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Functional Specification

"MaaS operation and integration with demand-responsive transport in Tampere"

System Architecture for MaaS Operation

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Mobility Division

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Contents

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Acronyms used

Acronym	Meaning
API	Application Programming Interface
B2B	Business to Business
B2C	Business to Consumer
COSS	Commercial Open Source Software
DDS	DDS Wireless International
JSON	JavaScript Object Notation
POI	Point of Interest
PSP	Payment Service Provider
PT	Public Transport
REST	Representational State Transfer
SP	(Transport) Service Provider
TL	Tuomi Logistics

1 Executive Summary

The Tampere region is a growing and vital area, and the local administrations are continuously striving to offer excellent mobility services to their citizens and tourists alike and to support new business development in the area.

In recent years, a novel transport paradigm has emerged, which aims to reduce travelers' reliance on privately used car by providing them with easy access to a range of alternative transportation services packaged according to personal preferences and paid based on actual use. This innovative concept, known as Mobility as a Service (MaaS), seamlessly combines offerings from different transport services – including public transport as the backbone, taxis, shared services, and demand-responsive transport – and provides details on alternative travel combinations and the possibility to flexibly pay for used transport services. The obvious advantages of a better utilization of higher-capacity, environmentally-friendly means of transportation include a reduction of the overall environmental footprint and of urban congestion.

The City of Tampere intends to support the emergence of MaaS in and around the Tampere region, removing initial development barriers and jump-starting an innovative market place for new service providers to match end-customers' needs.

A particular opportunity offered by the Tampere MaaS ecosystem is to integrate existing and upcoming transport services with the operations of the local paratransit services, run by the city-owned procurement and logistics agency Tuomi Logistics. Such integration will enable the City to a) extend some of Tuomi Logistics' offerings to travelers without special mobility needs and thus increase their utilization rate, and b) to increase synergies between the local public transport services and the various flexible-demand services, such as taxis and shared-taxis, especially in the sparsely populated areas around the city.

In Tampere, a MaaS architecture will be developed which integrates various providers of transport services, initially public transport, taxis, and parking garages, and provides travelers with value-added services, such as multimodal travel information and flexible, use-based reservation and payment options.

The architecture is composed of the following main elements:

- A front-end layer which comprises all end-customer-related functionalities as well as a mobile app to offer travelers a uniform and comfortable user experience when planning their travel and making reservations or buying tickets for the appropriate modes of transport. This layer also includes an e-commerce module responsible for managing the financial transactions.
- A modular and open middle-layer platform connecting the transportation service providers with the front-end layer and the various end-user interfaces. This platform, distinct from both transportation service operators and providers of user interfaces, removes the need for each stakeholder to address technical and organizational obstacles individually by managing the internal processes for data and service collection for clearing and for making relevant data available to MaaS operators in form of API,

thus avoiding to generate redundancy for such processes when interfacing with multiple MaaS operators. The platform itself will be open, enabling all actors to engage in the ecosystem and promote their offering, without excluding specific modes, or service providers.

The Tampere system will enable travelers to search for multimodal transport options, plan trips, and make booking and payment operations through a smartphone app, according to “Use Case 0”, as described in this document.

Furthermore, an interface between the middle-layer platform and the dispatching system of Tuomi Logistics will enable offering the Tuomi Logistics services to “regular travelers”: MaaS customers, i.e. people who are currently not eligible for special Tuomi Logistics services, will be offered the option to use pre-planned Tuomi Logistics routes in addition to the various available transportation services sharing the price of the trip. This functionality is described as “Use Case 1” in the document.

Finally, a further interface between the middle-layer platform and the dispatching system of Tuomi Logistics will provide taxi and public transport information and travel options for Tuomi Logistics customers: those Tuomi Logistics customers which are able to use public transport to cover longer portions of their trips will be provided the option to use a combination of taxi and public transport. This functionality is described as “Use Case 2” in the document.

Due to the dynamicity of the mobility service ecosystem, the system architecture is developed and operated with a phased approach, which consists of incrementally integrating services and functionalities.

In a first phase the basic interfaces between the various players are developed, enabling the transmission of the available data from the service providers and the provision of value-added services. Also, the middle-layer platform, the smartphone app, and the e-commerce module are customized so as to enable the deployment of Use Cases 0 and 1.

After the development and successful testing of phase 1, phase 2 consolidates the proposed services and extends the developed interfaces, through the development of the functionalities for payment of the offered services, such as mobile ticketing on public transport and trains, smart-phone payment for taxis and parking structures, all within the same MaaS smartphone application. This phase also includes extending the interface between the middle-layer architecture and the Tuomi Logistics dispatching system to deploy Use Case 2.

The Tampere architecture is modular and open so that, upon completion of phase 2, it can be progressively expanded both through the addition of additional transportation services and through the extension of the geographical coverage. Furthermore, additional functionalities such as the development of mobility packages tailored to different user segments, and further use cases can be developed.

The Tampere MaaS architecture is made available as a "managed service", with the complete technical operation managed by developers of the respective components. All back-end systems including the middle-layer platform run in the cloud following the fundamentals of a service-oriented architecture with a DIN ISO/IES 27001 certified data center located in Europe.

Maintenance and technical support service are provided by the developers of the respective architecture components

2 Introduction

A trend from monomodal habits up to a multimodal lifestyle can be clearly recognized in modern traveler behavior especially within urban areas.

The demands placed on mobility providers will be to make different mobility services available to travelers in an easy and extensive way.

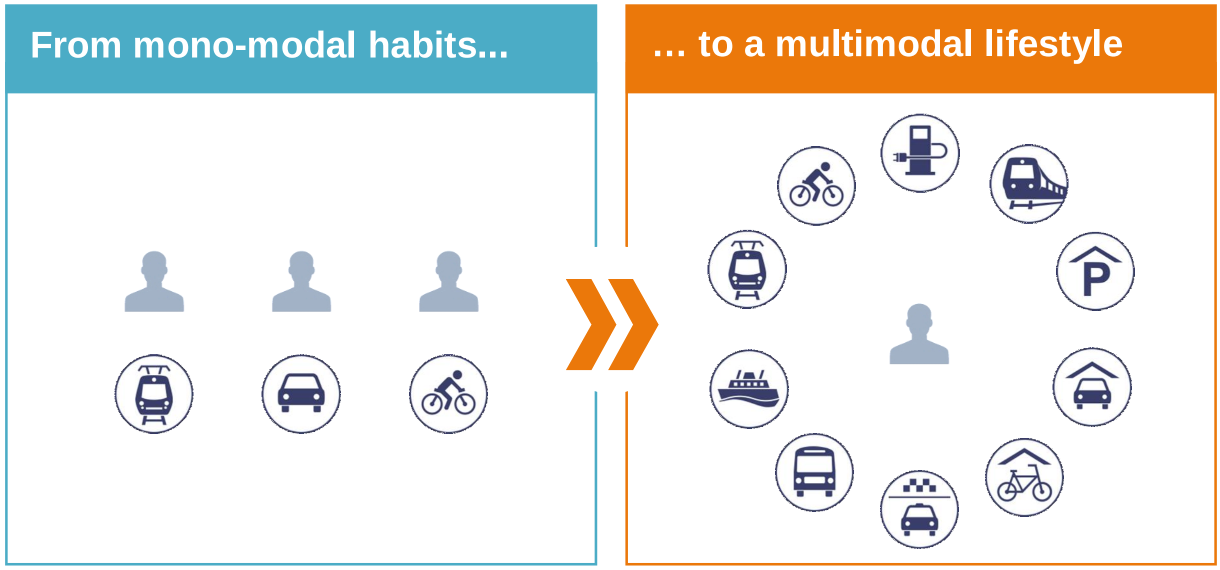

Figure 1: Trends in traveler behavior

Mobility as a Service (MaaS) proposes a novel transport paradigm which aims to reduce the need to own a car, by providing travelers with easy access to a range of transportation alternatives, which are packaged according to personal preferences and can be paid based on actual use. A truly effective MaaS environment seamlessly combines offerings from different transport services, including public transport, taxis, shared bikes, and demand-responsive transport; it provides details on alternative travel combinations in a transparent manner, and allows travelers to pay for services in a hassle-free fashion, either per use or based on subscription plan, in essentially the same way we pay our smartphone bills.

Mobility as a Service is expected to revolutionize the way we move around: with access to personalized, smart mobility services, travelers will be less dependent on their cars. Public and private providers of transportation services will benefit from a more efficient allocation of resources, enabled by a better understanding of travel demand; local authorities will profit from the deployment of sustainable transport services; and business enterprises will have access to new markets and opportunities for the development of smart mobility services.

In a MaaS ecosystem, data from various transport service providers are collected onto a single platform layer, are enhanced with features such as multimodal journey planning or mobile payment services, and are made available to travelers.

Mobility as a Service is a vision that Siemens believes in and which is expected to have significant impact on the future of transportation. Since our participation in the Open Mobility initiative in Berlin, and through multiple project activities in several European cities to create the technical, legal, and commercial prerequisites for setting up MaaS operations, Siemens is one of the leading international providers of smart solutions for combined mobility.

The SiMobility Connect platform enables operators of transportation services to set-up the technological base for the realization of MaaS and the implementation of sustainable business models.

2.1 The City of Tampere

Tampere is the third largest city in Finland and the largest inland centre in the Nordic countries. As of 2015, the city has 225,000 inhabitants, while close to half a million people live in the Tampere Region, which comprises Tampere and its neighboring municipalities.

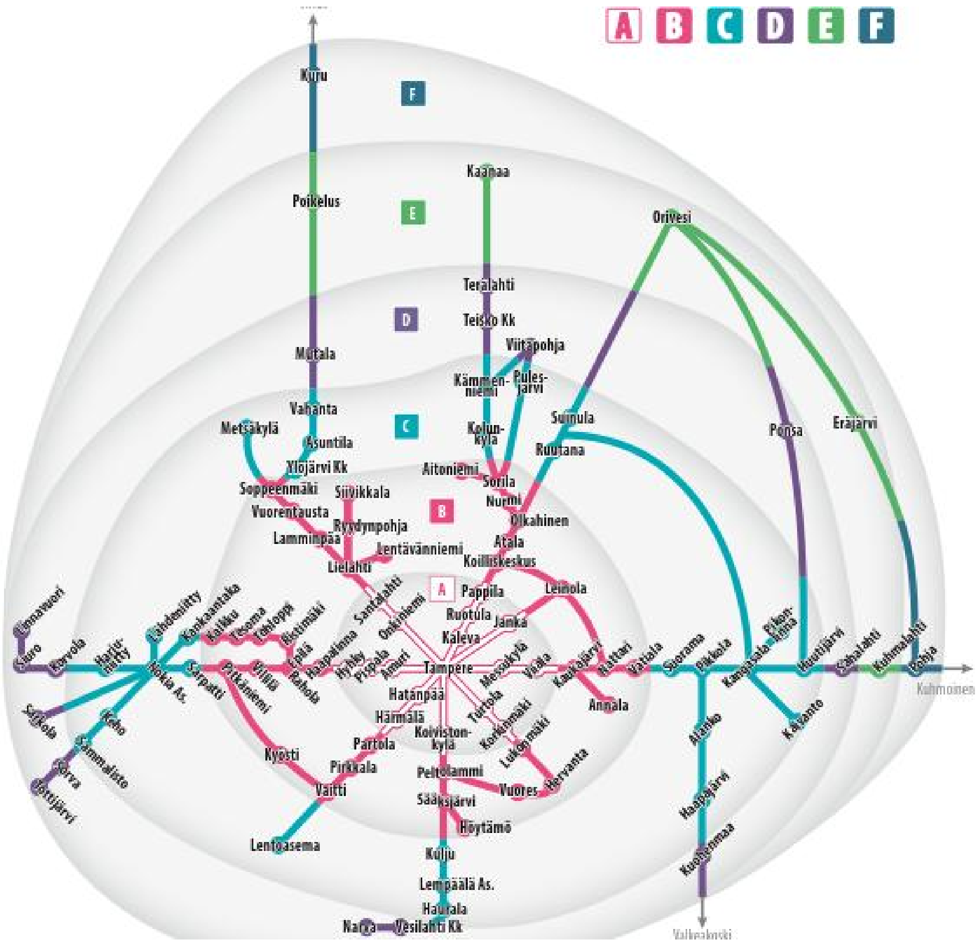

Figure 2: Tampere public transport zone system (joukkliikenne.tampere.fi).

