Design and Implementation of DATEX II common model for truck parking systems

MASTER’S THESIS

2016 Angie Nataly MELO CASTILLO
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- State of the art which contains the technical and theoretical background from parking systems and DATEX II.
- Methodology definition and specification.
- Desing of a DATEX II common parking model based on profile extensions for each type of parking.
- Analysis and design the architecture solution for truck parking system and its detailed specification.
- Development and implementation of the system, specifically the software part developed.
- Evaluation of case study and its results.
- Conclusions and future work.
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Master’s thesis

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I hereby declare that the presented thesis is my own work and that I have cited all sources of information in accordance with the Guideline for adhering to ethical principles when elaborating an academic final thesis.

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In Prague on 31st May 2016

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Czech Technical University in Prague
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Abstrakt

Standard DATEX II hraje významnou roli při zavádění ITS se zaměřením na výměnu informací. Poskytování informačních služeb pro bezpečná a chráněná parkovací místa pro nákladní dopravu je jednou z prioritních akcí Evropského akčního plánu pro ITS. Cílem této práce je využít DATEX II jako standardizovaný způsob komunikace a výměny informací o parkování. Práce obsahuje identifikaci problému, výzkum použití DATEX II a analýzu a návrh tří DATEX II profilů pro parkování. Navíc, tato práce zahrnuje návrh a implementaci informačního systému pro sdílení informací o parkování, který je vyhodnocen prostřednictvím případové studie. Scénáře studie zahrnují dynamické a statické informace o parkování, transformační proces do DATEX II a proces výměny informací.

Klíčová slova  parkovací systémy pro nákladní dopravu; DATEX II; systémy výměny informační; profilování

Abstract

Standard DATEX II has important role in the implementation of ITS focused on traffic information exchange. The provision of information services for safe and secure truck parking places is one of the priority actions of the European
ITS action plan. The aim of the thesis is to utilize DATEX II as standardized way for exchanging truck parking information. The work includes problem analysis and identification, research of DATEX II uses and analysis and design of three DATEX II profiles. In addition, this thesis includes the design and implementation of an exchange information system which is evaluated through a real case study. The scenarios of the case study cover dynamic and static parking information, transformation into the DATEX II and the exchange information process.

**Keywords**  Truck parking systems, DATEX II, exchange information systems, profiling
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Chapter 1

Introduction

Nowadays, the Intelligent Transportation Systems technologies for gathering traffic information use several kinds of data forms, contents, sources and formats; it make the integration and interoperability between systems more difficult. These heterogeneous data sources are becoming a challenge for harmonization and standardization of data and exchange services, generating the need to create a standard for regulation. In light of this, DATEX II has been developed to provide a standardized way of communication and exchange of traffic information between traffic centers, service providers, traffic operators and media partners. This thesis focuses on the design and implementation of a common DATEX II profile for truck parking systems.

1.1 Problem statement

Secure parking places for trucks and commercial vehicles have been listed as a top priority in the ITS Action Plan and the ITS Directive 2010/40/EU [9]. In fact, European truck drivers need to have appropriate information on safe and secure parking places in order to guarantee the road safety and efficiency of logistics. Consequently, there exist regulations which support the safety of truck parking places, avoid reduction of driver’s attention due to lack of sleep and improve driver’s working conditions. The regulation EC No 561/2006 provides a common set of European Union (EU) rules regarding driving time and rest periods, the following are the most relevant rules established [10]:

- Daily driving period shall not exceed 9 hours, with an exemption of twice a week when it can be extended to 10 hours.
- Total weekly driving time may not exceed 56 hours.
- Total fortnightly driving time may not exceed 90 hours.
- Daily rest period shall be at least 11 hours, with an exception of going down to 9 hours maximum three times a week.
1. Introduction

- Daily rest can be split into 3 hours rest followed by 9 hour rest to make a total of 12 hours daily rest.

- Breaks of at least 45 minutes should be taken after 4 hours at the latest.

![Figure 1.1: Total offense rate per 100 working days checked in the EU [1]](image)

Truck drivers are often confronted with insufficient number of parking facilities, as a consequence they often park in non-secured zones or unsafe locations like hard shoulders, exposing themselves and other road users to potential thefts and high risk of accidents [9]. In light of this, enough parking areas are needed and these areas should be adapted in terms of capacity, security and safety. In 2007 the EU carried out a preliminary study which determine an investment of 1.2-1.5 billion euros until 2020 on the Transeuropean road network (TEN-T). Likewise, significant and constant offenses have been detected, the report from the European Commission (EC) in 2011-2012 presents the total number of offenses detected per 100 working days (see Figure 1.1), comparing with the previous reporting period, in 2011-2012 the average rate of offenses detected declined significantly by 22% and equaled to 2.43 offenses per 100 working days [1]. The categories of infringements detected at roadside and premises are distributed between breaks, rest periods, driving time, driving time records, recording equipment and lack of records from other work (see Figure 1.2).

As a consequence, the EU is active to improve these conditions and recognizes a group of key aspects to achieve this goal: overall capacity of truck parking areas needs to be increased and the current capacity needs to be optimized through digital information. Besides, public or private parking operators and service providers shall share and exchange data related to safe and secure parking areas through a national or international access point. The exchange information process have to be done in the DATEX II format [9].

DATEX II is a standard which provides a standardized way of communicating and exchanging traffic information between traffic centers, service
1.1. Problem statement

Figure 1.2: Categories of infringements detected [1]

providers, traffic operators and media partners. The DATEX II data model is a key component which allow to describe data and is composed by packages, classes, attributes, enumerations and data types. The overall number of instances within the model is 2729 and they are distributed as can be seen in the figure 1.3.

![Figure 1.3: Number of instances of different types of the model [2]](image)

Nevertheless, this model does not allow to describe deeply parking places and neither truck parking places. As a consequence, the parking publication extension was created and more than 200 attributes and 400 enumerations have been added. It took into account a group of comprehensive requirements from different fields: Urban parking, rest areas and truck parking. Due to the
size of the DATEX II data model including the parking extension, it is necessary to tailor and profile the model for particular applications. Furthermore, it is important to highlight that traffic information systems usually require only a small part of the data model [11].

1.2 Motivation

Nowadays, DATEX II plays a strong role for implementing integrated ITS in Europe, being an important component of the exchange information process. The main motivation is to use properly the standard and take advantage of it for providing truck parking information services. As was mentioned above, profiling the DATEX II data model is needed. Several profiles can be created having in mind different users needs and focusing on what is strictly required or what gives useful information about truck parking places. The thesis is also motivated by the fact of use the DATEX II profile tool and provide quality information about truck parking places for logistics, planning and safety on the road.

1.3 Objectives

This thesis takes advantage of DATEX II to solve some of the truck parking problems mentioned above. The main objectives of the thesis are mentioned below:

- Analyze, design and implement DATEX II profiles for truck parking systems based on the parking publication extension and different levels of information.

- Analyze, design and implement a data exchange platform which provides parking data services regarding to parking data publication, consumption and transformation.

To accomplish these goals was necessary to include the following specific goals:

- Research and analyze the technical and theoretical background of DATEX II and its implementation around Europe.

- Analyze parking extension publication, identify and classify its attributes in three levels of specification. From minimum data coverage to complete data coverage.

- Compare the parking extension proposed profiles against the existing parking extension profiles from other countries.

- Analyze, design and define the system architecture for the data exchange platform.
1.3. Objectives

- Implement the data exchange platform which main responsibility is the transformation of data to DATEX II format.
- Evaluate and analyze the results of a case of study.
2.1 DATEX II general overview

2.1.1 Background

"DATEX II is a standard designed and developed as a traffic and travel data exchange mechanism. It has been developed to provide a standardized way of communicating and exchanging traffic information between traffic centers, service providers, traffic operators and media partners" [12].

Figure 2.1: Datex II usage over Europe [3]

The development of DATEX II begun in late 2003 supported and funded partially by European Commission. At the end of 2006 was produced the first version and it was disseminated among countries which started to implement
2. State of the art

The first implementations have had some mistakes and as result was necessary to request for changes of the standard [3]. Then, European Committee for Standardization (CEN) through the standard CEN/TS 16157:2011 defined a stable version 2.0 and subsequently, some researches and implementations have contributed to improve DATEX II and developed the current version DATEX II 2.3.

DATEX II is playing a strong role in the implementation of integrated ITS in Europe and is widely used within European states (see Figure 2.1). The main usage areas includes:

- Network management and traffic management planning
- Lane or line control systems
- Car-to-infrastructure systems
- Multi-modal information systems

"For all theses domains DATEX II pays special attention to interoperability issues resulting from the need for multiple operator cooperation and the unhindered exchange of data or information. However, DATEX II is also designed to be used within single operator systems" [12].

2.1.2 Basic system overview

DATEX II modeling is based on Unified Modeling Language (UML) and the implementation platform for messaging uses the W3C standard for XML schema definition. The mapping is well defined in the specifications and has been implemented in a tool which contains the model itself, the whole specification and additional materials that users can download from DATEX II website (www.datex2.eu) [12].

In a general perspective the system is composed of five main actors who interact with each other. The Figure 2.2 provides a basic system overview which includes the following actors:

- **Supplier**: Provides data as input to the system.
- **Client**: Receives traffic and travel related data.
- **Management Administrator**: Manages the list of authorized users, create and maintains a catalog of the available data and the available filters.
- **Operating administrator**: Monitors the data input from the supplier and the physical data delivery status.
- **Subscription Service**: Manages the subscriptions.
2.2 DATEX II data

2.2.1 Data model

Data to be exchanged are described in a DATEX II data model comprising of analytic, dynamic, functional and logical diagrams based on UML. To ensure flexibility and extensibility principles, the data model uses three levels which allow to extend the basic model [3]:

- **Level A**: Contains the standard data model.

