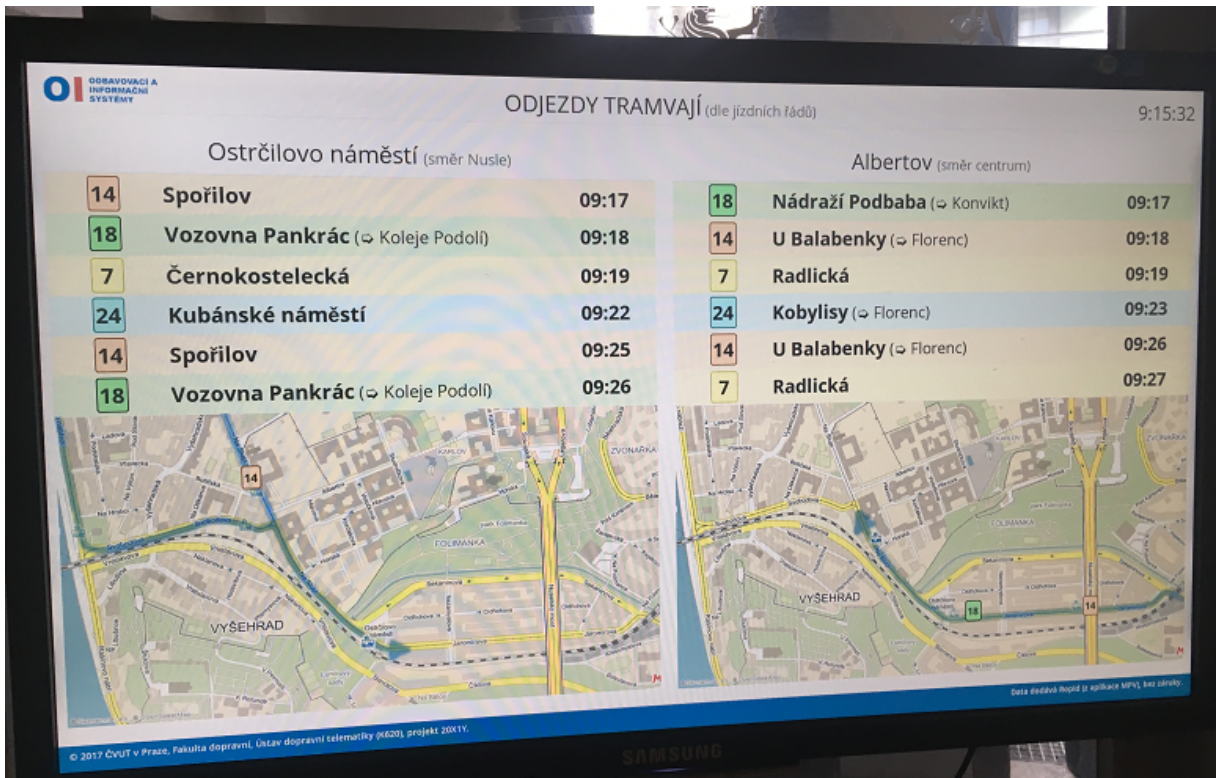
Figure 3.6: Indoor departures information LCD panel installed at CTU FTS Horská building to inform students and university employees about tram departures from nearest tram stops in directions that are used by most users. It have also simulation of tram vehicle movements on the map as it is faster to estimate remaining time to departure from a picture. Unfortunately the system have estimated departures from timetable only as real time departures are not provided by DPP that operates trams in Prague. System is created and photo is taken by author. Data provided by MPV (Ropid).

4

Ticketing and Tariff Systems Across the World

4.1 Ticketing Types in PT

There are three different ticketing types of integrated transport systems. The free of charge public transport service and two paid: open public transport system and closed public transport system.

4.1.1 Free of charge PT (aka zero-fare PT)

Free of charge wide area public transport is rare type right now. Only very rich cities with such an income that covering all expenses of public transport system isn't the big part of their budget. There are also cities that fights big traffic issues caused by the individual transport by offering free public transport to its citizens. There is only one capital city in the world that offers free public transport – it is the city of Tallinn, Estonia, where it is available since 2013 after referendum about free PT in 2012. Unfortunately the zero-fare tariff applies to citizens only. Others are small or mid-sized cities (mostly European). As an example with longest tradition is often used Belgian city of Hasselt where free PT was established in 1997 but already ended in 2013. But it is not even true, the city with the longest tradition is the city of Colomiers, France, where zero-fare public transport was introduced in 1971 and it is still in operation. In the Czech Republic there are only two cities with free PT, city of Frýdek-Místek and Valašské Meziříčí. In Frýdek-Místek free PT was established in 2011 and it applies on free PT local card users only. In Valašské Meziříčí was free PT shortly tested in 2009 and established permanently since September 2017. In Valašské Meziříčí all passengers can travel for free, there is no need for any card. All passengers receives so called zero-fare tickets to collect statistics about free PT usage.

4.1.2 Opened public transport systems

Opened public transport is a paid PT without ticket inspection when entering PT vehicle. It allows anyone to travel even without ticket. Only random ticket inspections are done and passengers without valid ticket are charged by expensive fine. It allows PT to operate very smooth without delays on every stop or station. That saves travel time mainly on buses where inspecting or issuing tickets take lot of time on each stop. Result is higher travel speed of vehicles and more attractive PT. Disadvantage is its availability to non-paying passengers, homeless people and therefore results in decreased quality of vehicles caused by vandals and people who doesn't respect rules. Typical example of open PT is Prague (city zone only).

4.1.3 Closed public transport systems

Closed public transport is a paid PT with ticket inspection when entering a PT vehicle. It allows paying passengers on board only. That result in need of ticket inspection devices or officers on every station entrance or on board of all vehicles. When ticket inspection is performed by driver it causes delays on every stop and therefore result in slower travel speed of such vehicles and decrease attractiveness of PT. Yet closed PT is usually more comfortable as only paying passengers are allowed on board.

4.2 Tariff Models of PT

There are more PT tariff models. They usually depends on historical development, geographical specifications and also on type of area they are established on. Main types are centric models with circular outer zones around central zone, zones tariff where zones of similar sizes are evenly distributed around whole covered area, distance tariff model where passengers are charged by exact distance traveled or by distance ranges and zone-distance tariff which combines zone and distance tariff models together with small zones and price is calculated from the number of zones traveled through.

4.2.1 Centric tariff model

Centric (or semi-centric) tariff models are mainly used around big cities that creates center of wide area and most of the journeys have radial character into the city center and back to suburban areas. Therefore are also these journeys used as determining for payments. More zones you cross during travel, more you pay. Of course it is cheap to travel in tangential direction, but since most journeys are into the center and back, there is usually

Figure 4.1: Proposed ticket barriers for metro in Prague. [18]

only limited offer of tangential PT lines in such systems. The typical example is Prague as it is natural center for the quarter of the Czech Republic population.

4.2.2 Zones tariff model

Zones tariff models are used in areas without one significant center. Therefore there are used mainly in regions with smaller towns and rural areas. PT passengers are charged by number of zones they enter during travel. Zones are usually covering whole towns and sets of villages. Typical example in the Czech Republic is South Moravia region with its system IDS-JMK.

4.2.3 Distance tariff model

Distance tariff model is probably the oldest model used in the PT since first PT were established. Passengers are charged by exact distance they travel or by distance ranges. That means that there is a matrix of all stops and stations with known distance and they have known prices. It can be exactly proportional to distance traveled or there can be some discounts for higher distances. Typical example is railway tariff of the Czech Railways Company. It can be also found on metro lines as is Delhi Metro, where station
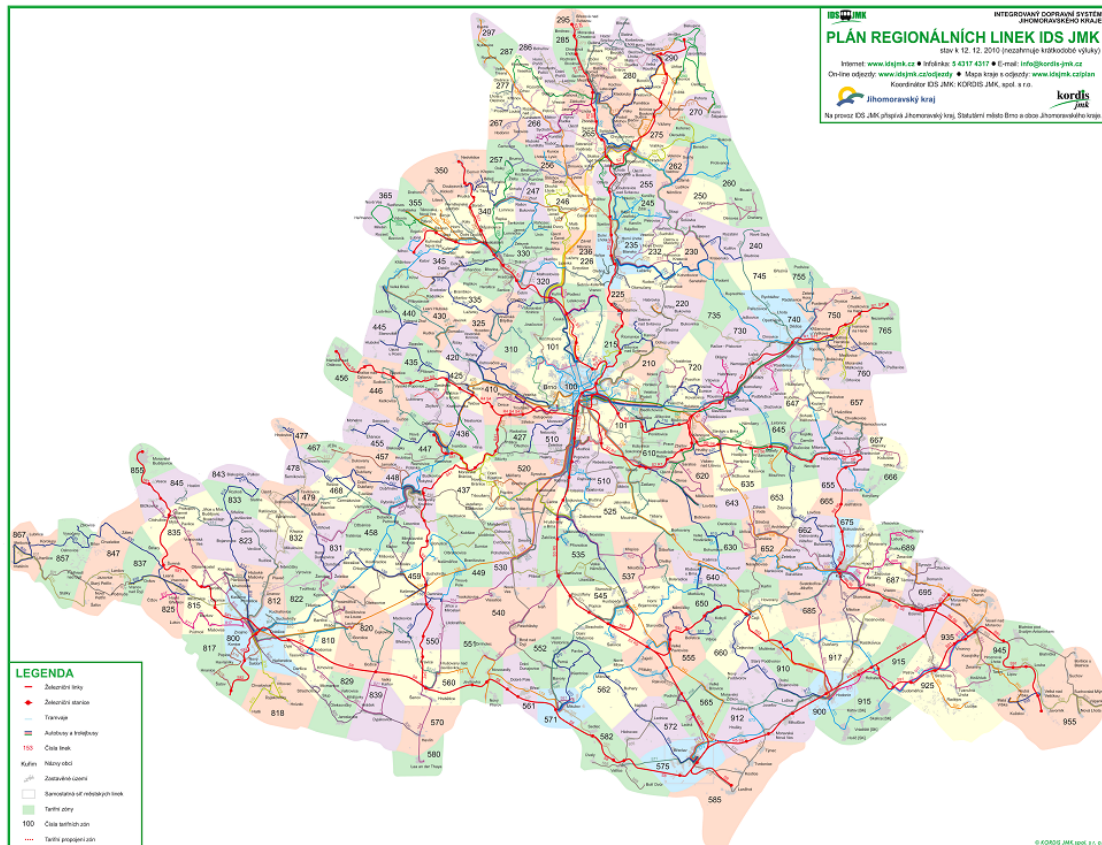
Figure 4.2: Excellent example of zones tariff is IDS JMK system in the South Moravia. [19]

to station matrix with prices for each combination exists.