Public transport in the Tampere region is organized jointly between eight municipalities, Tampere, Pirkkala, Nokia, Kangasala, Lempäälä, Ylöjärvi, Vesijärvi and Orivesi. The Tampere Regional Transport, called Nysse, operates about 50 bus lines in six zones which boundaries primarily based on distance.

The public transport system has a pivotal role when building up Mobility as a Service capabilities in a city. All the existing services and infrastructure need to be utilized to form the foundation for the new MaaS offerings.

In the Tampere region, also the taxi company Tampereen Aluetaksi Oy and the fully city-owned parking facility provider Finnpark Oy provide critical existing services for MaaS.

- Tampereen Aluetaksi Oy is owned by the taxi-owner association operating in Tampere region having a fleet of 520 taxis and has an annual volume of about one million taxi orders.
- Finnpark Oy is a Finnish parking service provider operating mainly in the Tampere region with few locations in Helsinki. Total in 28 location with over 15,000 parking spaces.

The motivation for MaaS draws from the objective to create benefits for all the stakeholders involved. Some of the benefits are described in the table below.

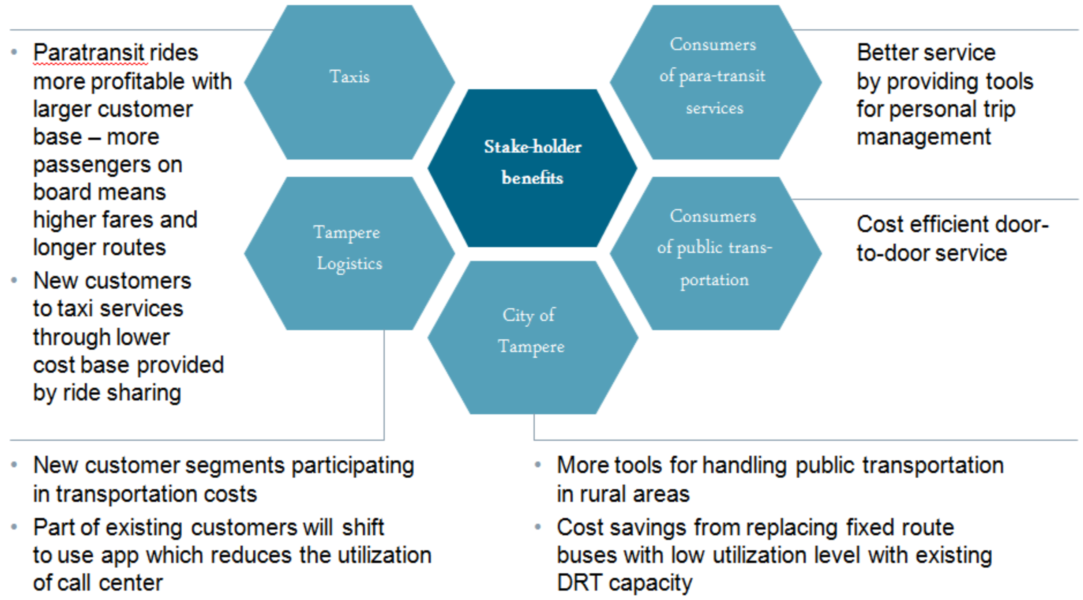

Figure 3: stakeholder benefits gathered in a joint workshop 2015

The city of Tampere is a growing and vital area. The net migration rate has been positive for long and Tampere region is expected to grow. The city has been active to improve the services to its citizens and several developments are ongoing and in the planning e.g. the Tampere tunnel project Rantatunneli and Tampere Tram.

The City of Tampere has shown excellent potential on supporting new business development in the area e.g. Tredea, the Tampere Region Economic Development Agency, has a good track record on increasing the attractiveness of the Tampere region in the eyes of investors, skilled workers and innovators. For the development of intelligent transport systems Tampere wants to be a forerunner and has interesting initiatives e.g. ITS Factory, which is an innovation, experimentation, and development environment cooperated by the city of Tampere and companies from relevant sectors. (http://www.hermiagroup.fi/its-factory/).

The City of Tampere have expressed the support to the MaaS to emerge in the Tampere region and beyond e.g. being part of Growth Corridor Finland which is the biggest pool of workforce in Finland, forefront basis of national growth and competitiveness, strongly pushes MaaS to go forward (http://suomenkasvukaytava.fi/maas/). In addition the University of Tampere has taken a role in the global MaaS Alliance leading one of its working groups (http://maas-alliance.eu/european-mobility-service-alliance/).

The natural role for a city in a development such as MaaS is to enable the new services to be designed. Removing possible barriers and concretely supporting the environment for MaaS to emerge is really visible in Tampere's actions. MaaS could create a new market place for even new service providers to enter the market and actors able to interact with real end-customers have advantage to design the services to match actual customer needs. Thus it is needed step from the city to jump-start and foster these developments. Objective is the citizens to benefit from the new services and companies to deploy the early users in the development and utilize the very important home market.

2.2 Tuomi Logistics

Tuomi Logistics (TL) is owned by the City of Tampere and Pirkanmaa Hospital District which is a joint municipal authority owned by 23 surrounding municipalities. There are half a million inhabitants living in this area. Tuomi Logistics is a procurement and logistic company providing procurement, material, mobility and person transport services to their owners.

In the context of the work behind this document the highest interest of Tuomi Logistic portfolio is the transport services. Tuomi Logistics organizes yearly nearly half a million paratransit trips which the municipalities are responsible for providing to the citizens who are not capable to use the standard public transport.

There is a notable potential to increase the utilization rate of the Tuomi Logistic trips: Tuomi Logistics has the capabilities to be driving new innovative service models as TL has been a forerunner in organizing logistic services in a centralized and cost effective way. By this new operation model introduced in this document TL will be a pioneer and design new ways of optimize the operations as well as be part of enabling the MaaS services in a larger context. Furthermore, since Tuomi Logistics is owned by the City of Tampere and Pirkanmaa Hospital District, the savings on transportation costs which can be achieved by the interfacing with a MaaS operation are passed in full to TL's owners and customers.

2.3 MaaS activities in Finland

The term MaaS, Mobility as a Service, is becoming widely used with not yet unified meaning. The essence of the MaaS concept is the new way of offering and organizing transport services of people and goods. The usage of the term has a long range from combining two different transport modes e.g. train and taxi as a one route and in the other end all the way to offer comprehensive all-you-can-travel packages with a high service-level-agreement. In addition the term MaaS-operator is used to describe a new ticket sales channel, complete travel agency or anything between. This naturally confuses and increases the possibility of misunderstandings. Furthermore the same kind of development has different names in different regions, e.g. Combined Mobility, Shared Mobility, or Mobility on Demand.

In this paper the term MaaS is used in its simpler form, since this term is well-known in Finland and was extensively used within the project preparation workshops, where a shared understanding of the meaning of the term was gained. It could be described that the MaaS-operator is the one offering services to the traveler. MaaS-operator combines different service provider’s offerings into one refined service to the end-customer, e.g. MaaS-operator adds value combining the use of a private car, parking, public transport and added services to create seamless transport services. The MaaS-operator also creates value by utilizing the capacity of service providers more efficiently thus it should be more than a new sales channel of existing services.

The development has been strong in the Nordics countries particularly in Finland. The environment is pro digitalization and many independent studies and rankings confirm what we have recognized, as exemplified in the Figure below

The top 10 countries harnessing information technology

Networked Readiness Index 2016	Global rank*
Singapore	1
Finland	2
Sweden	3
Norway	4
United States	5
Netherlands	6
Switzerland	7
United Kingdom	8
Luxembourg	9
Japan	10

Source: World Economic Forum 2016
*2016 rank out of 139 economies.
The index measures how economies use the opportunities offered by information and communications technologies for increased competitiveness and well-being.

Figure 4: the strong Finnish pro-digitalization environment

In Finland several actions have been taken by the government to support and accelerate the MaaS development. The Ministry of Transport and Communications hosted Traffic Lab initiative, the Ministry of Employment and the Economy's Tekes – the Finnish Funding Agency for Innovation started a Mobility as a Service program, and Digitalization is a pivotal theme in the Governmental program. In the Governmental program it is explicitly said that publicly subsidized passenger transportation aim to save 10% costs and a growth environment will be created for Mobility as a Service.

To achieve such a paradigm change, the governmental program highlights Digitalization, Experimentation and Deregulation. For deregulation the Ministry of Transport and Communication have started to reform the transport code. Objective is to achieve a comprehensive reform of personal and goods transportation, utilizing digitalization and enabling new kinds of market based and innovative services by developing legislation. From the perspective of MaaS the new transport code is very positive and the ministry has worked long-term to accelerate the phenomenon as described in the picture below drawn already in 2014.