- **Level B**: Is used to extend mechanisms, concepts and attributes. There are some new applications that want to add additional concepts and attributes, therefore, the level "B" enriches the "A" model with additional and specific application information. The extended model remains interoperable with "A" model compliant suppliers/consumers.

- **Level C**: Is used when specific data models cannot be included into the level A/B content. The "C" level extends new concepts with different contents and as a result, the level "C" systems are not interoperable with level "A" systems. However, they use common modeling rules and exchange protocols.

2.2.2 Data dictionary

In order to make the DATEX II data model more readable and understandable, the DATEX II definitions had to be automatically extracted from the data model. Based on these definitions a "data dictionary" is created and it
should be available on a website. This document specially focuses on non-IT professionals.

2.2.3 XML schema

For exchanging data the system uses Extensible Markup Language (XML) and for validating data the XML schema definition language (XSD) is used. The XSD is based on the data model and for generating it, there exists a conversion tool that allows to convert from UML DATEX II data model to XML schema. The UML model is first exported from the UML modeling tool (For example Enterprise Architect) to a XML Metadata Interchange (XMI) file which is then converted to XSD file based on a predefined configuration (see Figure 2.3).

2.2.4 Profiles

Profiles are defined as a customized subset of options which allow to personalize particular implementations and provide more or less functionalities based on the user needs [3]. Prior to create the XML schema for exchanged data the content provider can define a schema that is fully tailored to his particular service, by deselecting unused level A data elements and by adding missing data elements from a level B extension [13].

2.3 Modeling methodology

2.3.1 Definition

DATEX Methodology is the basis for mapping the data model to UML and for creating profiles and extensions. It is divided into three model levels: data, data model and meta model [14]. The data model is available in Enterprise
2.3. Modeling methodology

Architect format (.eap) or in HTML format for web browsers. The tree structure of the data model contains a main package (D2LogicalModel), the whole view, the sub packages and the starting point of the model (see Figure 2.4).

![Figure 2.4: Tree Structure of data model](image)

Each sub package has a specific responsibility in the model [14]:

- **Exchange package**: Contains data related with protocols for exchanging traffic information such as: type of subscription, keep alive message, delivery interval and update method.

- **Extension package**: Is the container for customized level B extensions.

- **General package**: Is the main package and contains the data types, groups of locations, enumerations and reusable classes.

- **Management package**: Contains some information for the life cycle of specific situations like traffic messages.

- **PayloadPublication package**: Contains the main payload packages for different types of messages. For example: the variable messages signs, traffic messages, data directly recorded and data created through algorithms. In addition, it contains the "GenericPublication" class which is used to make level B extensions at the publication level.

2.3.2 Modelling principles

For modeling a DATEX II data model or creating a new profile, some principles should be followed. First of all, it is required to separate the payload content and the exchange information. Secondly, UML should be used as a tool for specifying the payload content and the exchange mechanisms.

After the UML model is exported in the interoperable XMI format, it can be used for creating mappings of the data model for specific implementation platforms via Platform specific models (PSM). These mappings use the
model driven architecture approach and some conventions on naming, structuring/packaging and interpreting UML concepts are also required. Indeed, it is possible to avoid conflicts with different platform dependent implementations and to convert from UML model to XML schema. Furthermore, for mapping the model it is important to notice three tagged values: data types, enumerations and data structures; and the importance of the constraints of multiplicity.

On the other hand, although UML is used also for the information exchange modeling, it cannot be used in the same way of data modeling. UML concepts are just used to visualize the specification of the exchange platform independent model (PIM). The DATEX II exchange PIM is currently mapped to the internet family of communication protocols, using a plain HTTP or the web service protocol family (WSDL and SOAP) [13].

2.4 Exchange information system specification

2.4.1 Architecture and main subsystems

![Figure 2.5: DATEX II exchange system architecture [5]](image)

One of the most prominent features of the exchange system is its architecture and its subsystems. DATEX II exchange system is composed of three subsystems: publisher, delivery and management subsystem. However, DATEX II only describes the specification for the delivery subsystem and developers are free to design and implement the other subsystems [4]. The figure 2.5 shows the interaction among all subsystems and the system’s actors.
2.4. Exchange information system specification

- **Publisher Subsystem**: Makes data available, creates the payload package and interacts with the delivery subsystem.

- **Management Subsystem**: Manages the client, catalog and subscription lists.

- **Delivery Subsystem**: Exchanges specific information and performs the physical delivery to the client.

2.4.2 Operating modes

For delivering the traffic data there are three possible operating modes and one operating mode for subscription management [5]. Users have to choose the operating mode based on their needs.

<table>
<thead>
<tr>
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<th>Subscription management mechanism</th>
<th>Specialized operating mode to handle subscriptions</th>
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<td>Publisher Push on occurrence</td>
<td>Data delivery is initiated by the Publisher every time data is changed</td>
</tr>
<tr>
<td>1</td>
<td>Publisher Push periodic</td>
<td>Data delivery is initiated by the Publisher on a cycle time basis</td>
</tr>
<tr>
<td>2</td>
<td>Client Pull</td>
<td>Data delivery is initiated by the Client and data is returned as a response</td>
</tr>
</tbody>
</table>

Table 2.1: Operating modes of DATEX II exchange system

2.4.3 Exchange profiles

![Exchange profiles communication](image)

Each operating mode has one or more ways to implement it over internet, as can be observed in the figure 2.6.
2. State of the art

2.5 Parking publication extension

2.5.1 Description

The development of the parking publication extension begun in the last quarter of 2012 taking into account comprehensive requirements from different fields: urban parking, rest areas and truck parking. Parking publication is governed by the standard CEN-TS 16157 part 6 which introduces the DATEX II data exchange specifications for traffic management and information.

The parking extension is composed of static and dynamic parking data and contains exhaustive number of elements. It implements 8 new data types, 48 enumerations, 57 components with 219 attributes, 46 figures and 89 pages data dictionary.[15].

2.5.2 Parking publication model

The parking publication model is modeled as level B extension and allows to describe two types of information:

- **Static information:** Has low frequency transmission and includes basic information about rest areas and urban parking.

- **Dynamic information:** Has high frequency transmission and includes information about status facilities and occupancy.

Consequently, DATEX II parking publication consists on three publications derived from "GenericPublication" which allow to specify static and dynamic information about parking sites and individual parking places.

![Figure 2.7: Parking Table Publication](image-url)
2.5. Parking publication extension

**ParkingTablePublication (PT):** Is used to publish static information and is the base for dynamic occupancy information. Besides, it is the biggest publication and the main classes are shown in the figure 2.7.

**ParkingStatusPublication (PS):** Is used to provide dynamic information of parking sites or groups of parking sites (see Figure 2.8).

![Figure 2.8: Parking status publication](image)

**ParkingVehiclePublication (PV):** Allows to specify information about parking vehicles, the figure 2.9 represents the abstract of this publication.

![Figure 2.9: Parking vehicle publication model](image)

The mentioned publications are complex and describing the attributes inside them could be really complicated, however, the basic topics and the information available for each parking publication are summarized in the figure 2.10. The data is grouped in five main groups: parking lot, parking space, reservation, vehicles and users.
2. State of the art

The parking publication extension can be used for implementing different types of parking taking into account common elements such as: parking areas, opening times, entrances and facility layouts. Likewise, it is possible to add new elements for specific implementations, for example, truck parking systems need additional elements such as junctions, permits, services facilities, vehicle measurements and additional equipment [15].

2.6 Directives and Standards

Prior to DATEX II implementation it is important to identify and understand the standards, directives and plans which support intelligent transportation field. The most significant legal framework is the Directive 2010/40/EU which is aimed to harmonize the implementation of ITS in Europe to keep the interoperability and compatibility on ITS services.

To ensure a coordinated and effective deployment of ITS within Europe, European Commission has approved specifications, standards and procedures prior to ITS development and implementation. This specifications have been based on open and public standards [16].

This directive defines the optimal use of road, traffic and travel data and the continuity of traffic and freight management ITS services as two of the priority areas within European states. Besides, priority actions include "the provision of information services for safe and secure parking places for trucks and commercial vehicles" and "the provision of reservation services for safe and secure parking places for trucks and commercial vehicles" [16]. Moreover, it is necessary to define the minimum requirements for the continuity of ITS services based on the use of electronic exchange systems for traffic data across borders and the use of standardized information flow or traffic interfaces between relevant traffic information/control centers and other external systems.

In addition, the ITS action plan in Europe includes freight parking in its priority areas. The priority area "Continuity of traffic and freight
management ITS services” supported the eFreigth project with the aim to identify ITS services and use ITS technologies for providing "en route" information of the location and condition of transported good in a secure way. Likewise, this priority area supported the definition of an ITS framework architecture for urban transport mobility, including an integrated approach for travel planning, traffic management, road pricing and the use of parking and public transport facilities[17]. For instance, Spain has developed real time traffic information services and information exchange based on DATEX II. Also, Czech republic, Germany, Finland and United Kingdom has been very active in this priority area (See Figure 2.11).

In the same way, the priority area "Road safety and security" establishes as an action the development of appropriate measures on secure parking places for trucks and commercial vehicles, and on telematics-controlled parking and reservation systems [17]. For example, in Germany has been implemented several intelligent truck parking projects which accurately records occupancy in various parking areas, feeds a central system and made the data available in a wide variety of information platforms [18].