4.2.4   Zones-distance tariff model

Zones-distance tariff is similarly to zones tariff used in areas without significant center. It combines distance tariff with zones by establishing lot of small zones (usually one for each village) and "distances" between them (distance units) and price is counted as a lowest sum of shortest distance units of zones passenger crossed (so called zone-distance). Example of calculation in such system is on figure 4.3. Such systems in the Czech Republic are Integrated regional transport (IREDO) in Hradec Kralove and Pardubice region, Integrated Transport System of the Liberec Region (IDOL) and Usti Region Transport (DÚK).

4.2.5   Time based tariff model

Time based tariff offers passengers to buy tickets for a prespecified period of time without need of knowledge of any zones. It is used mostly in areas with high density of PT options like large towns or cities. Passengers in such systems can use the first possible line that

Summary overview of tariff models			
Tariff type	Benefits	Disadvantages	Example
Centric	Universal default model for monocentric areas, simplicity, low technology and information costs	Low charging of tangential journeys can be solved by setting segments, then switches to the zones system	PID, MVV, VGN
Zones	Universal default model for regional deployment, "Simple" pricing based on the number of zones traveled	Alternate routing through intermediate zones impossible, Nonclarity with higher number of zones, For larger zones leads to higher price jumps, The uniform size and distance of one zone does usually not match the settlement structure, leads to exceptions	IDS JMK, ODIS, ID-SOK, SID, IDOK, IDP, VVO
Zones-relational	Universal default model for polycentric areas, Possibility of easier alignment of zones and territories of municipalities, Allows ticket sales from A to B, Passengers need not to deal with tariff zones, Possibility of alternative routes including subscriptions for multiple origins and destinations within the territory (personal sub-network)	Challenging preparation and pricing, Greater demands on handling systems (OD distance matrix for all zones)	IREDO, IDOL, DÚK, VOR
Other systems	Possibility of arbitrary pricing	They are not applied in a larger scale PT systems	

Table 4.1: Table Current tariffs used in the Czech Republic and neighboring countries. Based on [20].

comes along their way and that is in right direction and adjust their journey according to it and therefore not always use the same route and not always get off one the same stop. Tickets are usually sold for short travels around thirty minutes, longer travel around one or one and half hour and for whole day or multiple days. Time needed for travel is always available in connection search applications and therefore it is usually easy to decide which ticket to buy.

4.2.6   Summary of tariff models

The table 4.2.6 summarizes the current tariffs used in integrated transport systems in the Czech Republic and neighboring countries, including their advantages and disadvantages.

Figure 4.3: Zone-distance tariff in Ústí region. Price is calculated as a sum of distance units between zones in the system. In this example it is 9+1+9=19 distance units that will determine final price.[21]

4.3 Single ticket variants

Single tickets and also short-term tickets are mostly used by non-regular PT passengers. Some of them are intended for only one trip by one vehicle (mostly in smaller PT systems) without any specified time validity and others have short time validity. Some of them are also valid for one vehicle only (yet also limited by time), some of them are transferable (without limitation for just one vehicle, yet limited by time). In most of the PT systems are available single tickets for a short time (in Prague for 30 minutes) and for longer time (in Prague for 90 minutes). Short-term tickets can be also issued for a one day or few days. Most of the single tickets are printed on (protected) paper or can be just virtual if used contactless payment card for purchase (traveling in London with just contactless payment card) or smartphone application. In some PT systems there are also short-term SMS tickets available.

Figure 4.4: Example of at stop vending machines. From the left: Trieste (IT), Prague (CZ). Photos taken by author.

4.4 Season (long-term) ticket variants

Season or long-term tickets are issued to citizens that live in area where PT systems operate or to long-time visitors. They have different variants starting with traditional protected paper coupon, over Radio Frequency Identification (RFID) cards and contactless payment cards to virtual tickets on smartphones. They have also different validity. Most popular are month tickets, quarter year tickets or one year tickets. They have usually quite reasonable price as their main purpose is reducing individual traffic by getting regular passengers into the PT vehicles.

5

ETIS - Evaluation of Ticketing and Information Systems

Figure 5.1: The logo of ETIS.

5.1 Introduction

ETIS – the evaluation of ticketing and information systems is a web application that allows users to easy access information about specific areas in public transport. It aims to create easy to use database that will be accessible to anyone providing information that were entered by public transport organizers, public transport companies as well as public transport fans. Those information should by used by public transport organizers to improve theirs systems by inspiring from others all around the world, by students for their studies and school works, public transport fans for whatever purposes and by journalists to easy create interesting graphs to inform the public and to promote the public transport as a whole. ETIS is available online on the World Wide Web (WWW) on the address https://etis.fd.cvut.cz

Figure 5.2: The ETIS homepage.

5.1.1 Motivation

When I was preparing my bachelor thesis or some seminar works, I was many times faced to bad transportation information sharing. In newspapers or on web news, there were many times some graphs about where is the public transport cheap and where is it expensive based solely on comparison of absolute value of single ticket or month ticket price converted to single currency (usually USD or EUR). It is a nice information, yet without knowing of how much this price is expensive considering local salaries or other expenses, quality, quantity and coverage of the service, it is just a number. To provide information that makes sense and create valuable comparison, analytic needs more information about compared systems and local data. There is no place to get all those data and information easily even in such a small country as is the Czech Republic. No mentioning if I would like to compare public transport systems around the world.

5.1.2 Comparable systems

In the Czech Republic there is IODA – the transport database. It uses some data sets provided by the Czech Statistical Office and by the Ministry of Transport of the Czech Republic. Unfortunately most of the information there is about transport of goods and other economic values. It also provides data about transport in the Czech Republic only.

Serbian Numbeo designed in 2009 by former software engineer from Google is a web application that offers users to insert data from location they live in. Information concerns data real live users don't have to think about of because they use them daily (prices at
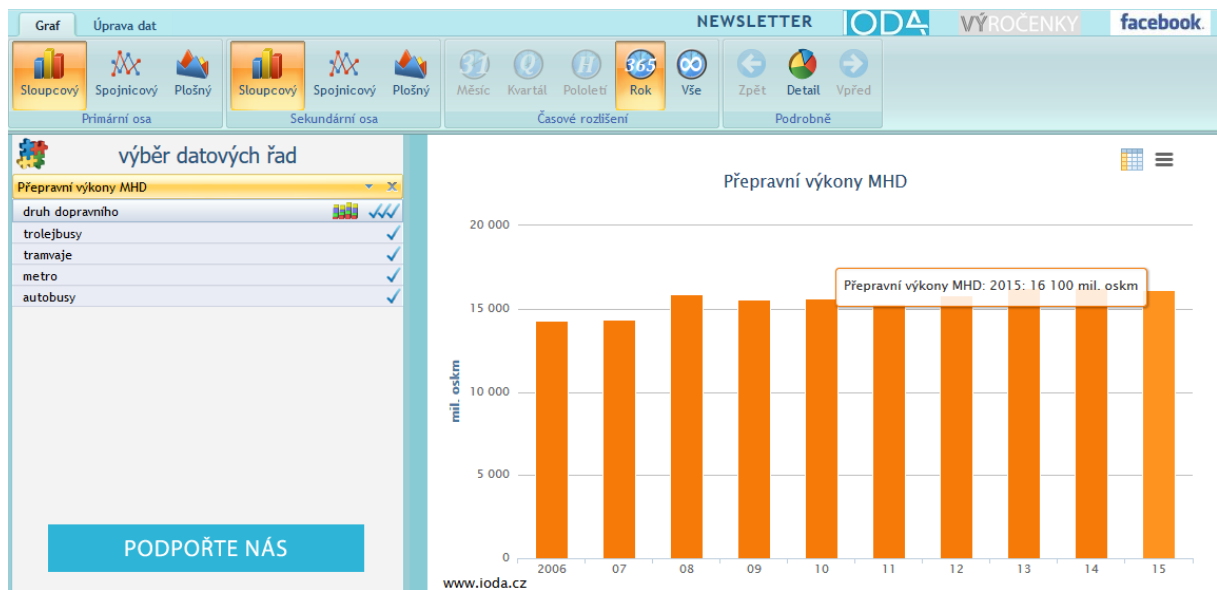
Figure 5.3: Example of IODA results on total performance of city public transport in the Czech Republic (as of 2017-05-28) [22]

restaurants, housing expenses, food prices or public transport ticket prices). It is using price ranges, average and median to express values inserted by different people. This service is used as a data source for some of the global journals all over the world (even those as BBC, The New York Times, China Daily or Forbes).

5.1.3   Main idea and purpose

ETIS aims to be the number one in providing all sorts of public transport information around the world. Its goal is to help public transport organizers in unifying public transport information services and ultimately to reduce the fear of using public transport in unknown location in general and allow users to use the easy to understand system and similar interface for purchasing tickets and finding connection using public transport anywhere.