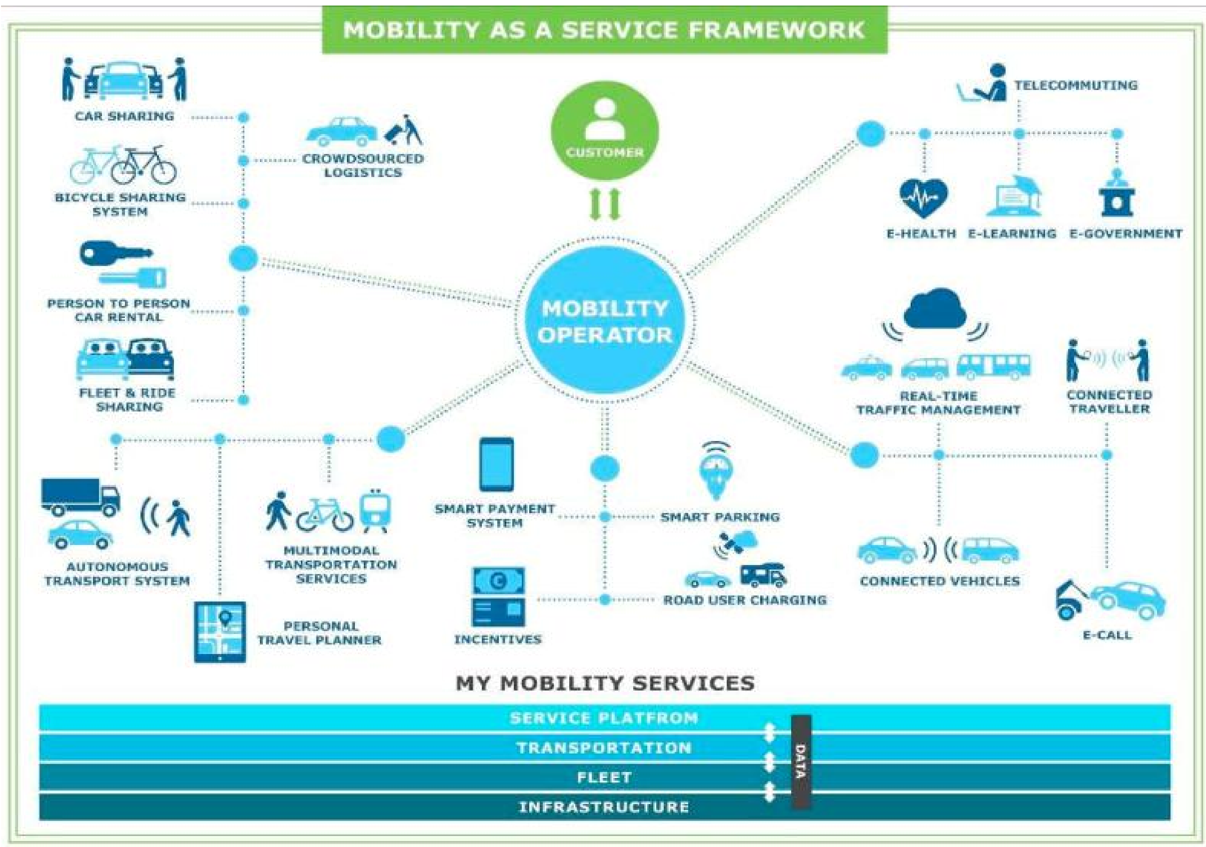

Figure 5: Mobility as a Service Framework, (LVM, Finnish Ministry of Transport & Communication, 2014)

2.4 Experience of Siemens

Siemens is strongly active in the area of Mobility as a Service and intermodal mobility services, both in Finland and internationally. To this end, a Business to Business (B2B) Platform was developed to facilitate collaboration within the mobility ecosystem and act as a hub for the integration of mobility services. This enables operators of different sectors such as public transport, car- and bike-sharing, taxi and parking to create bundled mobility offerings.

Key features of the B2B Platform are:

- Sourcing, aggregating, managing and delivering mobility data, incl. real time information
- Multimodal travel planning and reservation processing
- Transmission of tickets
- Accounting, B2B billing and revenue apportionment
- Managing partners and services

In the Tampere MaaS development project a MaaS system is to be implemented for the City of Tampere which interfaces the scheduling system of the local Paratransit Agency, Tuomi Logistics, with local transportation providers and a MaaS operator.

Siemens has experience in connecting several transport suppliers together, generating added value from the collected data. Such experience can be used to provide structured information for the MaaS operator. The most relevant reference projects, with details on the scope of supply, the main functionality, the customer, and the project duration are described below

2.4.1 Reference Project 1

Title	Traffic Information Center (VIZ – Verkehrsinformationszentrale) Berlin
Scope of supply / detailed description of the project	For the federal state of Berlin, Siemens operates the Traffic Information Center (VIZ). The information portal of the VIZ is the most comprehensive mobility portal of the city of Berlin. viz.berlin.de offers numerous information services, which inform the population of Berlin, the media and the economy up to date about the situation on the roads and in the rail network of Berlin. Apart from that, the mobility portal of the VIZ contains all latest news related to road traffic (Berlin Transport Authority BVG, suburban train S-Bahn, regional traffic), air traffic, flexible mobility services such as car sharing and bike sharing, charging posts, and intermodal routing services. The VIZ informs about obstructions and unpredictable disruptions, and shows alternative route proposals with the help of connected information services. The positions incl. the delay situation for the complete bus, tram and subway fleet of Berlin are obtained through VDV453 interfaces to the municipal transport services. In a control center application, this data is referenced to the road network, in order to calculate a delay situation in public transport (in particular, the occurrence of the delay), and this is made available to the traffic

	control centers of the city – incl. the transport services and the air-ports.
Period of execution	01.2011 – 12.2020
Functionalities	• Superior function: Provision of all traffic-relevant information for the citizens of Berlin • Detection, processing and provision of traffic news and the latest traffic situation in road traffic • Provision of traffic information and multimodal routing services (car, public transport, bikes, pedestrians, P&R, B&R) for different end user applications such as viz.berlin.de or BerlinMobil-App • Integration and provision of the following traffic information in mobility card: traffic situation of motorized private transport, traffic news (private and public transport), parking garages, P&R parking lots, stops of public transport, taxi stands, tourist destinations, bus stops, bike sharing stations, DriveNow vehicles, charging posts
Procedure model	• Continuous further development of the system based on evaluation and requirement changes, agile development
Customer	Senate Administration for Urban Development and Environment Traffic Department

2.4.2 Reference Project 2

Title	BerlinMobil App
Scope of supply / detailed description of the project	The BerlinMobil App is a central mobility app, which offers comprehensive real-time information about the latest traffic situation and all available mobility services in Berlin and the surroundings.
Period of execution	01.2015 – today
Functionalities	Intermodal route planner: • Intermodal routes for all relevant inner-city means of transport: public transport, private transport, bike, pedestrians, car and bike sharing • Consideration of Park&Ride, Bike&Ride in short-range public transportation • Consideration of the latest road traffic situation • Consideration of private and public transport news • Consideration of delays in short-range public transportation • Routing to free parking spots or charging posts • Optimization of route proposals by duration, costs and CO2 emissions Mobility card: • Public transport stops with actual departure times • Traffic news for private and public transport

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	• Car sharing & bike sharing: locations and availabilities • Charging infrastructure: locations and availabilities • Detected parking spots in the public area, and availabilities Vicinity search in a table view: • Dynamic content: webcams, public transport stops, car sharing, bike sharing, charging posts, private transport news, public transport news, gas stations incl. current prices, available taxis • Static content: parking lots, P&R parking lots, as well as handicapped parking Setting of personal preferences: • Optimization criteria: fast, cost-effective, low CO2 emission • Selection of means of transport to be integrated • Selection of car sharing services to be integrated • Max. walkway • Max. bikeway • Own car / own bike The BerlinMobil-App was implemented for the Android and iOS platforms.
Procedure model	Agile software development
Customer	Particular development in cooperation with the Berlin Senate Administration for Urban Development and Environment and the Berlin-Brandenburg Broadcasting Corporation.

2.4.3 Reference Project 3

Title	**DORA – Door-to-Door Information for Airports and Airlines**
Scope of supply / detailed description of the project	In the DORA project, a door-to-door information service is developed, which integrates the means of transport on the ground, the air traffic, and the processes at the air terminal. The overall system thus combines long-distance traffic with relations of short-distance traffic as well as indoor navigation. The information service is put at the passengers' disposal as a smartphone app. The service is prototypically developed for the connection Berlin – Palma de Mallorca, and demonstrated during a one-year test phase. The main component of the service is a cross-provider, intermodal route planner for the way from and to the airport, based on real-time data related to the situation in the road, rail and air traffic Furthermore, the route planner offers In-App-Ticketing functions for the short-range public transportation, as well as specific routing information for different target groups such as families, business travelers, or persons with restricted mobility. In this EU project, Siemens holds the technical project management, and is responsible for the integration of the developed services and interfaces, as well as for the implementation of the overall system and the smartphone application.

Period of execution	06.2015 – 05.2018
Functionalities	Door-to-door routing functions for the complete travel chain by combining ground, local traffic with air traffic and terminal navigation in the pilot cities Berlin and Palma de Mallorca Route monitoring and re-routing in case of disruptions Intermodal routing for access to / departure from the pilot airports incl. motorized private transport, public transport, bike, pedestrians Intermodal routing integrates the following additional mobility services: car and bike sharing, taxi, charging posts, rental cars, parking garages at the airports Door-to-door routing considers mobility preferences and restrictions for the entire travel chain (accessibility without barriers, buffer times at the airport, selection of means of transport, etc.) In-App-Ticketing functions for the short-range public transportation (interface to VBB - Transport Association Berlin-Brandenburg) Integration of terminal processes in mobility information by installation of technologies to detect waiting lines, indoor position determination and indoor navigation
Procedure model	Waterfall model for backend services Agile software development for mobile applications
Customer	European Commission (EU) / Brussels / Belgium

2.4.4 Reference Project 4

Title	**Provision of Data and Services for VBB Trip Information (VBB – Transport Association Berlin-Brandenburg)**
Scope of supply / detailed description of the project	Within the area of the Mobilitätsagentur Potsdam (MAP - Mobility Agency Potsdam), a multimodal mobility management was conceived. Here, the citizens and visitors of the city shall be informed and advised regarding the environmentally friendly mobility services corresponding to their needs. The focus of the MAP is to show the available mobility services by interconnecting the existing services of short-range public transportation with bike traffic, car sharing, bike sharing and private transport, and then to offer them as an alternative to private cars and make them bookable and affordable in a most integrated way.
Period of execution	Since 06.2015
Functionalities	Provision of: car router (IMR) Bike router of BBBike Car sharing vehicles with locations and availabilities Bike sharing stations with location and availability P&R parking lots Bike rental stations
Procedure model	Agile development

Place of service provision, geographic coverage	Berlin and Brandenburg

2.4.5 Reference Project 5

Title	**Mobility Platform for the SOB**
Scope of supply / detailed description of the project	Integrated mobility platform with focus on mobile ticketing, routing and timetable information
Period of execution	Since January 2016; anonymized tender of SOB (design competition) was won by Siemens in the 4th quarter of 2015.
All covered functionalities	Delivery and operation of a mobility platform based on SiMobility Connect, BiBo, eCommerce platform, Mobile App and Web UI
Procedure Model	Agile development Managed service
Place of service provision, geographic coverage	Switzerland
Customer	Schweizerische Südostbahn AG (Swiss South Eastern Railway)

2.5 Objectives of this system

1. The main goal of the Project is to create readiness for the start/opening of Tampere MaaS operation. During the Project MaaS technology will be established. In addition the objective is the development of the local ecosystem capacity to purchase, develop and operate the MaaS services. This enables MaaS development for the specific needs in the City of Tampere.

2. In the Project the solution for Tuomi logistics will be developed, which technically allows the opening of their trips to the citizens, as well as the travel reservation via user interface.

3. In addition, the target is to enable bundling of trips and increase the use of local public transport as a part of Tuomi Logistics trips.

   Such an ecosystem is expected to yield a variety of benefits to all the players in the ecosystem. These include a significant cost reduction potential for Tuomi Logistics, an increase in the use of local public transportation, access to a larger spectrum of transportation services – with varying pricing options – and a significant improvement of the environmental footprint within the region

3 Solution Overview

The Tampere MaaS system will transform how users plan and purchase services to meet their mobility needs. Today, transportation users must navigate a fractured array of payment systems when making trip decisions. There is no way to easily assess how different travel options stack up against one another in terms of cost, schedule reliability and climate impacts. Without this information, people default to the familiar or the known, leading to an overreliance on single occupancy vehicles – even when other means of travel could better serve everyday transportation needs. For people who drive, real-time parking information can be made available for Finnpark garages and payment can be integrated.