Figure 2.11: Member states report of priority action 2 from ITS action plan [6]

The positioning of ITS services for trucks as one of the priority areas is supported by the Commission delegated regulation 885/2013 . This regulation specifies that member states shall designate areas where traffic and security conditions require the deployment of information services, and define priority zones where dynamic information should be provided. The data to

exchange has to use DATEX II or other internationally compatible formats [8]. The minimum data required is specified in this regulation and it can be classified into three groups: static data, dynamic data and safety and equipment data (see Table 2.2).

<table>
<thead>
<tr>
<th>GROUP</th>
<th>DATA</th>
<th>SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static data</td>
<td>Identification of parking area (name and address)</td>
<td>limited to 200 characters</td>
</tr>
<tr>
<td></td>
<td>Location information of the entry point (latitude/longitude)</td>
<td>20+20 characters</td>
</tr>
<tr>
<td></td>
<td>Primary road identifiers</td>
<td>20/20 characters</td>
</tr>
<tr>
<td></td>
<td>Indication of the exit</td>
<td>limited to 100 characters</td>
</tr>
<tr>
<td></td>
<td>Total number of free parking places</td>
<td>integer 3</td>
</tr>
<tr>
<td></td>
<td>Price and currency of parking places</td>
<td>300 characters</td>
</tr>
<tr>
<td>Safety and equipment</td>
<td>Description of security, safety and service equipment</td>
<td>500 characters</td>
</tr>
<tr>
<td></td>
<td>Number of parking places for refrigerated good vehicles</td>
<td>numerical 4 digits</td>
</tr>
<tr>
<td></td>
<td>Specific equipment or services for specific goods vehicles</td>
<td>300 characters</td>
</tr>
<tr>
<td></td>
<td>Consent of the operator to make his contact information public</td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td>Parking operator information (name, telephone and email)</td>
<td>100, 20 and 50 characters</td>
</tr>
<tr>
<td>Dynamic data</td>
<td>Availability of parking places (full, closed, or number of free places)</td>
<td>Not specified</td>
</tr>
</tbody>
</table>

Table 2.2: Required data to be collected for safe and secure parking places [8]

The static data shall be accessible through a national or international access point and for dynamic data, member states are responsible to set up and manage a central point of access, referencing all individual single points of access of each truck parking operator and/or provider on their territory as defined the article 5(2) and 5(3) of the regulation 885/2013. Besides, dynamic information shall be updated no less than once every 15 minutes [8]. According to the Commission delegated regulation 2015/962, given the diversity of data sources ranging from infrastructure based sensors to vehicles as sensors, the exchange specifications should apply to relevant data categories regardless of the source of data and technology used to create or update the data [19].
Furthermore, the service providers shall display information about next two safe and secure parking places along 100 kilometers, including the availability of parking places in a priority zone as in article 6 of the regulation 2015/962 [8].

2.7 DATEX II parking project implementation

2.7.1 ITP pilot project in Germany

Figure 2.12: ITP Pilot project motorway A9 Germany [7]

Bavarian road administration and Siemens were leading a intelligent truck parking (ITP) pilot project deployed on motorway A9 between Munich and Nuremberg. It started with 21 rest areas with automatic detection at access and exit points and real time information transmitted via fiber optics. The project implements DATEX II for ITP-data transmission to the German single access point, Mobility Data Marketplace (MDM) which provides to public or private service providers relevant traffic data [20]. Regarding data consumption (see Figure 2.12), truck drivers can check the parking situation along their route using channels such as smartphone apps, navigation systems in their trucks, broadcast messages and information kiosk at rest areas [18].

Taking into account that truck parking areas are often overcrowded and parking occupancy information is really needed for truck drivers and operators, there were defined three Traffic Message Channel (TMC) events to be transmitted: "No parking spaces available", "Expect no parking spaces available" and "Only a few parking spaces available".
2. State of the art

2.7.2 ParckR Project

ParckR is a project implemented for smart truck parking around Europe, nowadays it offers a group of information services in Benelux countries, France, Germany, Austria and Switzerland. These information services are offered by a mobile application "ParckR" (see Figure 2.13) which is available in 10 languages. The project developed a computer model to predict Truck Parking Areas (TPA) occupancy rates based on floating vehicle data which coming from mapping company and ParckR community; and based on truck parking data that coming from road authorities and web scraping.

![ParckR application screenshots](From Google Play)

The ParckR predictions are based on time-series analysis and forecasting. It allows the estimation of both, current and future TPA occupancy and provides them to the truck drivers via a smartphone application. The drivers can see an overview of TPAs along theirs route, the expected occupancy at the time of arrival and the available facilities of the parking place [21]. This project implements DATEX II as the basis of the data model where they store the static information of the parking places. As a result of this implementation experience, it is important to highlight that ITP is not complex but contains a lot of information [22].

2.7.3 Smart on-street parking in Czech republic

Czech Republic started a project which main objective was to develop a Czech standard with guidelines to develop one app for all national cities. The app should be able to provide free parking space information. It has to have standard terms for data collection, management and publication, that means one organization to manage data, parking management and payment enforcement.
2.7. DATEX II parking project implementation

Within the project was made a DATEX II profile with terms for system and data providers, terms for city central system managers and terms for payment data. The static and dynamic data was tested on a real system [23].
This chapter contains the basic guideline for methods, techniques and tools employed within the thesis. The design and implementation of DATEX II model for truck parking systems, has six phases and has to be complete from two viewpoints: the DATEX II profile and the information system perspective. The following list contains the phases identified as the core of this master thesis:

- Phase 1: Identification and planning
- Phase 2: Research and state of the art
- Phase 3: Analysis
- Phase 4: Design
- Phase 5: Implementation
- Phase 6: Evaluation and discussion

### 3.1 Identification and planning phase

One of the most important aspects of projects is the correct identification of the problem and users needs, when it is complemented by a good planning the result is a successful project. Therefore, the first phase of the thesis was to identify the problem and create a plan to solve it.

As was mentioned in previous chapter, the aim of the thesis is to take advantage of DATEX II and design and implement a exchange information system. It has to feed truck parking systems and other external systems using a DATEX II profile.

From planning perspective was created a step by step plan where each step or phase had specifics goals to achieve in a determined period of time. The following figure summarize the whole thesis process over the time:
3. Methodology

Figure 3.1: Thesis planning over time

3.2 Research phase

The research phase was one of the most important phases because it included a thorough research of DATEX II standard. Its main objective was to gather information about the standard and create the state of the art based on this information. It was necessary to read the standard specifications and understand how they are working and how they have been implemented in several projects around Europe, including European committee for standardization regulations for truck parking systems and traffic information exchange.

On the other hand, it was important to gather information about truck parking systems and about pilots projects where DATEX II has been part, in order to understand how they used the standard and what approach was used. This phase is explained in Chapter 2.

3.3 Analysis phase

This phase contains the analysis of DATEX II model, specifically about truck parking profile and the exchange information system.

3.3.1 DATEX II Profile analysis

In order to understand and analyze DATEX II model and truck parking profile were accomplished three activities. The first activity was to play with the truck parking extension and DATEX II profiles, creating three levels for profiling the data model. These levels include the minimum data required, a level with more data and one with almost all specified data in the parking extension (see Table 3.1). Based on this levels, the DATEX II conversion tool was used to created the respective profiles and XML schema.

The second activity was to create XML examples for each defined profile. These examples was created based on real parking data and was validated against the XML schema created previously. The examples used information from Asford truck stop in England and Letnay P+R in the Czech republic. The information gathered for each example come from internet resources. Asford truck stop data source was the website of the parking place [24], while Letnay P+R data source come from the technical administration of roadways.
3.4 Design phase

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Minimum profile</td>
<td>Minimum data to be collected for safe and secure parking places [8]</td>
</tr>
<tr>
<td>1</td>
<td>Medium profile</td>
<td>Enrichment of minimum data</td>
</tr>
<tr>
<td>2</td>
<td>Complex profile</td>
<td>Enrichment of level 1 including descriptions, URL, images and complementary information for data</td>
</tr>
</tbody>
</table>

Table 3.1: Information profile levels

of the capital [25, 2015] and a blog about a practical guide to live in Prague [26].

The third activity was to compare the created profiles with the profiles defined by MDM from Germany, National Access point for ITS from Netherlands, the ASFINGAG from Austria and the RSD CR from the Czech Republic. The result and analysis of this comparison can be found in Chapter 4.

3.3.2 Information exchange system analysis

The analysis phase included gathering functional and non functional requirements. In this phase was important to understand user needs and based on them define a group of requirements which have to be satisfied by the system. From a general perspective, the system requirements includes user management, data publication and data consumption; as well it includes security, availability and usability characteristics. The complete specification is in the Chapter 5.

3.4 Design phase

3.4.1 DATEX II Profile design

In this phase the DATEX II truck parking profiles were designed. It included analysis of the created levels and definition of an stable version of DATEX II profiles.

3.4.2 Information exchange system design

In this phase diagrams were elaborated from two viewpoints: functional and information viewpoint. From functional viewpoint were elaborated use cases which describe the system’s actors and their interaction with the system. The use cases were divided in three categories: user management, data publication and data consumption.
3. Methodology

From information viewpoint were created activity diagrams which describe dynamic aspects of the systems using a flow chart of activities. These diagrams help to understand the activities needed by the system, in this case, upload data operation and download data operation. In addition, the database design taken place in this phase.