5.1.4   Objectives

At first stage I select specific data sets to collect to test system on it. Those data are about PT ticket prices. After successful tests I opened the system to my friends and colleagues to test system more deeply and to remove hidden bugs and to improve user experience based on test results. In third stage ETIS is opened and promoted to the Czech public transport system organizers to test it under more users and to collect more data. When completed this stage ETIS will be opened to the worldwide use and its goal is to collect data from mayor world PT systems and its mission is to improve environment in the cities

Rank	City	One-way Ticket (Local Transport)	Monthly Pass (Regular Price)
1	Trondheim, Norway	4.85	78.95
2	Bern, Switzerland	4.02	70.38
3	Hamilton, Bermuda	4.00	61.33
4	Reykjavik, Iceland	3.93	104.88
5	Zurich, Switzerland	3.84	77.78
6	Bergen, Norway	3.84	81.56
7	Stavanger, Norway	3.73	74.63
8	Stockholm, Sweden	3.70	82.14
9	Zug, Switzerland	3.66	59.42
10	The Hague (Den Haag), Netherlands	3.50	70.00

Figure 5.4: Example of comparison of world cities by price of single ticket for local public transport in USD (as of 2017-05-28) [22]

worldwide by helping public transport organizers with easier cooperation, inspiring each other and ultimately to unify PT symbols and user interfaces across the world.

5.2 Technical Details and Used Technologies

In this chapter we will briefly go through the technical background of the ETIS application. Starting with overview of the server where ETIS is running on over basic and advanced web technologies and programing and scripting languages to database where all data are stored in.

5.2.1 Linux virtual machine

ETIS runs on VM Ware virtual Linux machine with Ubuntu 14.04.5 LTS operating system at server called Rumcajs in server room at CTU FTS Horská building B in Prague. It is connected to the Internet using the academic network connection on 1 Gigabits per second (Gbps) line.

5.2.2 Apache

To provide web services, the Rumcajs machine runs Apache2 Hypertext Transfer Protocol (HTTP) server that allows virtual hosts and one of them is also ETIS. Apache2 also supports Secure Sockets Layer (SSL) and Transport Layer Security (TLS) for secure connection of users using certificate issued for Rumcajs server by Trusted Certificate

Service (TCS), formerly known as TERENA of GÉANT (from National Research and Education Networks (NREN)). With this certificate users can easily determine that they visited the real ETIS website over Hypertext Transfer Protocol Secure (HTTPS) (the green lock at the address bar).

5.2.3 HTML

All websites around the world use the same language for the final web page to show, the HTML, currently in version 5.2 [23]. It is so called tagging language where tags are used to mark start and end of specific characteristics as are hyperlinks, pictures or just bold or italic text. They also determine form fields, buttons and all other things you can see on any website. Tags can have also parameters to specify tag functions as is the destination of the hyperlink.

```html
<div class="col-lg-12">
    <h1 class="page-header">
        Welcome to ETIS
        <small>it seems to us that you are here for the first time</small>
    </h1>
</div>
```

Figure 5.5: Example of the HTML code with a predefined Bootstrap class col-lg-12.

5.2.4 CSS

The CSS are used as additional styling files for HTML projects. They change properties of multiple elements which are defined by class name, id or by other property at once. These properties can be for example width, high, visibility, color and many others.

```css
/* google map */
#google-map{
    position:relative;
    margin-top: 50px;
    height: 500px;
    width: 100%;
}
```

Figure 5.6: Example of the CSS code.

5.2.5 Bootstrap

"Bootstrap is the most popular HTML, CSS, and JS framework for developing responsive, mobile first projects on the web." [24]. This framework helps web designers to create web pages that are easy to use for current devices with special focus on mobile devices like

smartphones and tablets. It consists of one CSS file and one JS. Current Bootstrap version is 4.1.0 [24]. ETIS is built using this v4.0.0-beta.2 version of Bootstrap on SB Admin template. It is required to use jQuery JS library when using Bootstrap JS files.

5.2.6   JavaScript

JavaScript is dynamic uninterpreted scripting language which is along with HTML and CSS considered as the core of modern web technologies. It runs at client side and therefore its performance is dependent on the client device. It is supported by all modern browsers and it is required for many pages to work properly. It can change dynamically most of the website content and properties depending on user actions.

```
<!-- Script to Activate the Carousel -->
<script>
$('.carousel').carousel({
    interval: 5000 //changes the speed
})
</script>
```

Figure 5.7: Example of the JS code with jQuery.

5.2.7   jQuery

jQuery is the JS library that aims to reduce amount of written JS code to necessary minimum. It makes programming using JS even easier and it introduce better event handling and also AJAX.

5.2.8   PHP

The PHP is a scripting programming language that runs on the server side and generates final HTML page using standard programing functions, loops and by accessing the database which is its native function. Whole ETIS application is generated by PHP.

```
<div class="col-lg-12">
    <h1 class="page-header">
        <?php lang('Vítej na stránkách ETIS','Welcome to ETIS'); ?>
        <small><?php lang('aplikace pro hodnocení odbavovacích a informačních systémů','Application fo
    </h1>
</div>
```

Figure 5.8: Example of the HTML code with PHP function lang().

5.2.9 AJAX

The AJAX is very important part of dynamic web pages where are some parts of the page loaded separately. For example form select dialogs where data are loaded from database after entering some letters in search field. This is also used in the ETIS for dynamic database search.

```javascript
//AJAX zeme - nacitani dat
$("#zeme").select2({
    placeholder: "<?php lang("Vyber zemi", "Select a country"); ?>",
    minimumInputLength: 1,

    ajax: {
        url: "/page-parts/etis-ajax/ajax-zeme.php",
        dataType: 'json',
        delay: 250,
        data: function (params) {
            return {
                q: params.term // search term
            };
        },
        processResults: function (data) {
            return {
                results: data
            };
        },
        cache: true
    },
    escapeMarkup: function (zeme) {
        return zeme;
    },
    templateResult: formatResult
});
```

Figure 5.9: The AJAX function for loading of the names of countries and theirs international codes based on entered letters into the form field with the Select2 JS and CSS module.

5.2.10 MySQL

MySQL is the SQL database with specific management layer. It optimize search process and creates faster search engine than SQL itself. It is natively supported for communication with the PHP.

5.3 Data Collection

Data collection and presentation are the main purposes of the ETIS. Therefore it is crucial to choose right data to be collected and other data that will help with main data sets interpretation. It is also very important to keep data updated and controlled by people that have access to PT data sources.
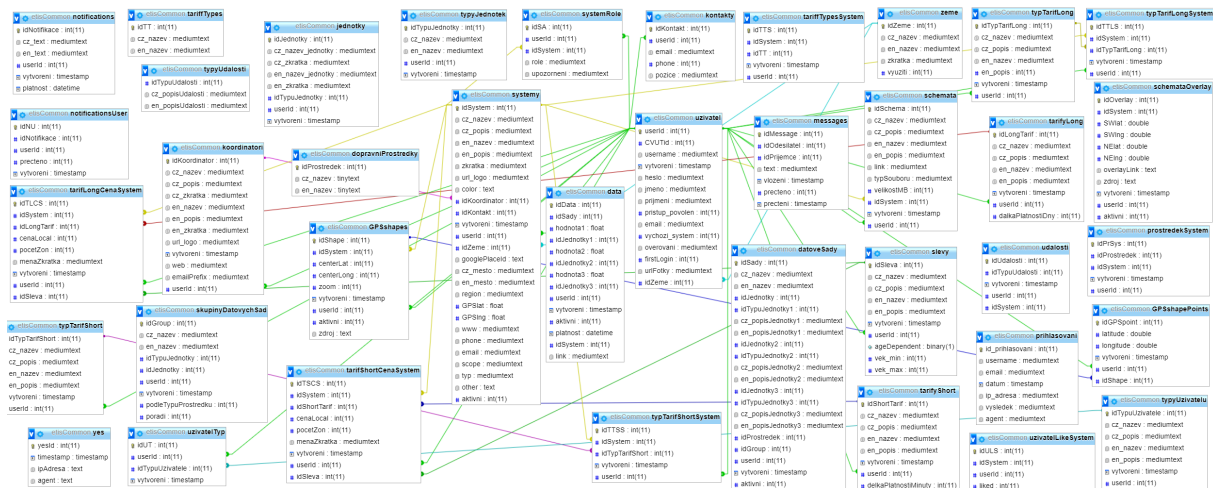
Figure 5.10: ETIS database structure. First draft created using WWW SQL Designer [25], current version redesigned and updated in phpMyAdmin (v4.6.6).

5.3.1 Data types to collect

Each data set about PT is of different kind. Some data represents economical aspects, some demographical aspects, some are just technical or operational details.

Economical data

Economical data are tickets prices, PT service expenses, donations from government, other local prices, Gross Domestic Product (GDP), salaries or Big Mac index. To choose the right data sets to collect is not easy because all represents different point of view on economical situation of region no matter how deeply are connected with transportation. Even such easy to understand thing as is one way ticket could become quite problematic to quantify as they may have different time or zone validity for a different price.

In ETIS we have decided to differ between city zone and regional zones, as city zones are easier to compare (offering comparable scale). When asking users for short-term tickets prices, ETIS also collect information about time and zone validity (zone validity for regional tickets only). User enter the price in local currency. ETIS use the Fixer.io API to convert different currencies when needed (eg. when comparing ticket prices across countries with different currencies). ETIS also collect information about long-term (season) tickets (and of course about time validity). Also sometimes there are discounts for multiple tickets packs (but this is not considered in ETIS yet).

Demographic data

Demographical data represents number of citizens in area of operation and specific groups of passenger as are adults, students, seniors, babies, dogs, handicapped people etc.

Current version of ETIS use only the number of citizens and population density (counted as number of citizens divided by area of operation) to compare systems and create analysis on (data are automatically generated using API of the Gridded Population of the World collection (GPW) version 4 from service area provided by users).

Technical data

Technical data are information about types and model of the tariff. How many zones are in the systems (if any), how many lines are in the system (specific number for all transport means), how many vehicles are in daily operation, if there is a night service and whether is there a special tariff for night lines, if the PT system is operated by private or public company (or by mix of companies). It is also information about where passengers can buy tickets and what kind of tickets are available (for short-term and for long-term). If there is a need of ticket validation or if the ticket is valid from the time it was issued. Also data about performance (travel speed, number of passengers, intervals, etc.) of PT systems are very interesting.