The City of Tampere and its partners will leverage national and international experiences from the public sector and industry to develop smart solutions that address safety, mobility, and climate change, and which support the integration of transportation services with the sharing economy. The range of new mobility services that have emerged in recent years that complement individual car use and traditional public transport includes modern bike-sharing systems, free-floating and spontaneous car- and ride-sharing services and on-demand bus services. The demand has been driven primarily by enabling technologies – such as really “smart” phones and affordable and user-friendly on-board units. In a similar way, data analytics coupled with geolocation and mobile devices have caused a rebirth of the traditional demand-responsive and paratransit services, with flexible offerings tailored to a variety of different user segments.

3.1 Tampere: the MaaS ecosystem

An interesting learning from such experiences, supported by empirical studies, is that in urban areas these transport modes do not compete with the public transport offering but rather complement it, by extending its reach in space and time. Ultimately, this new ecosystem of connected mobility can evolve into a true alternative to car ownership.

The Tampere MaaS system will create a modern and sustainable mobility ecosystem and can in the future evolve by integrating infrastructure and services associated with, for example, electric charging stations and parking locations, which greatly improve transportation’s environmental attractiveness.

A fundamental prerequisite for the effective deployment of a multimodal mobility ecosystem is an open **middle-layer platform** connecting the transportation service providers with the various user interfaces, whether mobile apps, websites or information kiosks. This B2B platform, distinct from both transportation service operators and providers of user interfaces, **removes the need for each stakeholder to address technical and organizational obstacles individually**. Furthermore, the platform **manages the business processes** related to the collection of data from the various service providers, including trip information, routing, and transactions, takes care of the various **Business2Business clearing process**, and makes relevant data available to MaaS operators in form of APIs, thus avoiding to generate redundancy for such processes when interfacing with multiple MaaS operators.

The platform itself will be open, thereby enabling all market participants to engage in the ecosystem and promote their offering. It **will not exclude specific modes**, or operators, such as a particular car-sharing fleet or a specific taxi company, but rather mediate between the different market segments.

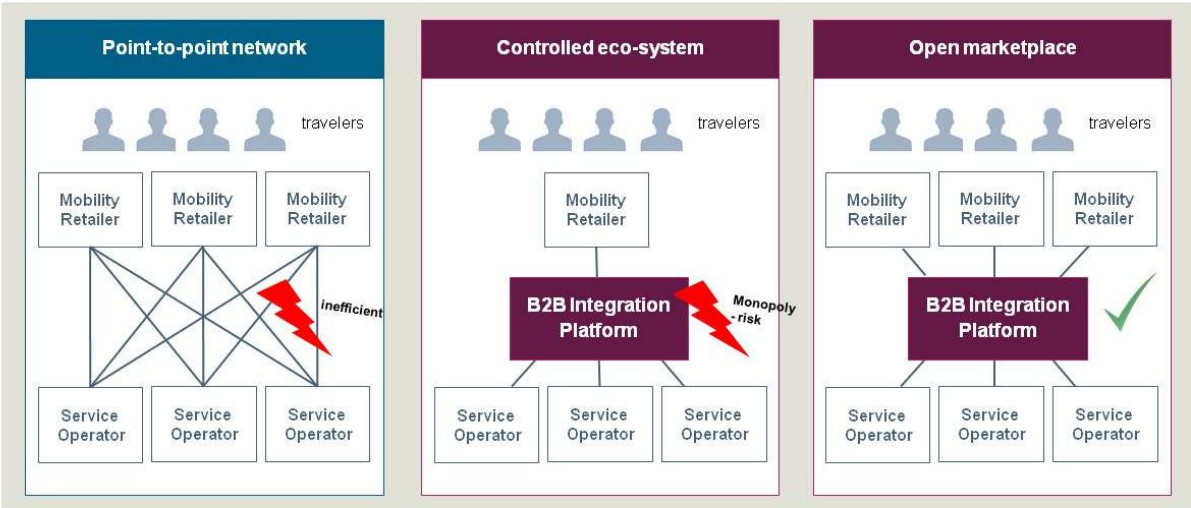

Figure 6: The rationale behind an integration platform

The Tampere platform will offer the following functionalities:

- Collect real-time data from various operators on the diverse transportation networks,
- Plan intermodal routes, which take into account real-time travel conditions, current availability of shared services, and user preferences, so as to enable people to make a well-informed, rational travel decisions,
- Enable booking, reservation, and purchase of MaaS partner services, whether public transport, taxis, or parking spaces, thereby lowering the barrier to access,
- Process electronic tickets and provide them securely to the traveler, possibly supported by the integration of convenient hands-free ticketing technologies,
- Administer partner accounts and manage service offerings and requests between partners,
- In a future step, support a discreet and intelligent travel companion, which feeds travelers with context- and location-sensitive intelligence, through the use of intelligently placed beacons or geosensing technologies interacting with the back-office platform.

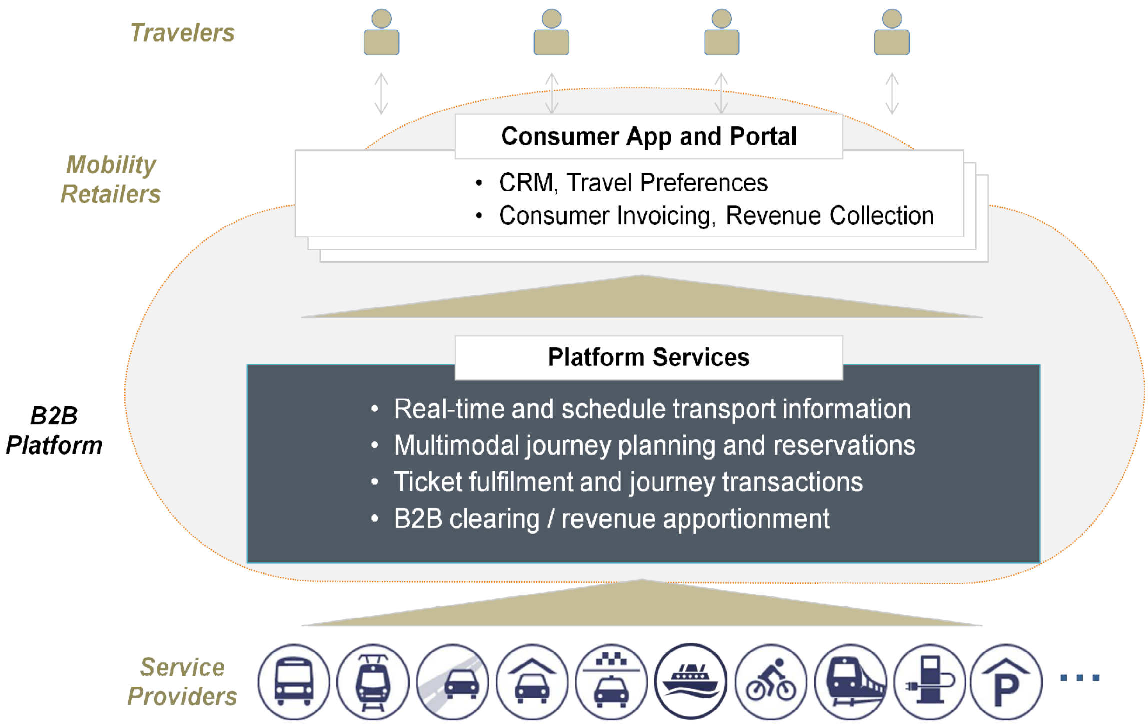

Figure 7: Traditional MaaS ecosystem

The B2B Platform provides fundamental services for all parties enabling them to integrate their offerings, thus reducing investments of each single party and overall complexity.

Typically, **Mobility Retailers**, such as a MaaS operator, provide travelers with trip information and sell or resell further mobility services to travelers, in form of reservations and ticketing.

They provide a front-end user interface in the form of a smartphone App and an E-commerce module which

- store customer data
- may collect revenue from the traveler

Service Providers deliver the actual transportation service. These can be different public transport operators, but can also include car-sharers, bike sharer, parking providers, etc. Service Providers may or may not be the same legal entity as Mobility Retailers.

When it comes to Mobility as a Service, typically a Mobility Retailer sells services from multiple Service Providers and each Service Provider deliver transport services to travelers who have a contractual relation with someone else, possibly different Mobility Retailers, such as the MaaS operator.

The two-layer model describes the specific requirements of the mobility sector:

- The Retail Layer or Business to Consumer Layer (B2C) comprises all customer-related functionalities as well as the Mobile App and, if required, the Web User Interface. In this way, a uniform and comfortable customer experience can be offered to travelers.
- In an integrated backend, the Wholesale Layer (B2B) summarizes all background activities in Tampere, which are related to other business partners. This layer enables not only the easy and cost-effective operation of the platform, but especially also the extension of the platform as well as the easy and fast integration of new partners and services.

One of the core modules of the proposed solution for the City of Tampere is the B2B platform. In addition to the B2B platform the Tampere MaaS ecosystem will include one or more MaaS operators which will act as Mobility Retailers and will interface with the B2B platform via a RESTful interface to perform the following functions:

- Multimodal travel planning (journey times and prices)
- Booking and payment for different services

Furthermore, within the framework of the Project, four transport service providers (the so called “Service Providers”) in addition to TL, will be integrated to the Tampere Maas operating environment.

The recognized service providers to be integrated are:

1. Tampere region public busses: TKL
2. Tampere Parking facility: Finnpark
3. Tampere local taxi center: Tampereen Aluetaksi
4. Train (VR)

Interfaces are to be developed between the system providing data from the Service Providers and the B2B platform, for the acquisition of transportation data: these include schedules, location of bus and train stops, location and availability of taxis and of parking structures, in real-time whenever available.

3.2 Tampere: the MaaS ecosystem with Tuomi Logistics

In Tampere, the traditional MaaS ecosystem will enable travelers to receive trip information and make booking and payment operations through a smartphone app, as follows:

1. Support travel booking and payment via a smart phone application and B2C layer, provided by the MaaS operator, which feeds on data delivered by the B2B platform (see description of **Use Case 0**)

Furthermore, the traditional MaaS ecosystem will be interfaced with the dispatching system of Tuomi Logistics (the so-called "DDS system"), to achieve the following objectives:

2. Opening of the Tuomi Logistics-trips to "regular travelers": MaaS customers, i.e. people who are not Tuomi Logistics customers which benefit from rights to specific transportation services, will be offered the option to use pre-planned TL routes in addition to the various available transportation services (public transport, taxi, or other modes), sharing the price of the trip. The actual price may be a fixed, flat fee or a price dependent on the trip length. This way TL will receive a portion of the route price from the MaaS operator, thus significantly reducing TL's overall costs (see description of **Use Case 1**)

3. Providing public transport information and travel options for Tuomi Logistics customers. Those TL customers which are able to use public transport to cover longer portions of their trips will be provided the option to use a combination of taxi and public transport. Longer trips using such Taxi/Public Transport (PT)/Taxi combination will be more cost-effective for TL, thus generating saving potential for TL (see description of **Use Case 2**)

A possible extension of the project may include the analysis of the future possibilities for combining KELA "hospital" trips with the trips operated by Tuomi Logistics

The pilot system consists of two different operating environments 1) Tuomi logistics environment, and 2) the regional MaaS environment of Tampere, which will be connected by the B2B platform through appropriate interfaces. The Tuomi Logistics environment will continue to operate its call center as "user interface" and will benefit from the MaaS environment, including user interface (the smartphone app) for opening their trips to "regular" travelers.