Based on the previous diagrams the system architecture was defined and the evaluation of technologies to implement the system taken place as well. The system architecture is composed of four basic components: User management, data processing, data publication and data consumption. From a technical viewpoint the architecture can be expressed as in the figure 3.2. The consumer and publisher access to some data services from a Restful Application Programming Interface (API), using an API access key. The server storage the parking data in amazon S3 buckets and notify subscribers through amazon simple notification service (SNS). It is important to highlight that the architecture is based on subscriber/Publisher pattern to communicate data between different system components without these components knowing anything about each others identity. The complete specification including diagrams is in Chapter 5.

![Figure 3.2: System overview](image)

3.5 Implementation phase

3.5.1 DATEX II Profile implementation

In this phase, the profiling of DATEX II model taken place through DATEX II conversion tool. The XML schema is generated after deselecting information classes and attributes from the complete parking extension, limiting the available literals in the enumerations and generating a new XML schema. For validating the XML schema was used Oxygen XML and Notepad++ tool.
3.5.2 Information exchange system design

The development of the system took place in this phase and it was composed of four stages. In the first stage was implemented user management, including user authentication, registration and manage of API access keys. In the second stage was implemented Restful API which is responsible for the implementation of the web services. In the next stage the data transformation was implemented and in the last stage was developed a web portal focus on user management and practical uses.

![Figure 3.3: Technologies used in software development](image)

Several technologies were involved in the system development for different components (see Figure 3.3). The description of these technologies and the complete specification of the implementation is in the Chapter 6.

3.6 Evaluation and discussion phase

The last phase included three main activities. First of all, it was defined a case of study with two scenarios which allows to test and validate the whole exchange information process. That means, from the time which publisher upload parking data to the time when consumer pull this uploaded data. The areas of user registration and topic subscription are covered by unit and integration test.

To summarize, these scenarios cover dynamic and static parking information and data transformation into DATEX II with the minimum data specification. The source of dynamic parking data come from Technická správa komunikací (TSK) and the source of static parking data come from Ředitelství silnic a dálnic čr (RSD CR), the figure 3.4 shows the type of data which are included from each provider. Based on these data, there was defined two scenarios which include manual and automatic upload of data, pull and push modes for downloading the transformed data and the DATEX II transformation process itself.
The second activity was to deploy these scenarios and test them. Finally, the last activity was to evaluate the results obtained, generate some discussion about it and make some conclusions regarding the results, the thesis project and future work.
This chapter contains analysis of parking data description with and without the parking publication extension; it was evaluated against the minimum data required by the regulation No. 885/2013 [8]. As a result of this analysis was defined three levels of data description that were compared with existing profiles defined by the MDM from Germany, the NDW from Netherlands, the ASFINGAG from Austria and the RSD CR from the Czech Republic.

4.1 Parking description without parking extension

The DATEX II data model allows to describe some parking data without including the parking extension, however, there are very few attributes and characteristics which can be described by the level A data model. It offers basic description for car park status, occupancy, exit rates, fill rates, queuing time, occupancy of parking spaces, location by coordinates and validity time specification. In fact, comparing with the parking publication extension, the level A model can describe some of the dynamic parking attributes, but just 27% of the static parking attributes. As can be observed in the figure 4.1 where the parking extension data were classified in 22 specific attributes.

In the same way, DATEX II level A data model do not allow to describe the minimum static data required; it just can describe two attributes of them: parking area name and location by latitude and longitude. However, DATEX II level A data model can describes the minimum dynamic data: full parking, closed parking and number of free places available. As a consequence, the use of the parking publication extension is necessary.
4. DATEX II Parking model profiles

4.2 Levels definition

To satisfy needs from different users three different data description levels for static data and dynamic data were defined. For each case, the levels include the minimum data required, a level with more descriptive data and one with almost all data specified on the parking publication extension.

4.2.0.1 Level 0: Minimum profile

This level contains the minimum data to be collected for safe and secure parking places [8] for dynamic and static data (See the appendix B.1).

4.2.0.2 Level 1: Medium profile

In general, the level 1 is an enrichment of the minimum data, but it tries to avoid too many details (See the appendix B.2).

- **Static Data:** Include basic data about parking equipment and services facilities, data about parking usage scenario, parking site status, parking queuing time and vehicle count and rates.

- **Dynamic Data:** The aggregated classes in this level including the parking space status description, basic data about whole parking occupancy like the number of vacant spaces, number of vehicles and occupancy trend. These attributes also are included for the group of parking spaces status specification.

4.2.0.3 Level 2: Complex profile

The level 2 is an enrichment of the level 1 and it tries to complement the data with more descriptive information about parking places (See the appendix...
4.3 Profiles comparison

In order to evaluate and validate the profiles mentioned above, they were compared against profiles defined by different countries. This evaluation is based on both, static and dynamic parking information. The sources of this comparison are four: the first one is a profile from Germany [27], the second one are XML examples from Netherlands [28], the third one is a XML example from Austria [29] and the last one are parking data from Road and motorway directorate of the Czech republic [30].

4.3.1 Dynamic Data Comparison

On the one hand, the three defined levels for dynamic parking information are compared against Germany and Netherlands sources. Three specific parameters were taken into account: general attributes, parking occupancy and group of parking spaces status. The following notation was used for the comparison: (C): classes, G: German Profile, N: Netherlands examples, L0: minimum level, L1: medium level, L2: complex level, Y: yes and N: no.

Regarding the general attributes (See table 4.1), all profiles provide the basic attributes, but just the complex level profile include the parking conditions data. An example of some of these basic attributes can be observed in the figure 4.2, the parking space status contains additional data such as if the parking spaces are occupied or closed, the overcrowding which are part of a group of threshold parameters and data about parking site status and opening status.

Likewise, information regarding parking occupancy (See table 4.2) is mainly used by German profile, the medium level and the complex level. Moreover, data related to measurements like vehicle rate and count within interval classes are only incorporated by G and L2 profiles. An example of how these data are located in the XML is in the figure 4.3. It includes parking occupancy data and vehicle rate statistics; in the example the fill rate of lorries is 7 and the exit rate is 8.
4. DATEX II Parking model profiles

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>G</th>
<th>N</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status origin time</td>
<td>Date time</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Space status (C)</td>
<td>Data about parking space occupation and availability</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Site status</td>
<td>Spaces available or not</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Site opening status</td>
<td>Opening status</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Overcrowding</td>
<td>The number of vehicles on the parking above which the overcrowding state</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Parking conditions</td>
<td>Defines if normal parking conditions are suspended or special parking conditions are in force</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

Table 4.1: General dynamic attributes comparison.

Figure 4.2: General dynamic attributes example

4.3.2 Static Data Comparison

The three defined levels for static parking information are compared against German, Netherlands, Austrian and the Czech Republic sources. The main classes and attributes evaluated were: general attributes, contact information, parking location, tariffs and payment, parking equipment and service facilities, parking thresholds, parking usage scenario, parking access, parking standards and security, only assignments for parking and parking site address. The following notation was used for the comparison: G: German Profile, N: Netherlands data, A: Austria data, C: Czech Republic data, L0: minimum level, L1: medium level, L2: complex level, Y: yes and N: no.

Regarding the general attributes (See table 4.3) most of the sources only involve the minimum required data, while G and L2 profiles incorporate addi-
### 4.3. Profiles comparison

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>G</th>
<th>N</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vacant spaces</td>
<td>Free spaces</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Number of vehicles</td>
<td>Total spaces</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Occupancy trend</td>
<td>List of terms used to describe the trend in parking space occupancy</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Occupancy graded</td>
<td>Parking occupancy percentage</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Vehicle count (C)</td>
<td>Gives incoming and/or outgoing vehicles and/or change of occupied spaces within a given interval</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Vehicle rate (C)</td>
<td>Gives information about fill and exit rates or vehicle flow rate</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Group of Parking spaces (C)</td>
<td>Information by group of spaces</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

Table 4.2: Parking occupancy dynamic attributes comparison

Figure 4.3: Parking occupancy dynamic attributes example

It is important to highlight that no-one include maximum parking duration into the description. The figure 4.4 contains a basic example of usage of some of these attributes. For example, one of the less used attributes is occupancy detection type, however it could bring useful information to understand how occupancy is detected in the parking place; its values can be: balancing, singleSpaceDetection, manual, modelBased or other.
4. DATEX II Parking model profiles

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>G</th>
<th>N</th>
<th>A</th>
<th>C</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking name</td>
<td>Name</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Parking alias</td>
<td>Alternative name</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Number of spaces</td>
<td>Total spaces</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Record version time</td>
<td>Date time</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Occupancy detection type</td>
<td>Type of parking occupancy detection</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Parking description</td>
<td>Additional description</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>URL link address</td>
<td>Internet address for further relevant information</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Maximum parking duration</td>
<td>Maximum duration</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Table 4.3: General static attributes comparison

<parkingName>
    <values>
        <value lang="en">Ashford International Truck Stop</value>
    </values>
</parkingName>

Figure 4.4: General static attributes example

Regarding the contact information (see table 4.4), there exist a plenty of attributes which can be used, the most of them are used, however details like fax, URL address and person name are not incorporated by all sources. The figure 4.5 shows an example of contact data description for a parking operator, it includes the organization name, telephone number, email and publishing agreement.