ETIS collects information about means of transport in systems and about the area of service.

5.3.2 Collection methods

Data are entered into the ETIS system by its users or over the API from various online data providers.

User entered data

User entered data are core of the system. Data are entered by users using the web interface. The web application ETIS guide users through the process of entering data quite intuitively and also asks users when entering some data to make them data guarantors. Data guarantor is usually working for the transport company or PT organizer. As for that it is assumed that he can access to up-to-date data at any time. Any user can contact him and ask him for the current data or to check data that may be corrupted or outdated. Also systems send once in a year (or more often if user set up different period) a request to check and update data for systems he care for. By doing this it is ensured that data will not became too old. If some data sets were not checked for a long time, system notify system administrator about it. Anyone can also become a volunteer that will be notified and asked to check some data set if getting old.

Data from online sources using API of various data providers

Some data needed for the comparison and analysis are available online for free using API of various data providers. They offer for example currency conversion (ETIS use Fixer.io), number of inhabitants in certain area (ETIS use GPW, version 4 of the Center for International Earth Science Information Network at Columbia University (CIESIN)), GDP and other often changing local characteristics that can make final analysis better by showing local specific data to compare with and provide better insight look. Yet sometimes providers change some details in their API and therefore to make the function working again requires an action of programmer.

```php
<?php
  $ip = $_SERVER['REMOTE_ADDR'];
  $details = json_decode(file_get_contents("http://ipinfo.io/{$ip}"));
  $mesto = $details->city;
  $kodZeme = $details->country;
  lang('Soudě podle vaší IP adresy ','As you have IP address ');
  echo $_SERVER['REMOTE_ADDR'];
  lang(' jste pravděpodobně z ',' you are most likely from ');
  echo $mesto.", ".$kodZeme;
?>
```

Figure 5.11: Example of super easy to use API of ipinfo.io that provides information about given IP address. ETIS use this API to center maps over user location.

5.4 User interface

Design of user interface of web sites and application makes it either easy to use and user friendly in case of a good design or hard to use and unfriendly. It determines the user experience and makes users to come back to the site or not. Design is therefore crucial for the success of web site or application. Very important is the first look that highly determines the user opinion during first few seconds of the time spent by visit. Using Bootstrap with templates makes it easier to create a good feeling by introducing the same principals of elements composition. ETIS is using Bootstrap template called SB Admin from Start Bootstrap to improve user experience and to make sure that site will be easy to use even on mobile devices with smaller screen than computers and laptops.

5.4.1 Login process

The ETIS web application allows any user to search in its data. But to enter new data or to edit data that are outdated, users have to log in so we can determine who made the change. Anonymous users are not allowed to enter, edit or delete any data. Actually no user can really delete data. Data that are "deleted" by users remains in database

and are only hidden. It is also for security reasons. When someone create fake account and try to damage ETIS database we can find changes he made and revert them easily and ban his account. Account is also required to save user preferences and user made analysis. Login to ETIS is possible in more ways. User can create his own local account by providing his email address. After new user provided required information and clicked on the "Register" button he have to check his email and confirm registration.
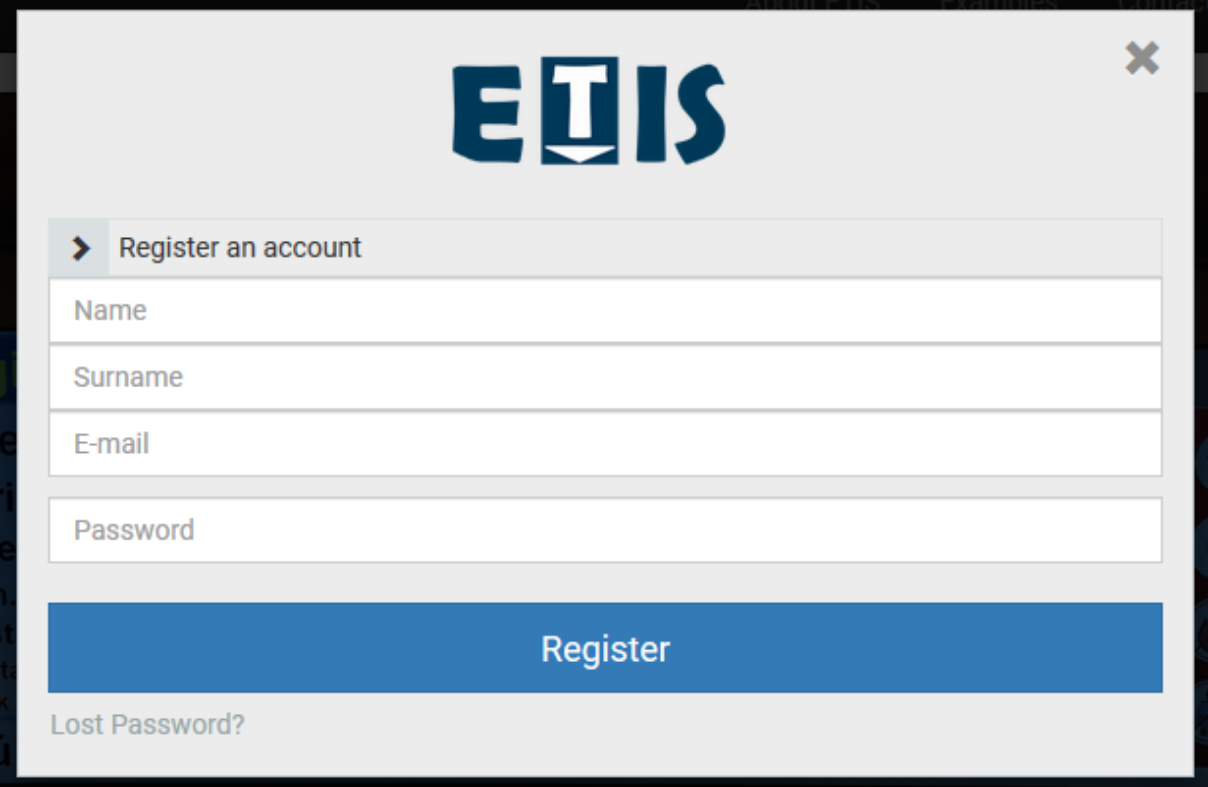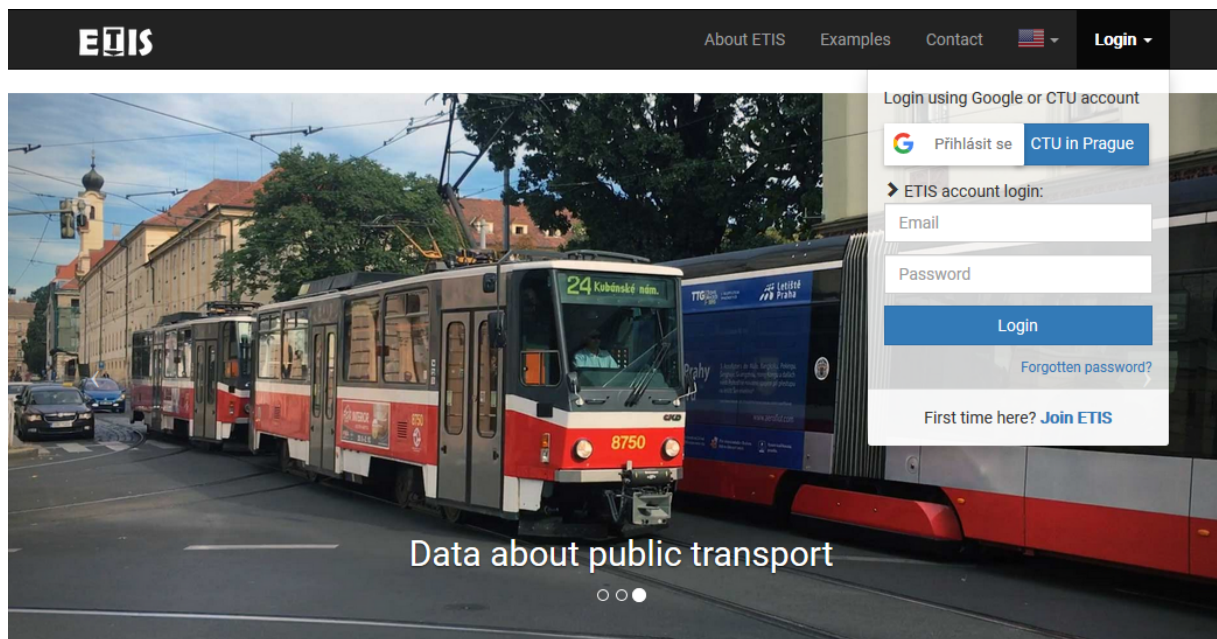

Figure 5.12: ETIS new account registration form.

After registration is confirmed he can login using email address and password he created in the login box on the ETIS home page. Forgotten password can be changed by entering email address into the forgot password form in login box. After sending request for the new password user receive email with unique link to the page where he can set a new password. There is also possibility to sign in using users Google account without need for a new password. Authentication of the user is done by Google API that provides ETIS with required information about user. Also users Google profile picture is passed on and so users signed in using Google have automatically their profile picture from Google account. Last possibility to log in is using CTU account as ETIS runs on the server of CTU FTS and is allowed to access secured Lightweight Directory Access Protocol (LDAP) accounting services (because there are other web applications as is WebTEST that also runs on Rumcajs and are using it).

Figure 5.13: ETIS home page with login box opened.

5.4.2 First login

When user sing in the ETIS application for the first time he is asked to provide some more information about place he lives in, about PT systems he knows or work for and about reasons that leads him to registration. This step can be skipped and user can add or edit those information on his profile page. It helps us to know users better and to know who to ask if specific information is needed to be checked or updated. Its always best to ask local people. In future versions users will have an option to specify visibility for every entered personal information in order to allow better interaction between users.