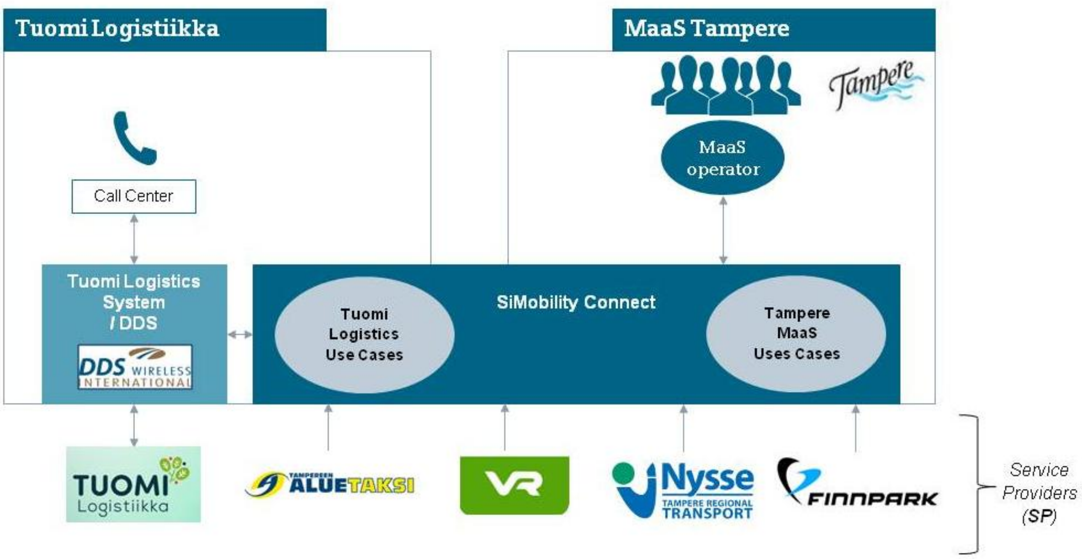

Figure 8: The high-level Architecture in Tampere

According to the proposed architecture and the use cases described above, Tuomi Logistic acts both as a Mobility Retailer and as a Service Provider.

In Use Case 1, TL acts de facto as an additional Service Provider, in that travelers using the MaaS interfaces will be able to use services offered by Tuomi Logistics (e.g. by sharing taxis with selected Tuomi Logistics customers)

In Use Case 2, TL acts de facto as a Mobility Retailer, in that TL's dispatching service will be able to consider services offered by the Tampere Service Providers (bus, train, taxi) in addition to their own services.

The selected modular architecture offers both conceptual and architecture-specific advantages for Tuomi Logistics, for a MaaS operator and for the City of Tampere. This modular concept enables the reproduction of the City of Tampere requirements in the short term, as well as the flexible implementation of further future requirements.

4 System Architecture

This chapter describes the system architecture in Tampere, through the functional and non-functional requirements of the various modules and the interfaces required among such modules.

At the core of the Tampere system architecture, the B2B platform provides the integration layer among the various systems. The functional and non-functional requirements of such layer are described in Chapter 4.1

The Mobility Retailer functionality in Tampere is provided by the MaaS operator(s), responsible for the User Interface, in the form of a smartphone app through which a traveler can plan their travel and make reservations or buy tickets for the appropriate modes of transport, supported by an E-Commerce module responsible for managing the financial transactions (booking or purchase of a ticket). In addition to the MaaS operator, in Tampere, a special case of User Interface for a specific user group (the Tuomi Logistic customers) is provided by the Call-Center of Tuomi Logistics, responsible for accepting calls from customers and requesting trips to the MaaS architecture, via the B2B platform, as described in Use Case 2. The functional modules and the roles of the Mobility Retailers in Tampere are described in Chapter 4.2.

The actual transportation services are provided by the local Service Providers. In order to enable a traveler to search for a given route, select a route option, and perform the necessary reservation (e.g. for a taxi), and payment (e.g., of a bus ticket), via the B2C and the B2B layers, the Service Providers need to make information about their services available to the B2B platform through specific interfaces. Such interfaces are described in Chapter 4.3

4.1 Integration Layer

4.1.1 Functional Requirements

A MaaS operator assumes the role of a Mobility Retailer, providing the smartphone App required by a traveler to interact with the Tampere MaaS system, and the required back-end B2C layer.

The proposed solution enables the implementation of the following functions in Tampere:

- Journey planning
- Real-time schedules, whenever these are made available by the service providers
- POI data (stations, departures, arrivals, etc.)
- Purchase of public transport tickets, whenever an electronic ticket is available and thus can be forwarded to the Maas customer’s App.

The B2B Platform is able to integrate functionalities from Service Providers across a wide variety of mobility modes.

Usually an individual Service Provider supports the following general functionalities:

- Providing static and dynamic information about the service offering (dynamic information may contain e.g. delays of public transport or availability of shared services)
- Enabling Reservation and/or payment by providing a proof or travel (e.g., a mobile ticket or a reservation)

To integrate the mobility services of a Service Provider the following prerequisites are required:

- Agreement to use the interface and provided data
- Interface specification (usually a web-service interface)
- Access to the interface (credentials); best practice is to have a staging and a productive system.

The B2B platform is operated on a thoroughly selected cloud provider. In this way, maximum scalability can be achieved for Tampere when the number of transactions increases and the functional requirements rise.

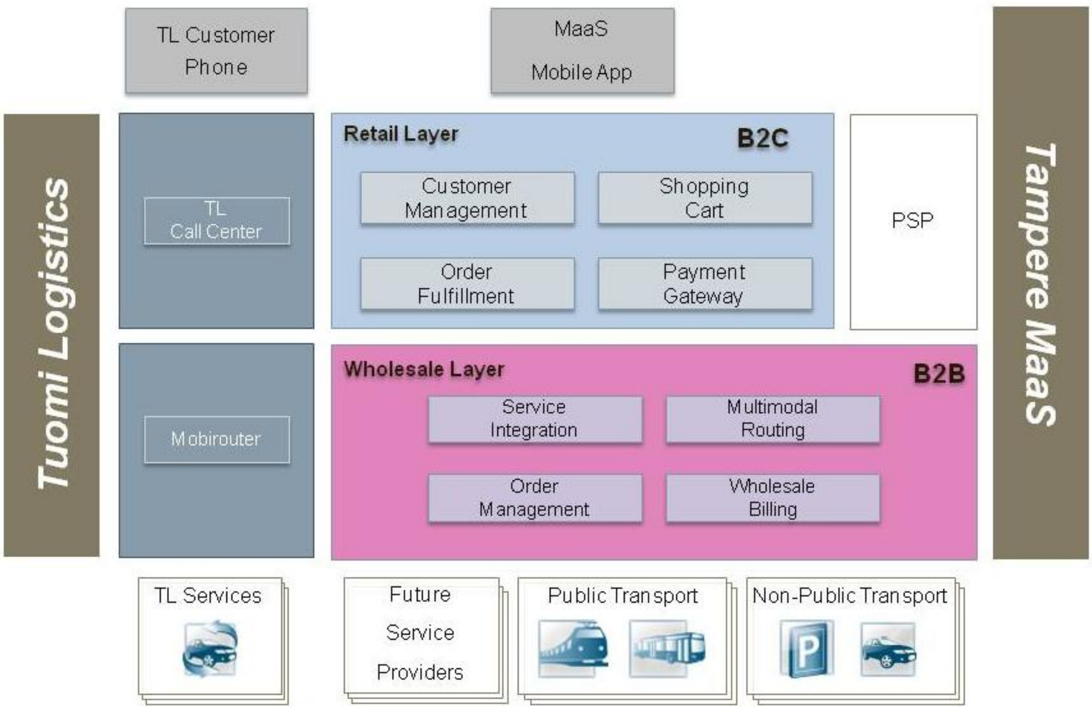

Figure 9: Functional View on the Tampere MaaS and Tuomi Logistics Architecture

The modules of the Retail and Wholesale layers are described as follows:

For the Retail layer:

- Customer Management – management of customer data, including settings, profiles and preferences
- Shopping Cart – virtual shopping cart of the end-customer
- Order Fulfillment –accompanies and monitors the process from customer inquiry to delivery of the solution to the customer
- Payment Gateway – gateway to the Payment Service Provider (PSP)

For the Wholesale layer:

- Service Integration - integrates functionalities from the Service Providers across a wide variety of mobility modes
- Multimodal Routing – multi-model journey planning, combining transit, pedestrian, bike, and car segments.
- Order Management / Wholesale Billing - mobility services are booked, followed up and settled; enables bundling the services of different mobility providers, and it takes over the settlements between the providers

The B2B Platform has a **standardized interface** in the form of a uniform RESTful interface. It makes the services of the partners available to the B2C Layer, regardless of their different interfaces.

In the solution architecture, the B2B Layer is completely addressed by the B2B Platform. Due to the modularity of the platform, individual modules can be replaced or added in the future if conditions change, but - in contrast to other solutions - the platform itself needs not be expensively replaced.

As a Wholesale Layer, the B2B Platform controls the major part of the activities "behind the curtain" between the service providers and the different mobility retailers. Here, mobility services are booked, followed up and settled. This layer enables bundling the services of different mobility providers, and it takes over the settlements between the providers, in a completely transparent manner for the end customer.

A **multimodal route planner** forms the basis for implementing the routing requests via the B2B Platform. The intermodal route planner is an extendable modular system, which integrates dynamic and static data from different service providers, and calculates a set of multimodal door-to-door routing options considering real-time data, so that travelers are reliably and completely informed about their journey.

The integration of the route planner within the B2B platform adds the flexibility when handling with different routing engines by providing a unified interface to the client. It also enables to add additional information to the routing response (e.g. pricing information in case the routing engine does not provide this information itself).