The next aspect evaluated was the tariffs and payment (See table 4.5), it is important to highlight that H, A an C sources only describe tariffs using the attribute free of charge, while G profile and the defined levels add more information like cost, currency and payment information. An example of rich description of tariffs and payment for parking places is in the figure 4.6. It can
**4.3. Profiles comparison**

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>G</th>
<th>N</th>
<th>A</th>
<th>C</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact basics</td>
<td>Data about contact (tel, email and name)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Publishing agreement</td>
<td>Indication, whether the contact accepted publishing its data</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Person and first name</td>
<td>Names</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Address data</td>
<td>City, country, postcode and street</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Fax</td>
<td>Fax Number</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>URL link address</td>
<td>Internet address for further relevant information</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

Table 4.4: Contact static attributes comparison

Figure 4.5: Contact static attributes example

be observed how is specified the charge price for a time interval, 10 euros per 24 hours (86400 seconds). Also, it is specified the accepted payment cards.

Figure 4.6: Tariffs and payment attributes example
4. DATEX II Parking model profiles

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>G</th>
<th>N</th>
<th>A</th>
<th>C</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currency, Charge and reservation fee</td>
<td>Payment data</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Maximum Duration</td>
<td>Maximum parking duration</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Payment Cards and brands</td>
<td>Card data</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Last updated</td>
<td>Payment data update</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Free of charge</td>
<td>Indicates if parking is free of charge</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

Table 4.5: Tariffs and payment attributes comparison

Regarding parking equipment and service facilities information (See table 4.6), L0 does not include these data, G an L2 profiles contains all attributes and the Czech rest area data includes just information about the existence of the equipment or service facility. An example of parking equipment description is in the figure 4.7, it describes basic data of a internet wireless connection in the parking area and it can be extended to a wide number of attributes like if it is applicable for a specific user, name or brand and photos as well.

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>G</th>
<th>N</th>
<th>A</th>
<th>C</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability and accessibility</td>
<td>When and who can use the service</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Equipment and service Type</td>
<td>Service name</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Description</td>
<td>Additional data</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Photo URL</td>
<td>Picture of the service</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

Table 4.6: Parking Equipment and Service Facilities Attributes Comparison

```xml
<parkingEquipmentOrServiceFacility equipmentOrServiceFacilityIndex="2">  
<availability available="true">  
<equipmentType>internetWireless</equipmentType>  
</availability>  
</parkingEquipmentOrServiceFacility>
```

Figure 4.7: Service facility description example
The table 4.7 contains the comparison related to parking standards and security. The most important attribute is the parking security itself, the other ones are optional and they are just used by G and H profiles. The figure 4.8 illustrates some attributes which describe the parking security. In the example, the parking places has level 5 of security national classification and it counts with CCTV and dog as security means.

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>G</th>
<th>N</th>
<th>A</th>
<th>C</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parking Security</td>
<td>Security means</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Security National Classification</td>
<td>Classification</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Certification and supervision</td>
<td>Indicates data about certification</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Label Security Level</td>
<td>Standard level</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Table 4.7: Parking standards and security attributes comparison

Likewise, the table 4.8 illustrates the comparison related to parking access and location. It is one of the most diverse tables from the whole comparison, where G, L1 and L2 profiles includes everything, while the other elements include a different range of attributes. This table presents different perspectives from each country, nevertheless, the common elements include access category, road id, parking site address and point coordinates description. In addition, it is important to highlight that parking location is supported by classes and attributes from DATEX II level A data model and they allow using a wide range of attributes which specify point, area or linear description.

For instance the figure 4.9 contains a basic parking location description which includes the road number, the road direction and the point coordinates.
4. DATEX II Parking model profiles

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>G</th>
<th>H</th>
<th>A</th>
<th>C</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Category and road id</td>
<td>Category of the access</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Road Destination</td>
<td>Name of road destination</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Point Coordinates</td>
<td>A pair of coordinates defining the geodetic position of a single point</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Access Name</td>
<td>Name</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Access Equipment</td>
<td>Specifies additional equipment for this access</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Distance to the road</td>
<td>Distance to the road in meters</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Type of road</td>
<td>Type of the road</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Parking site address</td>
<td>Location data</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

Table 4.8: Parking access and location attributes comparison

The last comparison joins several topics (See table 4.9): parking site address, thresholds, parking usage scenario and truck parking dynamic management. From it can be concluded that threshold is not used at all, in contrast parking usage scenario is used by all compared sources.

The figure 4.10 contains a basic example of the how the thresholds data looks...
with attributes like overcrowding, the parking usage scenario which is truck parking and the truck parking dynamic management which can contains values such as: queueParking, compactParking or noDynamicParkingManagement.

<table>
<thead>
<tr>
<th>NAME</th>
<th>DEFINITION</th>
<th>G</th>
<th>H</th>
<th>A</th>
<th>C</th>
<th>L0</th>
<th>L1</th>
<th>L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thresholds</td>
<td>Configuration parameters of the parking site, used among others for the dynamic attribute 'parkingStatus'</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Parking usage scenario</td>
<td>A special type of usage available for the parking site or the group of parking spaces.</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Truck parking dynamic management</td>
<td>Dynamic parking mode enum</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Table 4.9: Specific and descriptive attributes comparison

```xml
<parkingThresholds>
  <entrancesFull>40</entrancesFull>
  <overcrowding>20</overcrowding>
</parkingThresholds>

<parkingUsageScenario scenarioIndex="2">
  <parkingUsageScenario>truckParking</parkingUsageScenario>
  <truckParkingDynamicManagement>noDynamicParkingManagement</truckParkingDynamicManagement>
</parkingUsageScenario>
</parkingUsageScenario>
```

Figure 4.10: Specific and descriptive attributes example
Chapter 5

Architecture specification

5.1 System overview

The main aim of the system is to deliver services related to parking data publication, consumption and transformation. The system is responsible for uploading and publishing parking data for authorized consumers which are managed by the system as well. The figure 5.1 describes briefly the whole process where the three main actors of the system are: publisher, consumer and the broker (the system itself).

The process starts when the Publisher uploads parking data to the Broker, then the data file is stored in its original format and finally the transformation process takes place. Transformation process converts data to DATEX II based on provided data and predefined transformation templates where the data model level plays a role in initial mappings. The data is then published and it is ready to be downloaded. Consumers subscribed to this data are notified about data updates and even can receive the new data by push.

![Figure 5.1: Process of information exchange and DATEX II transformation](image)

Regarding the services consumption, the figure 5.1 presents two entrance points from Publisher side which means that there are two modes to publish
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data (see Figure 5.2). One manual and just reply to the request of the upload service, second automatic. The second mode specifies that data can be upload every specific time interval defined in seconds, minutes or hours. The parking data can be provided from a file or URL.

![Figure 5.2: Publish data modes](image)

The figure 5.1 illustrates two entrance points from Consumer side which means that there are two modes to consume data (See figure 5.3), one is by pull which consist of a simple request for new data and the second one is by push which means that consumer has to be notified about updated data and then downloads it. The Broker can notify consumers sending messages to an email or to a message queue and can receive the data through HTTP/HTTPS endpoint.

![Figure 5.3: Consume data modes](image)

From components perspective, the system is composed of three elements: a web portal, a Restful API and a Broker. The web portal is created to make user management easier and bring to user the opportunity to access the information services from a more intuitive endpoint, explore the API documentation and manage data subscriptions.
The second component is the Restful API which contains parking data services and the last component is called Broker and it is the system itself, described in the system architecture section.

5.2 Scope

Within the scope of this proposal is:

- Data publication and consumption.
- Data transformation from XML and CSV format to DATEX II format.
- Basic user management and API access key generation.
- Subscription management and system notification implementation.
- Basic security level in the web portal.

Out of the scope and as future work is:

- Implementation of API management platform such as 3Scale technology
- Archiving the parking data for more than three months
- Administrator console management
- Real statistics in the dashboard of web portal

5.3 System architecture

The system architecture is composed by five layers as can be observed in the figure 5.4. The first layer is the security layer which is important to ensure the integrity and protection of data. This includes user authentication in the web portal and the API access key which is needed for requesting services to restful API. The API access key has to be unique for each user.

The application layer is composed of a web portal and the Restful API. As was described above, it was created for user management, subscription management and for making more comprehensible and easier to use the system. On the other hand, the restful API is part of the core of the exchange system, because through this component data services are available to users. There are three main data services which users can access from web portal, command-line tools or some other restful endpoint: Post parking data from a file, post parking data from web service and get parking data.

The communication layer is the third layer and it is related to protocols for exchanging information. In this case, HTTP protocol is being used to access the data services through GET, PUT and POST methods. For security
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reasons, ensure high level of interoperability and reduce the management on firewall, it would be wise to implement the standard HTTP port 80 [4].

The service layer of the information exchange system can be divided in four components:

- **User management**: Is responsible for user registration, authentication, authorization and deletion. Also to manage the user subscription to data publications and the API access key generation.

- **Data processing**: Is responsible for data transformation based on the XSD schema and predefined templates.

- **Data publication**: Is responsible for publishing data in DATEX II format and notifying Subscribers when new data is available. Moreover, when the user set up automatic upload mode this component is responsible for creating and launching a trigger that request for new data by time intervals.

- **Data consumption**: Its responsible for manage and authorize the data consumption.

Finally, the data layer includes the DATEX II data model, the DATEX II profiles, the data dictionary and the data storage component. This last one is composed of a server local database and a group of buckets on Amazon S3 which are logical units of storage in Amazon Web Services (AWS) and are used to store the original and transformed data.
It is important to highlight that the architecture is based on Subscriber/Publisher pattern in order to communicate data between different system components without these components knowing anything about each others identity. As a consequence, there exist an intermediary, called Broker which function is to receive parking data in XML or CSV format type, then transform it into DATEX II format, publish the transformed data and forwards on those subscribers who are registered to receive them.