5.4.3 Data insertion

One of the most important function of the ETIS application is to allow users to enter new data about their PT systems. In ETIS it is done by the most easiest way. Just by filling forms. It is up to users to select which data sets he have and want to insert into the system. I have designed ETIS application to be as intuitive and user friendly as possible and therefore all data can be entered in the local units. For example entering prices of single or long-term tickets in public transport for Prague is much easier if user can just
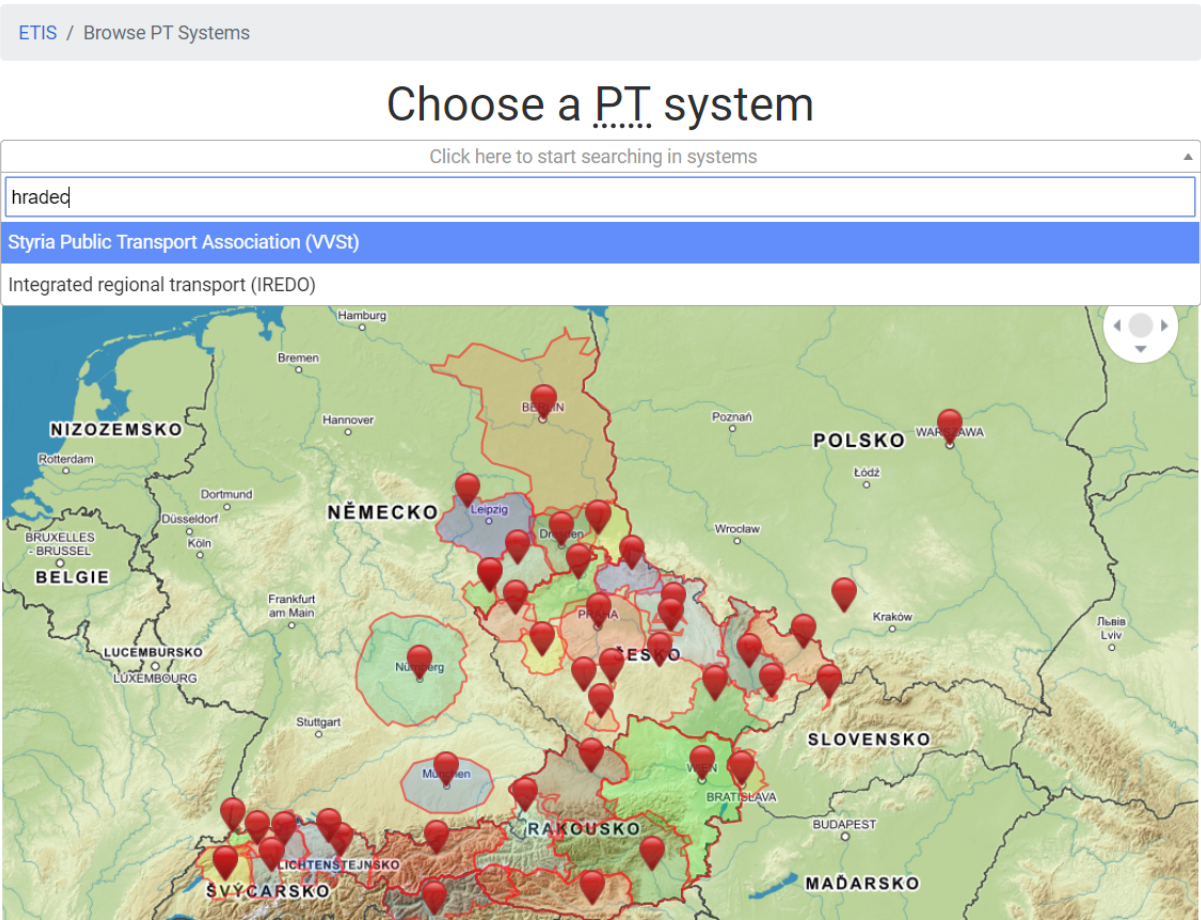
Figure 5.14: ETIS allows users to select desired PT system by choosing in the map or by intelligent search input above. User can also choose between Google Maps and Mapy.cz map service.

write the same number he see on the website of the public transport organizer and enter them in CZK (local currency - the Czech koruna) and don't have troubles with currency conversions. It also provides ETIS with more precise values as local price doesn't change frequently. ETIS then provides precise information as it converts current values as of the day user make his comparison or analyses. The same applies for other units (like SI units to Imperial and US customary measurement systems) ETIS have conversion APIs to.

5.4.4   Analyzing the data

ETIS offers various data analytics options and tools. User can view and compare data in tables or various charts. ETIS is using Google Charts API and therefore charts are very nice and dynamic. User can hover ever chart to display values of selected bar or other part of the chart (as can be seen on figure 6.1). This can be done with almost all charts in ETIS. Possible charts for analysis are various bar charts, pie or donut charts, histogram and area charts. Google offers also geographical charts and other interesting charts which

Figure 5.15: Form for inserting of the data into ETIS database (step 1 of 6). User enter the name of the city only, the rest is done by Google Places API. ETIS also check if there is a PT system in the city already.

can be implemented into ETIS in future versions.

5.4.5 Data interpretation

To interpret ETIS data observed and compared by user properly it is very important to give them meaning. Prices across the world can be converted into single currency (doesn't matter whether it will be finally USD or EUR) and compared together. This makes sense as long as the result is absolute value that means where it is expensive or cheap for the one who compares it. Yet is says nothing about how expensive tickets are for local citizens. We need to add some local value as is GDP or price level to determine how big part of family monthly income is payed for transportation (usually compared to the price of season long-term tickets).

5.5 API for other applications

In the save way as ETIS can access data of current currency conversions or metric to imperial units and other sources there will be also API for other applications to access data from ETIS in future versions. Unfortunately this feature is not implemented yet.

Figure 5.16: Form for inserting of the data into ETIS database (step 2 of 6). In this section users enter detailed basic information about system such is ticketing type, possible means of transport in the system or range of service. System also checks some fields dynamically, for example it shows you notification if you use the same abbreviation as some other system in ETIS already have.

6

Analysis of Public Transport Systems

6.1 Introduction

If we would like to understand the complexity of the PT systems, we have to look carefully into the past to see the motivation of our predecessors. They have created PT systems accordingly to possibilities and tools they had. Now we are often very surprised why are some components of PT so complicated, but we have to realize that there was always a reason for each single element. We need all the available information about current situation and from the past to make an informed decision about future development.

6.1.1 Evolution of PT systems

The oldest PT system as we understand it in nowadays Central Europe was the german Hamburger Verkehrsverbund (HVV) (English: "Hamburg Transport Association") established in 1966. It was founded by the carriers - urban transport services of Hamburg, german railways, ferry and ship operator and local bus operator in the region. Since 1996 it is owned by public transport authorities (PTAs) of the Free and Hanseatic city of Hamburg (85.5%), the State of Schleswig-Holstein (3%), the State of Lower Saxony (2%) and the Districts Herzogtum Lauenburg, Pinneberg, Segeberg, Stormarn, Harburg, Lüneburg and Stade (9.5%)[26].

The principle of one ticket (and one subscription) for all carriers and all modes of transport as an answer of public transport systems to growing mobility needs and congestions in individual transport inspired other cities and agglomerations in Germany and neighbouring countries, with german speaking in front of the others. As the responsibility for operating regional trains passed from central governments to regions in Germany

and in the EU in 1990's and tenders for train operating companies went on, the systems owned by the carriers were restructuralised and nowadays they are usually owned by local government - the public transport authorities (PTAs). Their function in responsibility for the tariff system and for the optimisation of service ordered and subsidized is usually combined.

Most of the systems studied have undergone development from integration of city and suburban transport to the integration of the entire adjacent territory. Loss of the natural single center has often forced transition from the centric system to semi-centric, cutting circular zones to "pie slices", and zones systems. An example might be Austria, which was the world's first ever country completely covered with transportation authorities since 1997. Although they were created in the same period, the 6 systems of the individual austrian regions are quite different. The most advanced system in the region of Vienna recently dropped down the semi-centric zones and switched to a modern zones-relational system, where passenger does not have to count zones anymore and still gets all advantages of ticket integrations between transportation modes and carriers.[27]

The limit for the deployment of modern systems was that of ticketing systems and adherence to paper tickets. Even the e-ticketing solutions were designed only as their paperless versions. Now it is possible to hide the function in the background and offer the passengers naturally understood tickets from A to B (already as zones), including full range of one-way tickets and subscriptions and enabling check-in/check-out systems of the future. Recent systems for larger regions are usually based on zones-relational tariff system.