To calculate routing options for cars (e.g. for taxi or “the own” car) external dynamic road traffic routers can be integrated. Bike and pedestrian routers can also be provided, as shown in the following figure

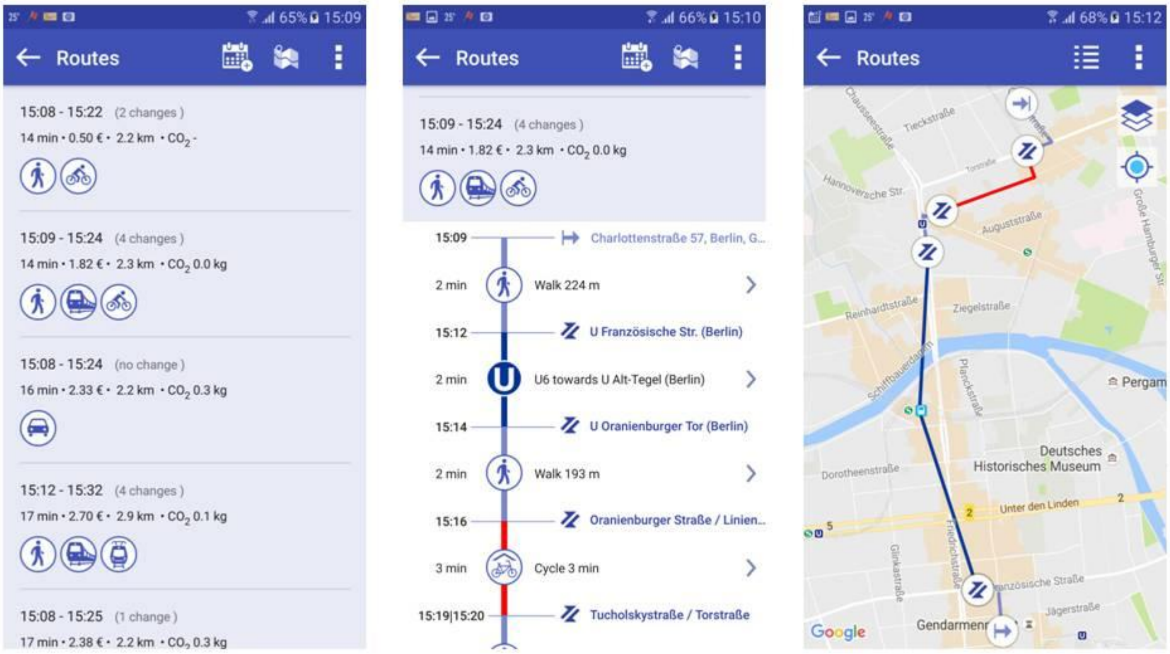

Figure 10: An exemplary display of the results of the multimodal Router

The multimodal router has the possibility to be expanded through the integration of the following services:

- Station-dependent car sharing (rental and delivery at the same station)
- Station-independent car sharing (flexible rental and delivery within a business area)
- Station-dependent bike sharing (rental and delivery at one station; the stations need not be identical)
- Station-independent bike sharing (flexible rental and delivery within a business area)
- Taxi
- Charging posts (considering the current availability)
- Parking lots (considering the current availability)
- Static parking lots (parking lots without availability information)
- Parking garages
- Park+Ride
- Bike+Ride

This provides a large number of modal, multimodal route combinations, which are taken into account by the multimodal router.

In Tampere, a specific intermodal routing service will be available that combines TL shared-taxis, regular Taxis and PT to address the requirements of the specific use cases.

The basic routing algorithm will consists of following steps:

- Search for the closest public transport station (S1) to the start location A
- Provide a shared-taxi/taxi route from location A to S1
- Provide a public transport route from S1 to end location B
    - o This route may include a last-mile walk segment from end station S2 to end location B, as shown below

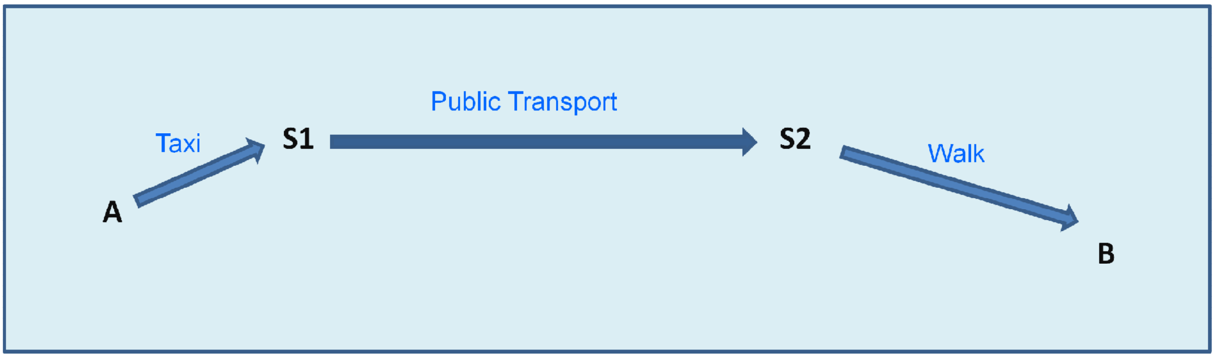

Figure 11: graphical representation of an intermodal route

Further improvements of this algorithm may include:

- Replacing the last mile walk segment with a shared-taxi/taxi route
- Searching for multiple public transport stations at the start location A in order to determine the most suitable public transport route, based on specified criteria (time, distance, number of changes)

4.1.2 Non-Functional Requirements

The proposed architecture has an open and modular design. The architecture stipulates a clear assignment and separation of data and processes. This makes the mobility platform scalable, and enables Tampere to flexibly and quickly integrate new products and functionalities. Moreover, the architecture provides a functional separation between B2C and B2B components. The further implementation and development of the platform assumes as a prerequisite that the developer is able to reference wide experience in the area of agile development with standardized methods and tools.

The flexibility of the proposed solution offers the City of Tampere comprehensive benefits from a conceptual point of view:

- With the **customer- and user-experience-focused architecture**, Tampere wins new customers: A core aspect of the proposed architecture is the transformation of presently anonymous travelers into registered MaaS customers, who are offered a simplified, comfortable planning and execution of multimodal journeys in the Tampere region, and who can be offered individual, journey-related services.

- **Open, modular architecture**: The proposed architecture has an open and modular design. The architecture stipulates a clear assignment and separation of data and processes. The flexibility and extensibility achieved in this way makes the mobility platform scalable, enabling further extensions.

- **Channel-agnostic architecture**: MaaS customers benefit from a consistent and holistic customer experience. A channel-agnostic architecture guarantees this across all possible sales channels (Mobility App, Online Shop, Mobile Web/Web). As customers per se do not think in a channel-related way, the MaaS customer channels – whether Mobile App or Online Shop – are based on congruent processes with adapted points of contact. This interaction with the customers across several channels makes the limits of the channels almost disappear.

- **Multi-tier architecture**: A multi-tier architecture makes an explicit functional separation between B2C and B2B components, so that MaaS retail and wholesale functions can be separated specifically for the enterprises.

- **Multi-tenant architecture**: A multi-tenant architecture enables the coexistence of multiple mobility retailers, thus providing a scalable infrastructure setup in Tampere. In this way, Tampere can make an even more cost-efficient use of the mobility platform's infrastructure. Separate instances of the eCommerce platform can interact with the B2B Platform at the same time, thus ensuring the use of the platform by several tenants (e.g., Tuomi Logistics, a MaaS operator, and possibly other mobility providers). Users of different tenants cannot see into the rules, data, processes, users and authorization structures of other tenants.

- **Data lake**: With the B2B Platform, Tampere receives a foundation for future analyses of mobility data: The data lake principally integrated in the base architecture of the B2B Platform can serve for archiving all journey-relevant data, and then be used for specific analyses (for example, for capacity planning, product development or pricing).

- **Data security** (IT security) and **data protection**: The proposed architecture guarantees all necessary data security for all system parts, interfaces and user roles, complying with all relevant data protection directives.

- Explicit **separation between layout / user experience and the core application**: Mobile App Framework and eCommerce provide the necessary core functionality. The project-specific user experience and layout are each implemented in layers based thereon.

- **Standardized interfaces**: Few and standardized interfaces between the products make integration easier and simplify project implementation. External partners can be efficiently integrated via the B2B Platform. This is done by abstraction from the partner-specific interfaces for the B2C Layer.
- Use of **future-proof software**: As the architecture relies on COSS (Commercial Open Source Software), Tampere will receive a state-of-the-art and, and at the same time, cost-efficient solution architecture. For this purpose the Java-based middleware JEE (Java Enterprise Edition) is suggested.
- Use of **microservices**: This is an architecture pattern combining complex applications from small and independent processes/services. Important advantages of the microservices used by The B2B Platform, in particular in the B2B area, are:
  - Microservices improve the robustness of the overall system, as the failure of individual services should not cause the breakdown of the overall system.
  - They can be scaled independently of each other.
  - They are independent of each other; therefore, different teams can develop independently of one another, even using different technologies.
  - Microservices are clearly overseeable as regards the scope of functions. This makes further development and maintenance of individual services easier.
- **Scalable operation** in the cloud: The components of the proposed solution architecture enable a scalable and cost-effective operation in the cloud. Furthermore, a high availability of the mobility platform can be guaranteed.
- **Agility in the development**: The proposed architecture enables an agile development approach as regards implementation. The successive extension of individual components can be done modularly to guarantee an agile realization of the mobility platform as well as an efficient operation in an appropriate time frame.

The B2B platform has to have state-of-the-art and, at the same time, cost-efficient architecture which is built based on mature commercial open source software, widely used in the industry, as shown in the figure below. Such open source software may include

- Java as the core technology
- JEE application server Glassfish
- Apache Camel as routing and mediation engine
- PostgreSQL as relational database
- MongoDB as NoSQL database
- AngularJS as UI framework
- Activity as BPMN engine

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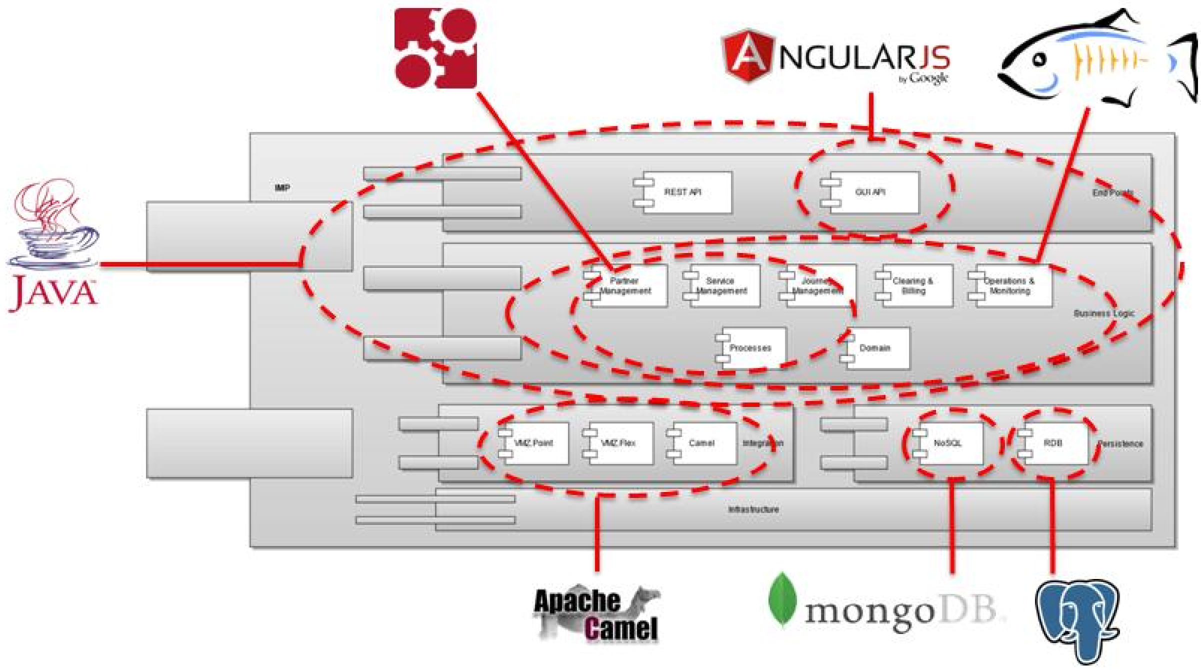

Figure 12: 3rd party Software used in the B2B platform

The relevant activities of the system will be written to log files. The system uses the Elasticsearch, Logstash and Kibana (ELK) stack to analyze the log files. Elasticsearch collects the logs from different sources and indexes and stores data and provides a retrieval engine. Old data in Elasticsearch is cyclically removed. Logstash is used to slice and dice the data whereas Kibana is a powerful tool to display the derived data in a graphical manner. Based on Kibana we will provide a standard dashboard and reports to monitor and analyze the activities of the system. This tool can also be used by the operator to create own dashboards or reports in a flexible way.