5.4 Requirements specification

5.4.1 Non functional requirements

The system non functional requirements are identified by the letter SNR and a consecutive number. They specify criteria and parameters that can be used to judge the operation of the system, the table 5.1 lists them.

<table>
<thead>
<tr>
<th>ID</th>
<th>REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNR-01</td>
<td>Security</td>
</tr>
<tr>
<td>SNR-02</td>
<td>Availability</td>
</tr>
<tr>
<td>SNR-03</td>
<td>Usability</td>
</tr>
<tr>
<td>SNR-04</td>
<td>Extensibility</td>
</tr>
</tbody>
</table>

Table 5.1: System non functional requirements

Security

- The access to the web portal is determined by user name and password.
- For using the API is needed an access API key generated by the system
- The subscriptions to parking data are accepted or denied by user administrator

Availability

- The API should be available 24*7 hours
- The web portal should be available 95 % of time

Usability

- The system should have a web portal for user management and easier access to information services
- The API should have documentation through some API modeling language
5. Architecture specification

- The DATEX II parking profile should contain documentation and XSD specification

**Extensibility**

- The system should be able to add additional functionalities or modify existing functionalities
- The system design should ensure low coupling, interfaces and encapsulation

### 5.4.2 Functional requirements

The system functional requirements are identified by the letter SR and a consecutive number. They represent the user needs and the functionality of the system, the table 5.2 lists them.

<table>
<thead>
<tr>
<th>ID</th>
<th>REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR-01</td>
<td>Register new users</td>
</tr>
<tr>
<td>SR-02</td>
<td>Login users</td>
</tr>
<tr>
<td>SR-03</td>
<td>Delete User</td>
</tr>
<tr>
<td>SR-04</td>
<td>Accept or decline User subscription</td>
</tr>
<tr>
<td>SR-05</td>
<td>Generate API access key for user</td>
</tr>
<tr>
<td>SR-06</td>
<td>Assign API access key to each user</td>
</tr>
<tr>
<td>SR-07</td>
<td>Upload parking data from provider manually</td>
</tr>
<tr>
<td>SR-08</td>
<td>Upload parking data from provider by intervals</td>
</tr>
<tr>
<td>SR-09</td>
<td>Transform data to DATEX II format</td>
</tr>
<tr>
<td>SR-10</td>
<td>Get parking data transformed into DATEX II format by Pull</td>
</tr>
<tr>
<td>SR-11</td>
<td>Get parking data transformed into DATEX II format by Push</td>
</tr>
<tr>
<td>SR-12</td>
<td>Visualize parking information related with data provided</td>
</tr>
<tr>
<td>SR-13</td>
<td>Request for parking data subscription</td>
</tr>
<tr>
<td>SR-14</td>
<td>Notify user when there is new parking data uploaded</td>
</tr>
<tr>
<td>SR-15</td>
<td>Generate API documentation</td>
</tr>
<tr>
<td>SR-16</td>
<td>Storage parking data provided</td>
</tr>
<tr>
<td>SR-17</td>
<td>Storage parking transformed data</td>
</tr>
</tbody>
</table>

Table 5.2: System functional requirements
5.5 System design

5.5.1 Functional viewpoint

5.5.1.1 Use cases

For describing the use cases it is important to specify the system’s actors and their responsibility in the system:

- **Publisher**: Is an external system and is mainly responsible for providing parking data.

- **Consumer**: Is an external system and is mainly responsible for receiving or requesting for transformed data. It interacts with user registration and data subscription processes.

- **Broker**: Represents the system itself and is responsible for managing the Restful API, data transformation, data distribution and data storage.

- **Administrator**: Is responsible for user management and data subscription.

The use cases summarize the key interaction between the system’s actors. The use cases are divided in three categories: User management, Data publication and Data consumption. The figure 5.5 contains the use cases related to user management, including registration, logging and subscription processes.

![Diagram](image)

**Figure 5.5: User management use case**

The figure 5.6 contains the use cases related with data publication process where the main actor is the publisher and the broker. The use case do not
5. Architecture specification

specify the type of data upload modes, but they are described in the activity diagrams.

![Data publication use case](image1.png)

Figure 5.6: Data publication use case

Finally, the figure 5.7 contains the use case related to data consumption, including the pull mode and the push mode where the consumer receives a notification of upload data event.

![Data consumption use case](image2.png)

Figure 5.7: Data consumption use case

5.5.2 Information viewpoint

5.5.2.1 Activity diagram

The activity diagram describes dynamic aspects of the systems through a flow chart which represents the flow from one activity to another activity. The
activity can be described as an operation of the system. For data exchange system is important to describe three basic activities. The first one is the upload data process where is important to define the storage data activity, transform data activity, the notification activity and the activities regarding the creation of a trigger for uploading data by intervals of time. The figure 5.8 shows the flow between this activities, it starts when Publisher upload data manual or automatic by intervals of time. When the API access key is
validated the upload process starts.

The second and third activity represent the download data process which can be completed by pull or push operation. The figure 5.9 shows in the left side the pull data process which basically is composed of a request from Consumer and API key validation. On the right side is the push process which is always waiting for some notification of new data uploaded by Publisher and when new data is founded it starts a request for downloading these data.

![Download data activity diagram. (a)Pull mode (b)Push mode](image)

Figure 5.9: Download data activity diagram. (a)Pull mode (b)Push mode
DATEX II implementation for truck parking

This chapter contains the description of the implementation stage which involves the DATEX II profiling process and the software development based on the architecture defined in Chapter 5.

6.1 Profiling process

6.1.1 Tools

For DATEX II profiling were used the DATEX II conversion tool to generate the XML schema, and Oxygen XML and Notepad++ to validate it.

6.1.2 Process Description

First of all, the UML model is exported to XMI format from Enterprise Architect software. Then, the DATEX II conversion tool is used with the XMI file and its configuration preferences should indicate the directory for resulting XML schema and the model information, it should be filled like in the figure 6.1. Afterward, the selection tab is opened (See figure 6.1) and inside this tab the attributes, classes and elements of the model can be observed, selected and deselected. The profiling process uses following steps:

- **Step 1**: Select the required “payloadPublication” classes and deselecting all other publication classes in Payload. For example, just select the ParkingTablePublication.

- **Step 2**: Select the required classes and attributes in the publication and all classes and attributes that are not required for this purposes, are deselected.
6. DATEX II implementation for truck parking

- **Step 3:** Select the supported location referencing systems
- **Step 4:** Select the check model option where the model is validated and if everything is right then use the start button to generate the XML schema.

![DATEX II Conversion tool](image)

Figure 6.1: DATEX II conversion tool. (a) Tool configuration (b) Selection and profiling tab

As a result the XML schema is generated and based on this result were generated some XML examples and validated.

6.2 Software development

6.2.1 Development Environment

The development environment refers to the software tools and programs used to implement the exchange parking information system. The following list contains these tools and the description about how they were used:

- **Restful API Modeling Language (RAML):** Is a human readable data serialization language (YAML) for describing web services. It makes easy to manage the whole API life cycle. The Restful protocol used for web services communication was JavaScript Object Notation (JSON).

- **Amazon S3:** Is an online file storage web service offered by Amazon Web Services which provides a secure, durable and highly scalable cloud storage. It was used to store the original and transformed data.
• **Amazon Push notification service**: Is a simple push messaging service that allows users to push texts, alerts or notifications. It was used to notify subscribers when new data is published by the system.

• **Spring Web model-view-controller (MVC)**: Is an application framework and inversion of control container for Java platform. It was used to implement the Restful API modeled with RAML.

• **Java**: Is a programming language used to develop the server of the web portal and to implement the data transformation process.

• **Apache FreeMaker**: Is a template engine for java which was used to convert data to predefined DATEX II XML templates (levels).

• **AngularJS**: Is a web application framework which was used to develop the client for the web portal.

• **MySQL**: Is an open source relational database management system (RDBMS) used to create a local database for user management.

In addition, it is important to highlight that the java/javascript project was configured with "springboot", "spring mvc", "hibernate", "jdk 8" and "angularjs". Also, some other libraries like "raml2html" were used in the programming stage.

### 6.2.2 Development Components

In the software development stage were developed four modules: Restful API, DATEX II Conversion, subscription management subsystem and web portal.

#### 6.2.2.1 Rest API

This component contains the web services specification for publishing and consuming parking data. As was mentioned in Chapter 5 there are three main services: upload data from file, upload data from URL and download data by topic (See Figure 6.2). The defined services were described using RAML and they required as parameters the *API access key* which ensure security of data, the *topic identifier* that references a subscription topic and relates the data to subscribers; and the *schema identifier* which is a predefined specification/structure of the uploaded data. The complete RAML file can be observed in the appendix C.

Based on the RAML file was generated an HTML with the Restful API documentation through "nodejs" and "raml2html" package. Then, using "Spring MVC" were implemented three entry points for the web services and they were validated against the RAML definition using "springmvc-raml-plugin" library.
6. DATEX II implementation for truck parking

6.2.2.2 DATEX II Conversion

The main responsibility of this component is to convert the parking data into DATEX II format. Therefore, it was necessary to create a data mapping algorithm which based on a predefined schema transforms the data into DATEX II format. The schema definition depends on data providers, hence, for the scope of this project were defined two schemas: one for dynamic data and one for static data. The conversion process starts when the data is validated against the schema, the file is then read and a java object with DATEX II structure is created. Afterward, “Freemaker” library creates an new XML file based on the schema templates and the java object created previously.