6.2 ETIS based analysis

ETIS offers various options of data analysis and visualization of results. Analysis in ETIS are made on the data collected in the database as well as data provided by other services through their API. ETIS user can compare data sets in tables and create bar charts and visualize them in the map. There are data sets that contains information about short-term and long-term (season) ticket prices divided into city zone and region validity, technical data as are numbers of stops, track lengths of track based means of transport and number of vehicles, socio-geographic sets as population density, number of citizens in area of PT operation and surface area and operation data as is the transport performance number. Examples of usage and visualizations are in figures 6.1-6.5.
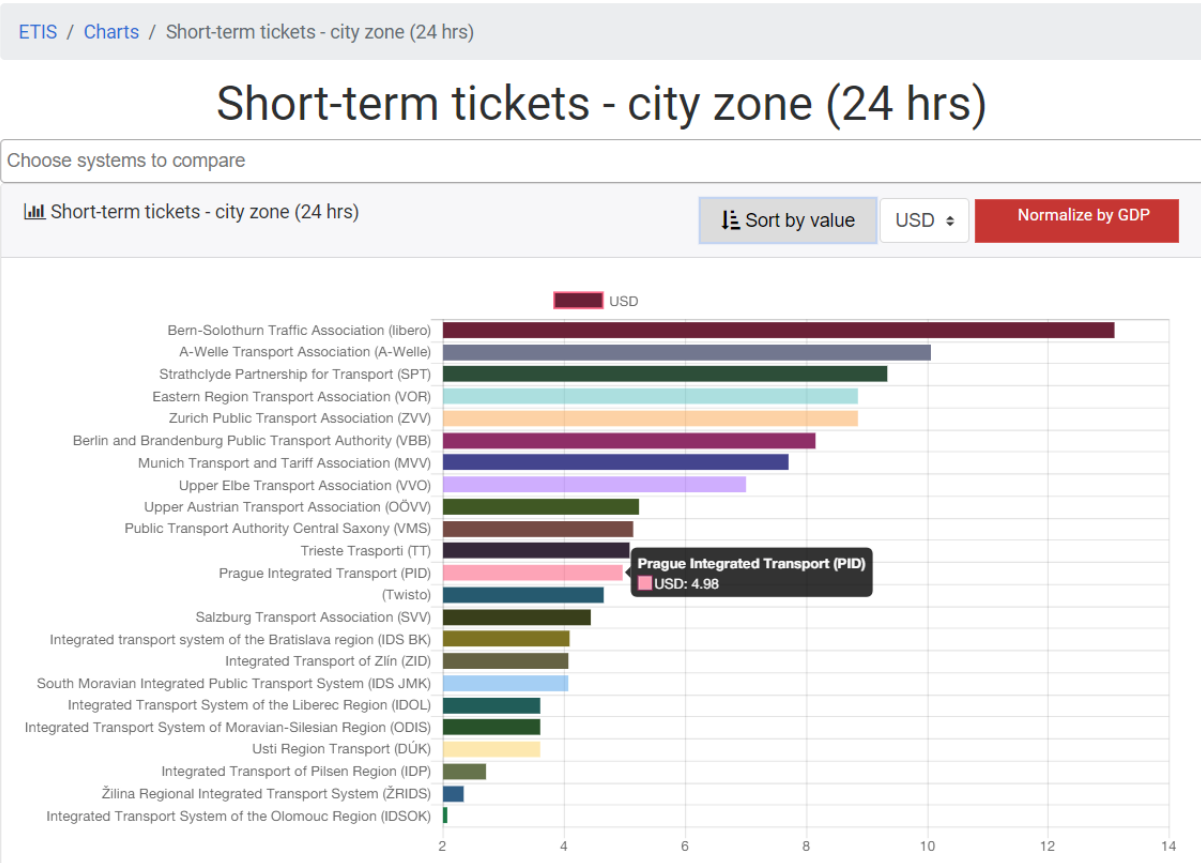
Figure 6.1: ETIS analysis results as a bar chart for comparison of day (24 hours) ticket prices (converted to USD) in various PT systems made using Chart.js.

6.2.1 Ticket prices comparison

ETIS analysis results as a bar chart comparing the day (24 hours) ticket prices (converted to USD using Fixer.io API) in various PT systems can be seen on figure 6.1. The same analysis but enhanced by GDP of country per capita gives us an overview on how many tickets can average citizen buy with year income (simply said). We can see that Strathclyde Partnership for Transport (SPT) 24 hours ticket in not only expensive in absolute value, but also expensive for locals. Even the higher GDP of Great Britain cannot compensate the difference. On the other side of the chart the same ticket in IDS OK is cheap and available also for locals. In figure 6.3 we can see that analysis results can be also visualized in the map. In this example we can see the month ticket prices (in EUR) comparison across Europe. We can see that most expensive month tickets are in Germany and Switzerland.

6.2.2 Visualization of tariff zones on the map

ETIS allows users to upload and place tariff plan of integrated PT system as an overlay on online map services (Google Maps and Mapy.cz). In figure 6.4 we use Google Maps
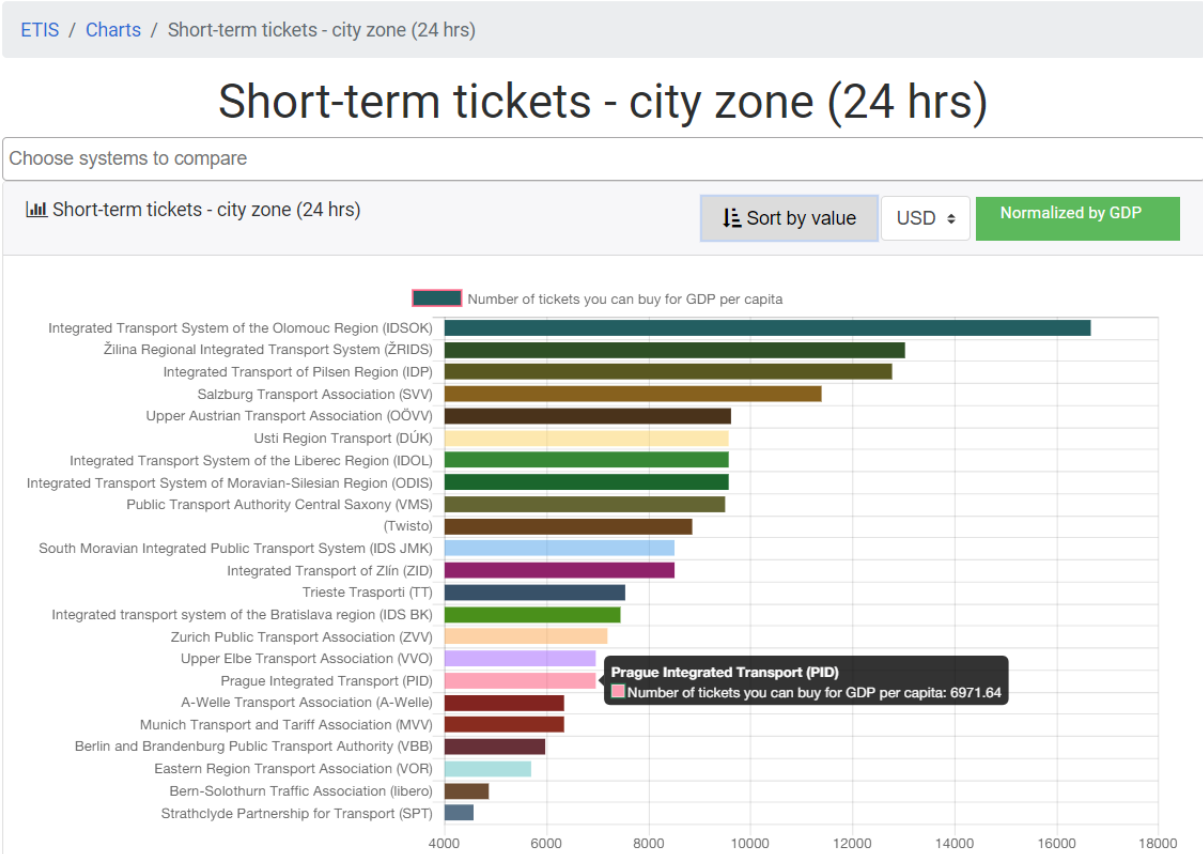
Figure 6.2: ETIS analysis results where GDP of country per capita is divided by the price of day (24 hours) ticket.

with edited styling, so tariff plans are nicely visible. User can now see how are tariff zones different in every PT system. This is the comparison that is available in one place for the first time in history.

6.2.3 Multiple data sets analysis

ETIS allows users to create their own analysis by combining multiple data sets together with some basic mathematical operation as is multiplication or division. In figure 6.5 we have created the total number of stops to area ratio. That represents quality of coverage by PT.

6.3 Quality standards

According to [28] the PT quality standards are enforced and controlled with following requirements and parameters:

- Frequency of connections
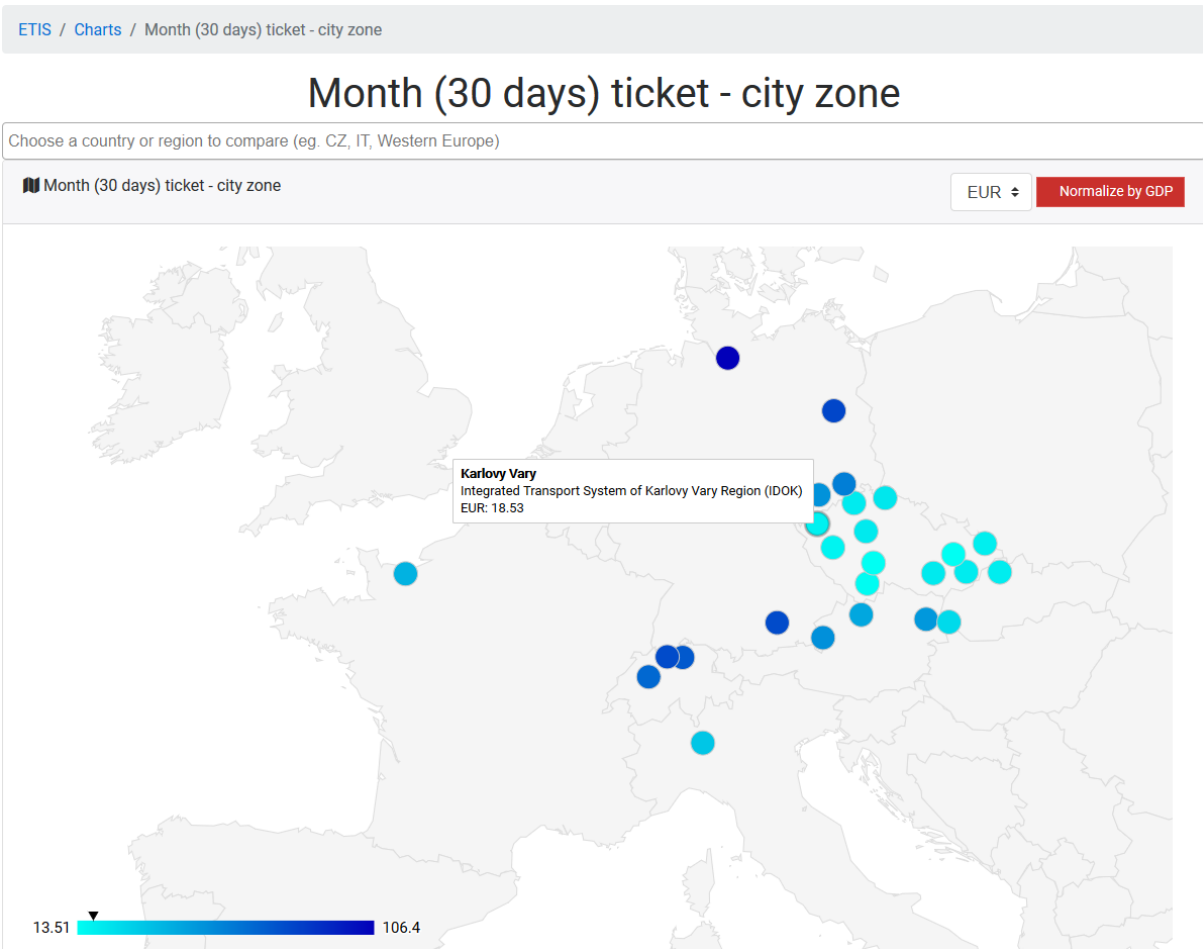
Figure 6.3: Map visualization of the analysis results. In this example: month ticket prices (in EUR) comparison across Europe.