As **open and modular architecture**, the B2B Platform covers a **"Workflow Engine"**, which centrally manages the flow of data and messages between the different components, thus guaranteeing a smooth interplay between the customer integration layer and the systems of the players in Tampere.

4.2 Mobility Retailers

The Mobility Retailer offers the mobility services via a retail system which may consist of a retail backend and the corresponding frontends like a smartphone app or a web UI to their end-customers, the travelers.

4.2.1 MaaS Operators

A MaaS operator assumes the role of a Mobility Retailer, providing the smartphone App required by a traveler to interact with the Tampere MaaS system, and the required back-end B2C layer.

4.2.1.1 Front-end

The Mobile App Framework is an already developed smartphone platform which supports a firmly defined scope of functions stipulated by the Service Layer. To cover Tampere-specific requirements, the Service Layer will be extended accordingly. Alternatively, an existing app can also be extended in accordance with the Tampere requirements, or a new app can be developed by a third party.

The Mobile App must perform the following functions:

- **Route request**
  The traveler can create point-to-point route requests. The entry of origin and destination can be done in different ways (form, map, favorites, address book, calendar, or search history). The traveler can modify departure and arrival times, or set specific preferences on the modes to be used.

- **Route results**
  The Mobile App displays search results graphically on the overview page, with price, connection times and means of transport. The traveler can filter the results. In addition, the detailed view offers various navigation options (purchasing the ticket, saving in "My journey").

- **In my vicinity**
  The Mobile App shows stops and similar issues on a map of the environment. This map also supports the representation of live data.

- **My journey**
  The Mobile App displays saved and booked connections in an overview page. The detailed view of a connection shows the customer the map, information, ticket and connection details on one page.

- **Tickets**
  The traveler should be able to buy tickets directly out of a routing request. Besides the classical tickets, the traveler can book further services on request. In a simpler form, ticket purchase and reservations can be obtained through a link to the booking system of the service provider.

- **Profile**
  The traveler can save personal settings in their profile.

- **Settings**
  In the settings, the customer can make telephone-specific settings. These are: push notification, language selection, wallet integration, and the use of the touch ID.

The modular architecture of the Mobile App Framework allows reusing the core functionality and the backend connection, also offering the flexibility to design an independent customer-specific user interface. The user interface and the platform-specific implementations should be provided separately in individual packages for each platform, thus ensuring maximum flexibility regarding the interface design.

4.2.1.2 B2C Layer

The B2C layer consists of a series of logically, partly also technically independent components. Here, open source software or commercial open source software are to be used to guarantee flexibility and openness to future expansions. Alternatively, components of an existing eCommerce platform can be integrated, or extended.

The B2C layer logically consists of two components: the Entry Layer, which accepts requests from outside and decides on their further processing and the classical eCommerce module.

The Entry Layer ensures a consistent point of entry for the native Mobile Apps. The separation allows for a clean distinction between the shop functionality and the security/admin functionality.

At the same time, the Entry Layer is in charge of the consistent authentication and authorization of external requests.

The core functions of the **eCommerce component** comprise:

- A shopping cart for collecting tickets or vouchers etc. before checkout
- Checkout: The actual purchasing process incl. payment
- Order management: the purchases made, as well as their management
- User management: Customer profiles, settings, registration, changes, deletion, etc.
- Reporting: Provision of commercial reports
- Admin-Back-Office: Functions to the administration of the solution, as well as access for service / back office staff.
- Management of customer account
- Management of invoice and delivery addresses
- Viewing of purchase orders
- Billing agreements resp. payment tokens.

The **payment transactions** are normally processed via an external payment service provider.

4.2.2 Tuomi Logistics

Use Case 2 describes the case in which a selected subset of TL customers is provided with the option to perform their trip using a combination of public transport and taxi. For the deployment of such use case, the TL Call-Center, supported by the underlying TL scheduling system, acts de-facto as a Mobility Retailer for TL customers, providing routing requests to the B2B platform and receiving in return routing options.

For this, a specific interface will be developed between the TL scheduling system and the B2B platform.

4.3 Service providers

Each Service Provider (SP) is integrated into the B2B Platform by implementing the specific interface provided by the SP. The details of the interfaces are provided below.

4.3.1 Public Transport and Trains

Travel information services, such as schedules, real-time deviations from schedules, as well as routing services for the Tampere local buses and for the National Rail (VR) can be retrieved by the Digitransit service.

Digitransit provides the most comprehensive PT router for Tampere and Finland. At time of writing the service is not yet fully productive and stable but the go-live is planned for autumn 2016.

An API is available to access the routing engine – the documentation is available under https://digitransit.fi/en/developers/services-and-apis/1-routing-api/

The routing engine supports different transportation modes, depending on the provided routing data. Currently used data are described here: https://digitransit.fi/en/developers/services-and-apis/6-data-containers/routing-data/

There are 2 options to use the API:

- GraphQL interface – a standard created by Facebook (http://graphql.org/), can be used for
    - Routing with itinerary planning
    - Disruption info about current and upcoming disruptions in public transport
    - Public transport lines information
    - Public transport stops information
- REST interface provided by OpenTripPlanner (http://docs.opentripplanner.org/en/latest/)

GraphQL interface is the preferred solution, as it is the primary interface provided by digitransit.

There are 2 options how the service can be integrated into the B2B platform:

- Using as a web service, in which the service provider is responsible for hosting and maintenance of the service. This is the preferred solution since it avoids redundancies and inconsistencies between the Tampere architecture and Digitransit. In this solution:

  - The service is hosted by Digitransit
  - The service is integrated into the B2B solution as all other service providers
- Using as a self-hosted solution, as all the source code is available for download. This however requires the MaaS system to periodically update the source code whenever new source code is made available by Digitransit.

Currently the service does not include any price information about the trips. For MaaS operation to be effective, a link to or the interface with a ticketing service is required. Such service can be provided in following options:

- Simple tickets
- Tickets based on routing with tariff information
- Tickets based on tracking information, e.g. through a Be-In / Be-Out (BiBo) solution.

A data use agreement must be reached between the provider of information service and the MaaS system.

4.3.2 Taxi

The local taxi service can be integrated within the MaaS platform through the following data interface, from Taksiliiton Yrityspalvelu Oy.

An API is available to access the national taxi system. The API is implemented as a REST/JSON interface:

- The use cases http://taxi-api.fi/taxiapi-use-cases-1.0.pdf describe how to order a taxi (ad-hoc, per-order, taxi-sharing), check the order status and how to cancel it
- The API specification http://taxi-api.fi/taxiapi-apidoc-1.0.pdf, can be used to
  - Check the availability of a taxi
  - Get an estimate price (non-binding)
  - Create/update/cancel an order

The API does not support payment. Currently there are two options:

- Pre-paid: travelers don’t pay the taxi directly, since they are charged by the MaaS-operator, which refunds the Taxi service.
- Travelers pay for the trip in the vehicle at the end of the service.

4.3.3 Parking

Information about Finnpark parking availability in Tampere can be made available via two alternative services:

- Parkopedia: with a wide range of parking garages and parking zones in Tampere. An interface already exists between the B2B platform and the Parkopedia service.
- Directly via Finnpark: Finnpark makes information available on their parking structure through a DATEX II interface, which provides the following services:

- o Static data, provided for Finnpark parking only
- o Dynamic data, such as the current occupancy status, is provided for some of the parking spaces
- o Reservation service is available for some of the parking spaces, but not as a web service, just as a contact information for where to find details about the service for (e.g. URL, telephone number)

  The following API are available (See DATEX II documentation for details):

  - Parking status publication – dynamic information about a parking site
  - Parking table publication – static information about a parking site
  - Parking vehicles publication – static information about parking vehicles

Depending on which service is used, a separate commercial agreement between the MaaS operator and either Parkopedia or Finnpark is required for using the services.

4.3.4 Tuomi Logistics

Use Case 1 describes the case in which MaaS customers, i.e., regular travelers are able to use TL travel services, whenever pre-planned trips have already been scheduled which have capacity for additional travelers. In this Use Case, the MaaS operator is able to provide an additional “shared-taxi” service, which will be available to travelers either at a fixed price or at a fee which is dependent on the length of the trip and is considerably cheaper than the regular taxi price.

For the deployment of such use case, the TL shared-taxi service acts de-facto as a Service Provider, receiving routing requests, comparing availability with already scheduled TL trips with spare capacity, and returning routing options to the B2B platform, which will be forwarded to the MaaS operator.

For this, an API is available to access the DDS system. The API is implemented as a REST/JSON interface and is based on the Transit API provided by DDS Wireless.

The document “DDS_Siemens_Mobility_platform_interface.pdf” describes the interface currently provided by the DDS system. As described in Section 5.2 TL may decide to offer MaaS customers only those routes which bring an economic advantage, thus this interface must be adapted so as to enable the DDS system to provide the B2B platform only a selection of the routes and not all valid routes

The basic functions provided by the new interface are:

- Getting a trip proposal (routing)
- Booking of a trip
- Cancelation of a trip

- Getting the current status of a vehicle

Following diagram depicts the basic flow including routing and booking a trip:

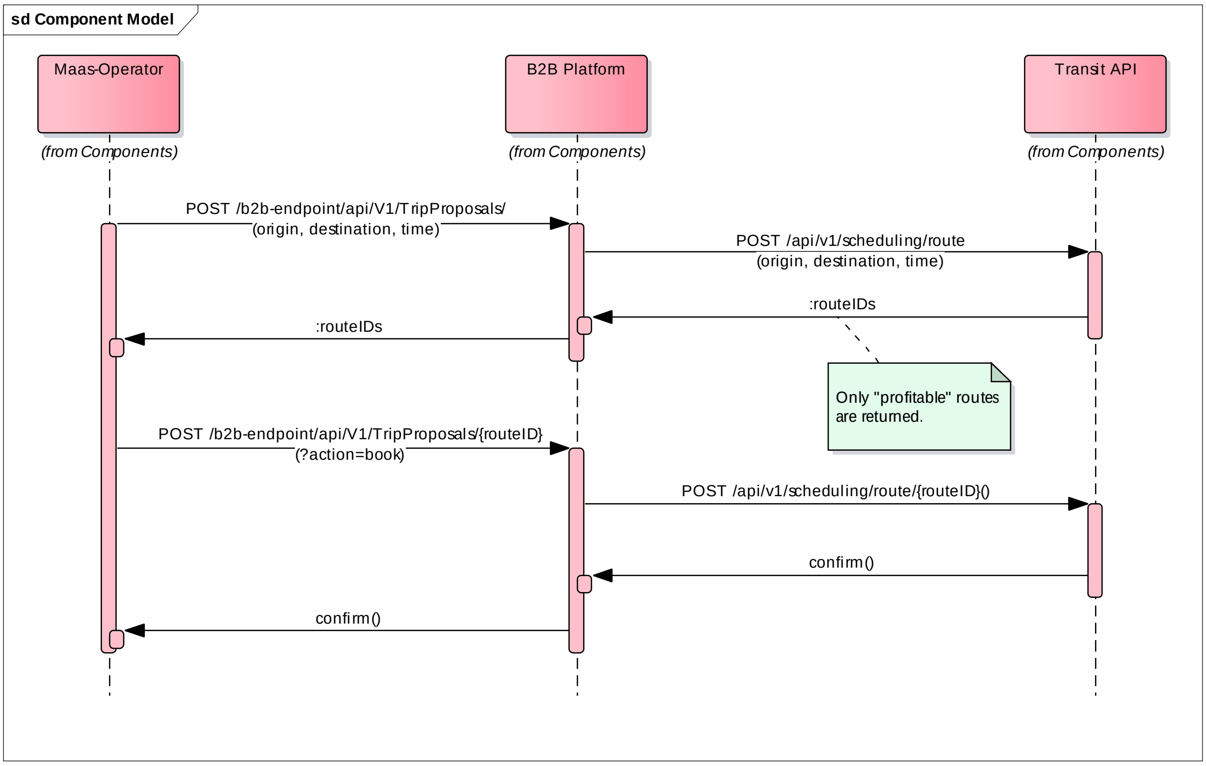

Figure 13: the interface between the DDS system, the B2B platform, and the MaaS operator

5 Use Cases

As introduced in the previous chapters, the main objectives of the proposed system are to a) create readiness for the start of a MaaS operation in Tampere, providing citizens with access to multimodal travel services (e.g., combined route planning, ticketing, booking for taxis and public transport) and thus reducing their need for driving; b) to extend the access to the pre-planned Tuomi Logistics trips to "regular" citizens, and c) to shift some of TL trips from taxi-only to a combination of taxi and public transport, whenever feasible.