6.2.2.3 Subscription management subsystem

This component is responsible for managing user’s subscriptions to parking topics. The topics are previously configured by system administrator and can be selected by users when they configure the mode of the subscription, pull, push or both. When the push mode is selected, its implies a subscription process to the SNS from amazon and then this external system is responsible for the notification process when new data is published by the broker.

6.2.2.4 Web Portal

The last component is an user interface which exposes several functionalities of the information exchange system and allows to use them for configuration and user management. In the web portal just registered users can access to the

![Figure 6.2: Rest API description](image)
subscription, publication and consumption of parking data. The web portal has a dashboard structure with different items in the menu (see Figure 6.3).

![Web portal screen-shot](image)

Figure 6.3: Web portal screen-shot

The following items are visible for everyone:

- **DATEX II**: Contains a basic description about DATEX II and the parking publication extension.
- **API documentation**: Contains the Restful API documentation with the request and response specification for each service (See figure 6.4).

Following items are accessible just for registered users:

- **Dashboard**: Contains a resume of all users activities, like subscriptions, data publication and data consumption (See figure 6.5).
- **API access key**: Shows the API access key for user and its status. It gives the option to regenerate or request for the API key.
- **Subscriptions**: Contains user subscription information and through this item, the user can add more subscriptions to different topics and unsubscribe of them as well (See Figure 6.7).
- **Upload Data**: Contains the user interface to upload data from local file or from URL. It allows to configure the upload mode for an specific topic and data schema (See figure 6.6).
- **Download Data**: Contains the data available to download.
6. DATEX II implementation for truck parking

Figure 6.4: API documentation screen-shot

Figure 6.5: Dashboard screen-shot
6.2. Software development

Figure 6.6: Upload Data screen-shot

Figure 6.7: Subscription screen-shot
Case of study

This chapter contains the definition, discussion and evaluation of the case of study for the thesis project. The case of study was composed by two scenarios: the first one is based on real time dynamic parking data provided by TSK while the second scenario uses parking static data provided by RSD ČR (see appendix E).

7.1 Dynamic and real time parking data - TSK case

7.1.1 Scenario definition

![Figure 7.1: TSK real time scenario]

This scenario is based on real time dynamic information about park and ride places in Prague. The data provider is TSK and it publishes data in XML format which is available in its website (http://en.tsk-praha.cz/wps/portal) and often updates these data. Scenario is completely in real time.

For implementing this scenario, the administrator has to create a new topic “Dynamic Prague Parking”, then data provider has to configure the upload data mode from URL through a task scheduler for every hour. That means
every hour the data available at defined URL is send to the broker, then it is transformed into DATEX II format and finally published in the system. On the other side, data consumer should be subscribed to this topic (Push mode) and as a consequence, when the data is published the consumer will receive an email which contains the URL to download the new data (See figure 7.1).

7.1.2 Scenario implementation
The implementation of this scenario could be divided in three stages:

- **Topic creation**
The administrator created the "Dynamic Prague Parking" topic. This process is manual and should be done directly in the server database.

- **Data upload configuration**
To configure the data upload by an scheduler for every hour is needed to specify the data source and the time interval in the upload data screen (see Figure 7.2). After configured these specifications, a task scheduler is created in the server (in this case windows system), it contains a curl request to the broker and it will be trigger every hour (see appendix D).

![Figure 7.2: Data upload configuration](image)

- **Consumer Subscription**
Data consumer should subscribe to "Dynamic Prague Parking" topic for pull and push modes.

7.1.3 Scenario results
The scenario implementation was successful and it was evaluated from two parameters: successful scenario and DATEX II transformation time.
7.1. Dynamic and real time parking data - TSK case

The scenario was complete and successful. From TSK portal the system got the park and ride data (see Figure 7.4), then the broker transformed these data into DATEX II and the consumer received an email with an URL to download the data (see Figure 7.5).

Figure 7.3: Consumer Subscription

Figure 7.4: Get P+R data from TSK Portal

Figure 7.5: Email endpoint push notification
7. Case of study

The figure 7.6 illustrates basic example of data transformation for one P+R in the TSK portal. The parking example is Chodov (P+R) which has some data inside the RSS such as the number of free spaces, number of taken places and number of total places. In the TSK portal is visible the number of free spaces which in the example is 591 and it is located in the attribute "parkingNumberOfVacantSpaces" in the DATEX II file. The number of taken places is 62 and it is located in the attribute "parkingNumberOfOccupiedSpaces", the attribute "parkingOccupancy" is calculated based on these attributes.

Figure 7.6: Chodov P+R example data transformation

Figure 7.7: DATEX II Conversion Time for dynamic data
The second evaluation parameter was the transformation time which has as average value 90.9 milliseconds and as can be observed in the figure 7.7 the time is almost uniform for each request. It is important to highlight that this test was under basic environment and more complex environment have not been tested yet.

7.2 Static parking data - Czech rest areas case

7.2.1 Scenario definition

The Czech rest areas scenario is based on static data from rest areas in the Czech Republic. The data provider is Ředitelství silnic a dálnic ČR (RSD ČR), they provide a Comma Separated Values (CSV) file which was saved in the server.

For the implementation of this scenario, the administrator has to create a new topic "CZ static data", then the provided data is uploaded to the broker, transformed into DATEX II and then published. In the same way, the consumer is subscribed to "CZ static data" topic, but just for pull mode, therefore he would not receive any notification of new data, but he can get the data when is needed (See Figure 7.8).

![Figure 7.8: Czech Rest Areas scenario](image)

7.2.2 Scenario implementation

The scenario implementation basically contains the same stages described in the previous scenario. They just differ in the topic name which for this case of study is "CZ static data" and in the configuration to upload data which is by file in this case.

7.2.3 Scenario results

The scenario implementation was successful and it was evaluated from two parameters: Successful scenario and DATEX II transformation time.

The scenario was completed successfully. The figure 7.9 extract a record of the file and 12 attributes were selected with their description and example values. The attributes were grouped in 5 parts: 1: parking location, 2: payment mode, 3: services, 4: parking places and 5: security.
7. Case of study

Figure 7.9: Static data record example

<table>
<thead>
<tr>
<th>Part of XML</th>
<th>Attribute</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CISLO_KOM</td>
<td>Road Number</td>
<td>D1</td>
</tr>
<tr>
<td></td>
<td>KM</td>
<td>Mileage</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>SMER_KOM</td>
<td>Direction of the road</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>X_WGS</td>
<td>Latitude</td>
<td>14.54135</td>
</tr>
<tr>
<td></td>
<td>Y_WGS</td>
<td>Longitude</td>
<td>50.00998</td>
</tr>
<tr>
<td></td>
<td>ZPOPLAT</td>
<td>Payment for parking</td>
<td>1:charge, 2:free)</td>
</tr>
<tr>
<td></td>
<td>RESTAURACE</td>
<td>Restaurant (1:yes, 2:no)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>PARK_OA</td>
<td>Parking spaces for cars</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>KLAS_LABEL</td>
<td>Security Level Classification</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>OSVETLENI</td>
<td>Lighting of parking places</td>
<td>1:yes, 2:no)</td>
</tr>
<tr>
<td></td>
<td>STREZENI</td>
<td>Security watch (1:yes, 2:no)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>MONITORING</td>
<td>Close loop tv (1:yes, 2:no)</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 7.10: Example of static data in DATEX II
Then the DATEX II conversion took place for the complete file and the values of the selected attributes were transformed into DATEX II format (see Figure 7.10). The red rectangles define the groups of attributes mentioned above and the data inside of them is the example data in the figure 7.9.

On the other hand, the DATEX II transformation time has an average value of 122.2 milliseconds (See Figure 7.11).

![DATEX II Conversion Time for static data](image-url)
Chapter 8

Conclusions

The thesis has been dealing with the implementation of a DATEX II profile to provide truck parking information services for drivers, parking operators and traffic centers. As has been explained, truck drivers often park in non-secured zones or unsafe locations, because they are confronted with insufficient number of parking spaces when they arrive to the parking lots. Besides, there are a limited amount of information about parking places and services facilities for their routes and as a consequence, they could not plan accurately the trip and schedule times for break, eat an rest. DATEX II appears as a response to a harmonized way of communicating and exchanging traffic information across borders and play a strong role for the implementation of integrated ITS in Europe.

This thesis took advantage of DATEX II to support truck parking information services through the development of a exchange information system. The investigation and practical processes generated result, discussions, analysis and conclusions.

First of all, I ascertained how important is to provide truck parking information and how useful is DATEX II standard to describe these data, because the provision of information services for safe and secure parking places for trucks and commercial vehicles is one of the priority actions of the ITS deployment over Europe. Likewise, it is supported by the ITS action plan, the directive 2010/40/EU and the commission regulation 885/2013 which specify DATEX II as the main standard for exchange of information.

Secondly, profiling the data model based on specific user needs is a great advantage of standard. It allows to limit the amount of data to exchange and provide the opportunity to focus on what is strictly required or what gives useful information. As the DATEX II data model (including the parking extension) is very extensive sometimes is complicated to navigate around the complete standard and to find the right attributes to provide some information. Therefore, the DATEX II profiling tool gives a big advantage to avoid these conflicts and provide a tailor data model which will be more easy to
In the same way, this thesis defined three profiles with different information levels for static and dynamic data: from minimum data level to a descriptive data level. The information included in these levels were adjusted to user needs. The minimum level describes just attributes which are compulsory for EU regulations, then the medium profile provides more information focusing on useful and descriptive attributes and finally the complex profile includes almost all attributes of the parking extension.