- Availability of public transport in the territory - distance to stop

- Requirements for vehicle equipment

- Requirements for stop and stop signs equipment

- Passenger handling, sales and design of travel documents

- Timetable appearance

- Guarantee of connections, waiting times and dispatching management

- Operational backup, outages and traffic restrictions

- Transport performance

ETIS capabilities for the quality analysis

ETIS offers for example the number of stops to area ratio as an availability of PT in area value 6.5 and data sets with ordered transport performance. ETIS is also ready to handle
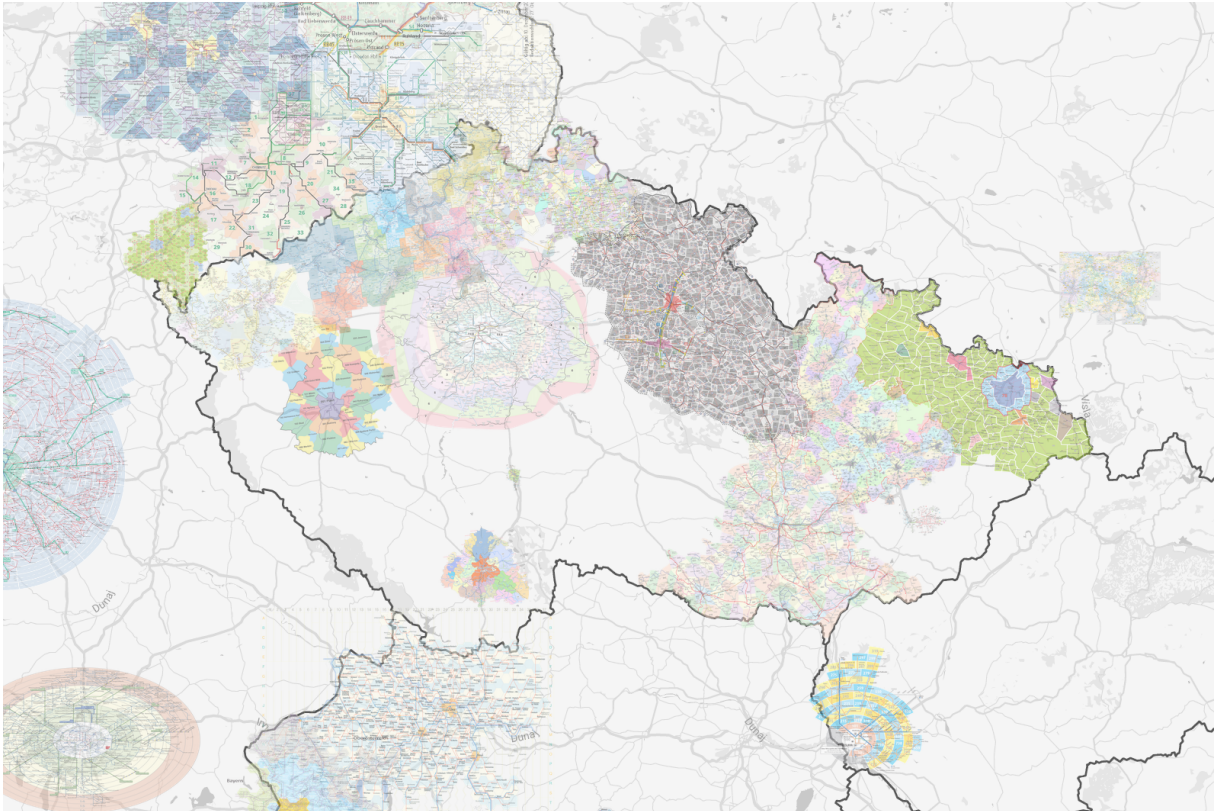
Figure 6.4: Visualization of tariff zones on the map. Google Maps with edited styling, so tariff plans are nicely visible

other data about PT quality. The only needed action is to set up new data set category. Then new data sets can be easily added by users and data input fields will appear in all systems.
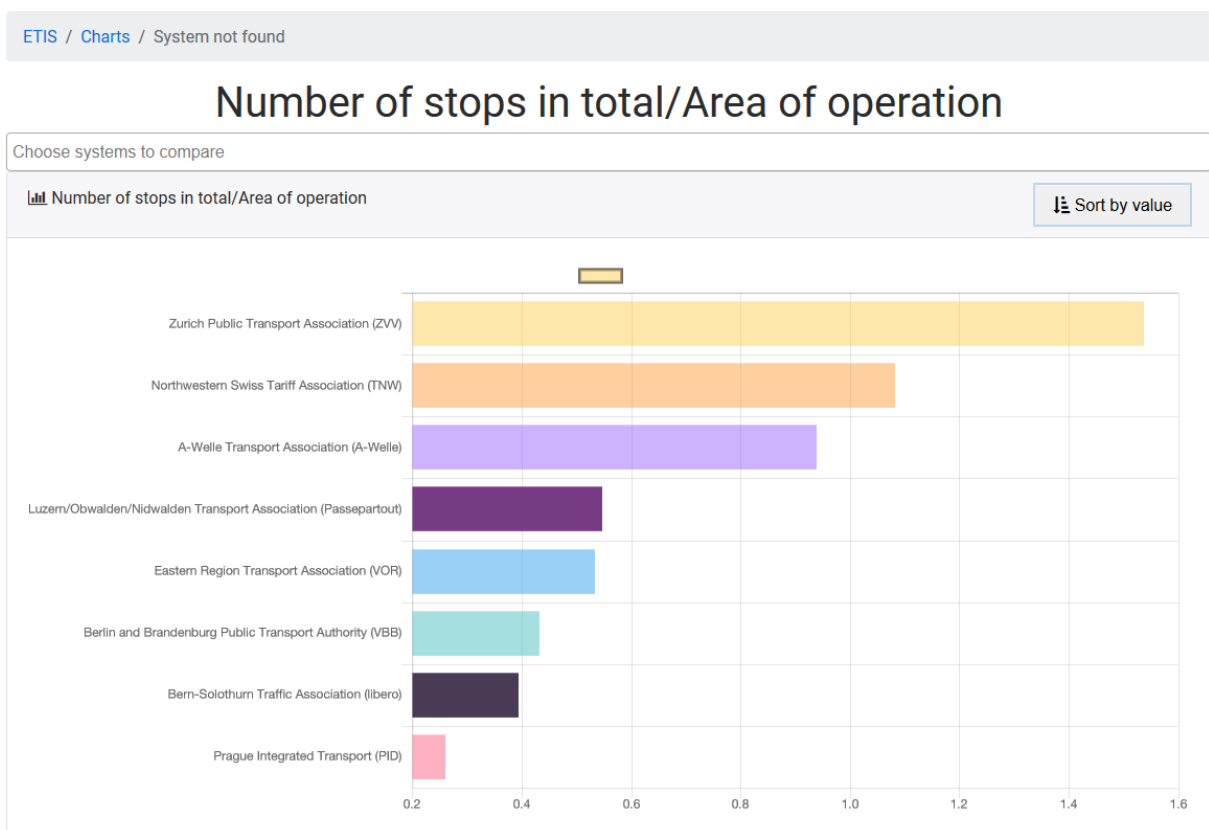
Figure 6.5: Multiple data sets analysis, the total number of stops to area ratio.

7

Recommendations for the PID System

> *"The state-of-the-art streetcar... has the potential to generate over \$US 25bn of economic impact for our city over 30 years.."*
>
> – Bill de Blasio, *mayor of the city of New York*

The Prague Integrated Transport PID is one of the most impressive systems I have ever seen. Prague is sometimes also called "The thirty minutes city" as you can reach most of the locations from any place in the city within thirty minutes (with some exceptions, of course). Metro lines are very good backbone for the PT. Tram lines are quite dense and with very short intervals. Bus lines serves mainly out of the city center, yet passengers have usually more options how to get to their destinations than just one line.

7.1 Simplify the tariff

The main disadvantage in PID system is complicated tariff with absurd amount of exceptions (it is 189 A4 pages in total)[29]. Typical example is SMS ticket. It is valid in Prague city zone only, it cannot be used in trains nor outer zones and zones B and zero. In the past SMS tickets were also invalid on ferries, but this exception was canceled recently. The same restrictions applies for tickets from the smartphone application Sejf (unfortunately this application is not developed nor provided by PID authorities and sales over it are negligible). Another exception is that most tickets are valid for most lines apart from line Airport Express (AE) which runs from the Václav Havel Airport Prague to the Prague main railway station and back. AE is operated by DPP for the National Czech Railway Company as a commercial line, yet PID tariff applies, but all regular tickets are not valid on this line.