Comparing these levels with existing profiles from other countries was concluded that German profile contains the biggest amount of attributes and data to be exchanged, they provide more descriptive and rich information; in most of the cases this profile contains the same data that defined medium and complex profiles. Similarly, Netherlands, Austria and the Czech Republic profiles provide basic parking data, avoiding too many details as the defined minimum profile.

Third, as a result of this thesis, a parking information exchange system was developed. It allows to deliver parking data services related to parking data publication, consumption and transformation. The development of this system uses many technologies which responded to the defined requirements and ensure the system capacity, efficiency, flexibility and usability. The cloud computing approach ensure many of these aspects and help to store the original and transformed data, and to notify subscribers when new data is uploaded. The development of a web portal allows to use easily the services and provides several useful and rich information functions such as the Restful API documentation, a dashboard with statistics and DATEX II information.

I can conclude that, throughout the thesis, most of the intended objectives have been addressed and the implemented case of studies provide a positive and visible result. For both cases the scenario implementation and DATEX II transformation were successful. The analysis of the parking extension offered the opportunity to define three levels of information which were adjusted to different user needs. These levels supported the DATEX II profiling process as one big advantage of the standard. The Restful API development supported the provision of parking data services and the web development provided the opportunity to use the information exchange system developed from the Publisher and Consumer perspective, including the process for uploading and downloading data, topic subscription, API key access generation and statistics of usage and users.

As future work, the parking information exchange system will be improved through the implementation of additional components such as: API management platform, the administrator console management, security improvements and the addition of more statistics in the dashboard of the web portal. Besides, I planned to publish an article about the work I have done with the master thesis.
Bibliography


List of acronyms

API - Application Programming Interface
CEN - European Committee for Standardization
EC - European Commission
EU - European Union
ITS - Intelligent Transportation Systems
ITP - Intelligent truck parking
JSON - JavaScript Object Notation
MDM - Mobility data marketplace
MVC - Model-view-controller
PIM - Exchange platform independent model
PS - Parking status publication
PSM - Platform specific model
PT - Parking table publication
PV - Parking vehicle publication
RAML - RESTful API Modeling Language
A. List of Acronyms

SNS - Amazon simple notification service

TMC - Traffic Message Channel

TEN-T - Transeuropean road network

TPA - Truck Parking Areas

UML - Unified Modeling Language

XMI - XML Metadata Interchange

XML - Extensible Markup Language

XSD - XML schema definition language
DATEX II Profiles for truck parking places

B.1 Minimum profile for truck parking places

B.1.1 Dynamic Data

The minimum DATEX II profile for dynamic data contains the basic and required data: the availability of parking places. It is possible to specify if there are spaces available and the opening times of the parking place. The XML schema which is produced for this profile is named "Dynamic data level 0 schema.xsd" and can be found in the "DATEX II Profiles" folder. Besides, the selection file "Dynamic data level 0 selection.sel" can be also found there.

B.1.2 Static Data

The minimum DATEX II profile for static data contains the basic and required data. It covers identification and location of the parking place, road identifiers, identification of the entry point, total number of parking places, price and currency of parking places, parking operator information and description of security, safety and service equipment. The XML schema which is produced for this profile is named "Static data level 0 schema.xsd" and can be found in the "DATEX II Profiles" folder. Besides, the selection file "Static data level 0 selection.sel" can be also found there.

B.2 Medium profile for truck parking places

B.2.1 Dynamic Data

This profile adds more descriptive information to the minimum profile and includes data such as overcrowding, number of vacant spaces, total number
of spaces and occupancy trend. The XML schema which is produced for this profile is named "Dynamic data level 1 schema.xsd" and can be found in the "DATEX II Profiles" folder. Besides, the selection file "Dynamic data level 1 selection.sel" can be also found there.

B.2.2 Static Data

This profile adds more descriptive information to the minimum profile and includes data related with occupancy detection, payment cards and brands, services facilities and equipment information and parking access. The XML schema which is produced for this profile is named "Static data level 1 schema.xsd" and can be found in the "DATEX II Profiles" folder. Besides, the selection file "Static data level 1 selection.sel" can be also found there.

B.3 Complex profile for truck parking places

For static and dynamic information, the high DATEX II profile is an extension of the medium profile. It aggregates several attributes regarding to more descriptive issues. The XML schema which is produced for dynamic profile is named "Dynamic data level 2 schema.xsd" while the XML schema for static profile is named "Static data level 2 schema.xsd" and both can be found in the "DATEX II Profiles" folder.
This appendix contains the RAML description where can be identified the web services implemented in the system.

```yaml
#%RAML 0.8
title: Truck Parking Data Services
description: Pull parking data based on topic subscription
version: "1"
schemas:
  - PushRequest: !include schemas/PushRequest.json
  - PullRequest: !include schemas/DownloadDataRequest.json
  - OperationResponse: !include schemas/PullResponse.json
/pullDataByTopic:
displayName: PullDataByTopic Resource
description: Pull parking data based on topic subscription
post:
  description: Pull parking data based on topic subscription
  body:
    application/json:
      schema: PullRequest
      example:
        {
          "apiKey": "1l0CSaKN4bUwGowNo1qbuLE03AHTig",
          "topicIdentifier": "DynamicDataPrague"
        }
    responses:  
      "200":
        description: Successful Response
        body:
          application/json:
            schema: OperationResponse
            example:
              {
                "operationMessage": "Successful",
                "url": "https://DynamicDataPrague.xml"
              }
/pushDataUrl:
displayName: PushDataUrl Resource
description: Push data from URL resource
```
C. RAML definition

post:
   description: Push data from URL resource
   body:
      application/json:
         schema: PushRequest
         example: |
            {
               "isContractFree": true,
               "dataType": ".xml",
               "url": "http://en.tsk-praha.cz/..",
               "topicIdentifier": "DynamicDataPrague",
               "apiKey": "1l0CSaKN4bUwGowNo1qbuLBo3AHTig",
               "schema": "tskSchema"
            }
   responses:
      "200":
         description: Successful Response
         body:
            application/json:
               schema: OperationResponse
               example: |
                  {
                     "operationMessage": "Successful..",
                     "wasSuccessfulOperation": true
                  }

/pushDataFile:
   displayName: PushDataFile Resource
   description: Push data from a file resource
   post:
      description: Push data from a file resource
      body:
         application/json:
            example: |
            {
               "isContractFree": true,
               "dataType": ".csv",
               "filePath": "C:\restAreas.txt",
               "topicIdentifier": "StaticDataPrague",
               "apiKey": "1l0CSaKN4bUwGowNo1qbuLBo3AHTig",
               "schema": "czRestAreasSchema"
            }
   responses:
      "200":
         description: Successful Response
         body:
            application/json:
               schema: OperationResponse
               example: |
                  {
                     "operationMessage": "Successful",
                     "wasSuccessfulOperation": "true"
                  }
Appendix

**Data upload by time intervals**

For creating an automated process for uploading data every specific interval of time (seconds, minutes, hours, etc) is needed to follow two steps:

**Step 1:**
Create a curl command which contains the data needed for requesting the upload data service: API access key, topic name, type of data, data schema and the URL or file path where the parking data is located. This curl has the notation `Content-Type` with value `application/json`. After creating the curl command it has to be saved as a batch file which could be executed in the system, different extensions could be used, for example .bat for windows systems. The following code illustrates an example of the curl command.

```bash
curl -H "Content-Type: application/json" -X POST -d
{
  "apiKey":"1l0CSaKN4bUwNo1qbuLBt3AHTig",
  "topicName":"DynamicDataPrague",
  "dataType":".xml",
  "schema":"tskData"
};
type=application/json
http://dataExchange:8080/pushDataUrl
```

**Step 2:**
Create a task scheduler which is responsible for executing the batch file created in the step 1. The command to create this scheduler depends on the operative system of the broker or publisher server. For example, for Windows system is used the `schtasks` command where should be configured the name of the task, the path where is located the batch file and the time interval in which the task will be executed. This command should be executed in a command-line interface such as the command shell of windows (CMD.exe), the information exchange system do this process automatically. The following code illustrates an example of the scheduler:

```bash
schtasks /create
```

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D. DATA UPLOAD BY TIME INTERVALS

/tn curlExample
/tr C:\curlUploadData.bat
/sc 20 MINUTE
Examples of parking data conversion

Both cases of study were implemented successfully and transformed real parking data into DATEX II format. In order to present some results was taken two samples of data for every case and they were transformed through the exchange information system. The original dynamic data and its corresponded transformation can be found in "case of study/dynamic data" folder and the original static data and its corresponded transformation can be found in "case of study/static data".
Appendix F

Contents of CD

readme.txt ....................... the file with CD contents description
data ................................... the data files directory
  case of study ................. the directory with case of study
    Czech rest areas ........... the directory with Czech case of study
      *.tsv .................................. original data file
      *.xml .................................. transformed data files
    TSK parking................ the directory with TSK parking data case of study
      *.xml ............................... original and transformed data files
  DATEX II profiles .............. the directory with DATEX II profiles
    *.xsd ............................... XML schema
    *.sel .................................. Selection file
doc .................................. the directory with web services documentation
  *.json ................................ data schema definition
  *.raml .............................. Restful API documentation
src .................................. the directory of source codes
  infoExchangeSystem ............ the directory of information exchange program
    *.war .............................. web application archive
database ........................ the directory of database scripts
thesis ............................. the directory of LaTeX source codes of the thesis
text .................................. the thesis text directory
  thesis.pdf ....................... the Diploma thesis in PDF format