Other tariff complication is city zone of Prague which consists of zones P, 1 and B. Moreover zone P is considered as doubled zone. So in total city zone of Prague consists of four zones (mixed together as P is for all city lines no matter where they are located, zone 0 is in central Prague used as start or end zone for suburban lines and B is on the border of the Prague city zone valid also only for suburban lines making border between Prague and outer suburban zones). When traveling in Prague, those zones cannot be accessed separately and also tickets up to three zones are not valid in Prague city zone (unless traveling from outer zones ending in B or 0). This makes sense for inner needs of PID officers and organizers, but when trying to explain this to non-frequent passengers or tourists usually ends up in very confused expressions. It is crucial to allow passengers to travel with ease and allow them to select ticket without deep knowledge of tariff (eg. ease to use tariff calculator).

7.2 Redesign of short-term tickets

As you can see on figure 2.8 all short-term tickets have not only time validity but also limitation by number of zones. Typical argument for this limitation is that it is not fair that passenger that travel 60 kilometers by suburban train for thirty minutes will have cheaper ticket than other passenger that travel just 30 kilometers in the city using slower means of transport (trams, city bus, etc.). He will pay more because he will travel for example for forty minutes. Therefore he will be punished two times - by having slower transport and by paying more. Yet I think that it will not make that big difference as most of the passengers from suburban trains continue by slower means of transport throughout the city as most of them doesn't work directly at railway station. But in the world where most of passengers have smartphones with some application that can search PT connection it is more suitable (especially for tourists) to have only time limited short-term tickets that are valid for entire network or to allow passengers to buy a ticket designed for their journey from stop A to stop B (smartphone application will calculate the price based on the tariff).

Long-term tickets should keep its zones validity as it is more expensive to cover wider area on regular basis.

7.3 Redesign the way most passengers buy tickets

In today's world paper ticket design is outdated. In current situation when most of payments in shops are done by contactless payment cards (72% in 2016) [30] and cash is about to be abandoned in some countries in near future it doesn't make sense to force

people to search for vending machine or keep some paper in pocket that can be lost easily. The mobile internet penetration among population is rapidly rising (in Prague 54,6% of population (from ČSÚ via [31])) and moreover some stops and vehicles are equipped with Wi-Fi internet connection for public use. Considering that, it makes only sense to redesign tickets and make them paperless. For example in Ostrava Region (ODIS) were more than 75% of all tickets paperless two years ago [32]. Passengers should have possibility to buy ticket in smartphone application or to use contactless payment card directly in vehicle without need for keeping any easy to lost paper. In Ostrava region, there is a possibility to just check in terminal with contactless payment card and use it as a ticket. It also keeps information about how have you traveled and charges you accordingly. When you use more connection a day, it charges you at the end of the day for the day ticket price. You can also check in and check out if passing only few stops to get lower price for short travel ticket [32]. Smartphone application should offer passengers choice between two kinds of tickets: ticket for known journey from stop A to stop B and time based tickets. The A to B ticket should be based on the connection search (no need for zones knowledge) and should offer to enter stops in the middle (passenger could need to stop by somewhere) and the return option to get better price. Time based tickets should be of two types: with previously known time period and open one, which will charge passenger after he stops the validity period manually or by reaching maximum time he set in advanced (this option is needed if he forgot to stop the validity period). There can also be the option to choose area of validity manually by swiping finger over map in the application and to create personalised ticket for each user, respecting his needs. Current smartphones have even the locality management services and therefore smartly designed application can notify user of exiting the area he purchased ticket for or to allow open time based ticket to charge by zones visited during validity period. Of course there can be situations that can cause troubles with this option active (like exiting the city with some express train while still having this option active can charge user for all zones accidentally).

7.4 Open the data and allow others to create more PT applications

Recent development in personal banking introduces the new approach based on the Payment services Directive of the EU. That forces EU operating banks to allow other banks and licensed providers to access data from internet banking of their customers that allowed access to it to remotely control their accounts. Result is that any bank customer can control all his bank accounts in various banks from one internet banking of one bank of his choice [33]. The same principal can be applied also to connection search and ticket

sale in PT. I suggest PT organizers to open the data, allow other subjects to use them and create API to access ticket sale environment. Map services providers like Google or Mapy.cz will surely welcome this option to allow not only connections search in their maps, but also to allow users to buy tickets directly without need for some other application. Also current connection search engines will use this API for sure. Maybe there will be even some startup companies that will offer their own solution. Pubtran can be named as an successful startup example from the past - it succeeded even there was nearly monopolistic IDOS application just by introducing new approach, combining city, regional and interregional connection search together.

8

Conclusion

8.1 Summary of the thesis

In this thesis I have summarized the information systems used in PT and ways of informing passengers before the trip in planning phase when passengers decides whether to use PT or individual transport, informing when they wait for their connection at stop and during their journey on board of PT vehicles. I have also summarized tariff models and variants of ticketing options available. All of this was first described on the example of PID system in Prague, the Czech Republic capital. Then I have briefly compared Prague information and ticketing systems to others around the world. Examples were taken in Brno (CZ), Bratislava (SK), Trieste (IT), Helsinki (FI) and other places. Collected and described information was used to design a web application ETIS, which was the main objective of the thesis.

8.2 Fulfillments of targets

According to guidelines I was supposed to meet four targets.

First was to design web-based system for collecting, storing and analyzing information about PT ticketing and information systems. This goal is achieved by creating ETIS available on the WWW on the address https://etis.fd.cvut.cz/. It is not only capable of collecting and storing user entered data, but also uses some other data by accessing them over APIs of other online data providers. It allows users to browse data sets available on ETIS, compare them in tables, make charts based on the data sets and even create a map based comparisons.

Second goal was to fill the system with the data of at least 20 cities or PT integrated systems. This goal is achieved as there are some data collected about more than 50 PT systems by the day of submission of the thesis. There may be even more data in the

future entered also by other users.

Third goal was to compare some of the collected data and create analysis of PT systems quality. Whole chapter 6 describes usage of ETIS and provides examples of analysis made using ETIS. Amount of data in ETIS database is capable to provide users usable overview on desired topics. There is also brief excursion into quality of PT systems.

Fourth achievement was to make suggestion for one of the compared systems to improve it on basis of the analysis results. I have made some recommendations to the PID system in Prague. The most important is to revoke zones validity for the short-term tickets as they have also time validity and therefore it is not necessary to complicate tariff for Prague visitors and tourists by having zones validity for tickets you are already limited by time. To attract more people into the PT it is necessary to make it as easy to use as possible even while making some unfairness. By trying to be as fair as possible PT organizers created such complicated tariff with lot of exceptions that it is very hard to fully understand it and that results in frightening potential passengers. I also recommend PID to focus more on the state-of-the-art ticketing options as is system wide usage of contactless payment card for the easiest passenger on board or at stop check-in and smartphone application where passengers can buy tickets just by tapping the screen (without necessity for having active premium SMS service) while paying by payment card online (with already saved details) or from credit already transfered to his account. Another improvement is to open the data for other companies - there are plenty of startups that will do some work better than city or state owned company and maybe if there will be more smartphone applications to buy PID tickets in and that will offer PID account management passengers will choose application that suits them best and competitive environment will make better service for lower price.

8.3   Further extensibility and recommendations

ETIS application have a great extensibility potential. It may offer more and more data sets as number of users is growing. Yet it needs to keep its super easy to use interface to keep the users satisfied. It can be also interconnected with more online data sources. Also there is a potential in offering social media services to more interconnect public transport organizers and allow them to better and faster exchange information.

As a good communication platform there is possibility to introduce a blog section where public transport organizers can share their ideas on newly installed innovations. Blog will also offer comments under each post so users and other professionals can say what they think of the posts and innovations. Those discussions will offer much faster way of idea spreading then specialized conferences that take place only once in a some

time and not all people that are interested in are able to attend (for example they are from the opposite side of the earth and it would be hard to explain conference expenses).

It would also make sense to create an open software section. Most of the PT system around the world are operated by publicly owned companies. Therefore it would make sense that every piece of software their programmers programmed will be licensed free and available to others. By this way information systems in PT should become more united and more unified. It is not a new idea, in current world of software engineers there are plenty of source code sharing services and lots of software developers share their codes. The greatest example is GitHub with more than 22 million developers in more than million teams that are sharing more than 59 million open source repositories worldwide [34]. It should be possible to introduce the PT developers team on GitHub that will share and consult their project also using ETIS. There is also Stack Overflow that helps programmers in sharing knowledge and helping each other in case of getting stuck. ETIS can also become a platform to exchange information.

By collecting enough data ETIS can find the best samples and examples of PT information systems across the world. Either by popularity of solutions monitoring or by opening a voting of the best system. After selection of the best system ETIS can be considered to become a global authority for PT information systems standardization. It would be very nice to have global standards for information systems in PT. This idea is inspired by telecommunication standardization that is lead by 3GPP (The 3rd Generation Partnership Project) that is created by seven united telecommunications standard development organizations. They create standards that affects our daily lives as there will be no unified fast internet connection in our mobile devices all across the world (3G and 4G LTE are telecommunication standards made by 3GPP).

8.4   The ultimate goal of ETIS

There are thousands of cities around the world which provides PT service to its citizens and visitors. All of them face daily the same issues and are creating various information systems, tariffs, smartphone applications and other systems for informing passengers and charge them for the service. That is tremendous, the amount of man power that have to develop the same things. It is in total wasting of lives of hundreds, maybe thousands of people working in the software development designing those systems. If PT providers would be united, they will need only one worldwide PT information system to develop together. It would have cost tiny fraction of public money (as most of the PT systems runs on the money from the government or cities) that is being wasted on developing the same things over and over again in cities all over the world. United PT interfaces,

tariff system and information systems for passengers will also help to promote PT to more people and to decrease of the fear of unknown while traveling to different cities. And that is the final goal of the ETIS.

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