Such objectives are to be achieved through the use cases highlighted below, which describe how the various subsystems are going to interact with each other. The various subsystems are named as follows:

- MaaS_OP: the MaaS operator
- CONNECT: the mobility platform
- SP: the service providers: Alue Taxi, Nysse, VR, Finnpark
- TL: Tuomi Logistics
- DDS: the dispatching system of Tuomi Logistics

5.1 Use Case 0: Regular MaaS operation

This use case describes the "standard" use of a MaaS system: the traveler (whether citizen or tourist coming to the Tampere region) needs to perform a trip from an origin to a destination at a given time. She queries the MaaS Operator for service availability, receiving a list of options with different modes (by public transport, by taxi, by car, by bike, walking, or a combination of these). She then selects one option based on her preferences. Depending on the setup of the MaaS operator, the traveler either already has a "mobility package" which includes for instance access to public transport and taxis, or has the possibility to purchase a public transport mobile ticket or to book a taxi. These different levels of access are to be achieved progressively, through a phased-development of the system.

The interaction process between user and system is described by the steps below:

Route Search

1. User searches MaaS_OP for trip (A, B, time)
2. MaaS_OP queries CONNECT for trip (A, B, time)
3. CONNECT queries SP: train, bus, road, walk, bike
4. CONNECT returns to MaaS_OP list of available routes and prices
5. MaaS_OP returns route options with prices to user

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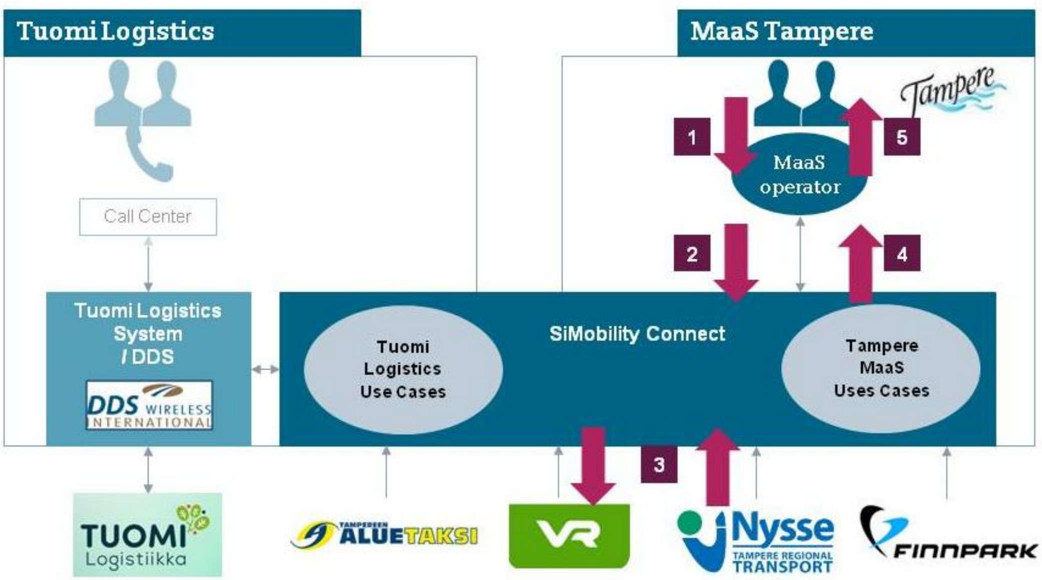

Figure 14: Description of Use Case 0

Route booking / payment

1. User selects trip X for booking via MaaS_OP
2. MaaS_OP asks CONNECT to book trip X
3. If trip is on
    - PT, CONNECT retrieves PT-ticket from SO (bus, train)
    - Taxi, CONNECT books taxi via SO (prepaid only, or user pays for taxi directly after trip)
4. CONNECT return PT ticket or taxi reservation to MaaS_OP
5. CONNECT manages billing & clearing with train, bus, taxi (with support by PSP[1)])
6. MaaS_OP returns ticket and proof of booking (MaaS_OP sends invoice to customer either immediately or every time period)

This use case is expected to yield the following benefits:

- Travelers have easy access to more travel options in addition to their cars, thus progressively reducing their need for driving
- Information about the availability of public transport and taxis, coupled with an easy access to booking and ticketing is expected to increase the use of these modes in the mid-term, especially when travel supply is adapted to user demand. Analytics on travel demand (trip origins and destinations, travel pattern such as time of days and day of week) which can be provided by the MaaS operator will facilitate the adaptation of public transport and taxis supply in the mid-term, thus improving their operations.

- <u>The City of Tampere and the local communities</u> will benefit from a reduced overall environmental footprint, resulting from a reduction of single-use car trips in favor of public transport and shared taxis.

5.2 Use Case 1: Public on-demand transport

This use case describes the opening of preplanned TL trips to "regular" travelers. Thus a MaaS customer receives scheduled TL trips via shared taxis, whenever available, as an additional trip option. The additional provided service is de-facto a shared taxi, operated for Tuomi Logistics, thus carrying one or more TL customers, but also offering a travel option to regular travelers who are willing to share a taxi at a reduced price. The travel price will have to be set by TL and be subject to market dynamics. A possibly pricing scheme may consist for instance of a given portion of a taxi price.

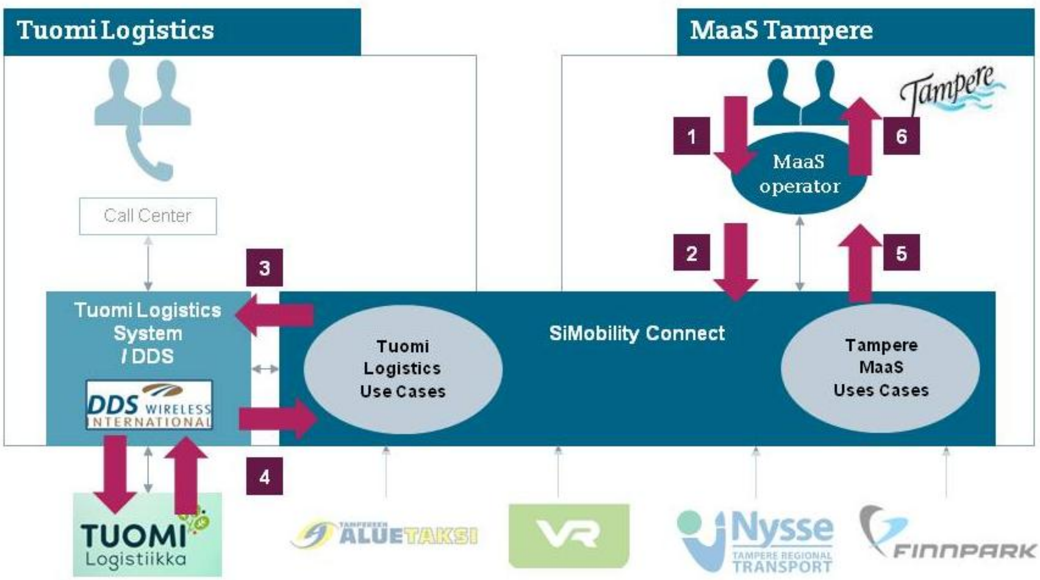

Figure 15: Description of Use Case 1

The interaction process between user and system is described by the steps below:

Route Search

1. User searches MaaS_OP for trip (A, B, time)
2. MaaS_OP queries CONNECT for trip (A, B, time)
3. CONNECT queries DDS for trip availability "**sufficiently close"** to (A, B, time)
    - If TL (via DDS) has a scheduled trip,
4. DDS provides CONNECT with availability and price
5. CONNECT includes option for TL in available routes to MaaS_OP

- If TL (via DDS) has no trip scheduled,

5. CONNECT provides only non-TL trips to MaaS_OP
6. MaaS_OP returns route options with prices to user

6. ***Route booking / payment***

1. User selects trip X for booking via MaaS_OP
2. MaaS_OP asks CONNECT to book trip X
3. CONNECT asks DDS to book trip X
4. DDS add trip X to TL planned trip and returns proof of booking to CONNECT
5. CONNECT returns proof of booking to MaaS_OP
6. MaaS_OP returns proof of booking and invoice to customer
7. CONNECT stores billing info on trip for TL

This use case is expected to yield the following benefits:

- Tuomi Logistics will be the main beneficiary of this use case, by having additional customers share the costs of their scheduled trip. The addition of an additional traveler to a pre-scheduled trip may increase the trip cost of a factor that is higher than the price to be paid by such customer. This information is available to TL prior to offering the trip to the MaaS operator, thus TL may decide to offer only those trips to additionally paying customers which provide an economic advantage.
- Whenever TL trips are available, the MaaS operator benefits from being able to offer the TL-shared-service as an additional service at an attractive price, in addition to the regular bus and taxi options
- The City of Tampere and the local communities are able to provide better service for everyone, while saving costs for TL and reducing the overall environmental footprint (since a number of MaaS customers refrain from using their own vehicle)
- Travelers have additional service options, in addition to public transport and taxi
- The local Public Transport operator may profit from a lower demand in sparse areas, which are partially covered by the TL service, and thus in the mid-term be able to improve its operations.

5.3 Use Case 2: MaaS services for TL customers

This use case is a further application of the integration between the TL operation and the MaaS operation via the integration platform: in specific cases a TL customer can be given the option of performing their trip not just by taxi but rather by a combination of taxi and public transport. A subset of the TL customers which do not have to travel exclusively by taxi to their destination, may book a TL trip which includes for instance a taxi service from home to the nearest public transport stop and a then the public transport to their destination. Thus when a TL customer intends to book a trip via the TL call center, the system queries not just the available TL taxi services but also the local service providers (including public transport), via the MaaS architecture.

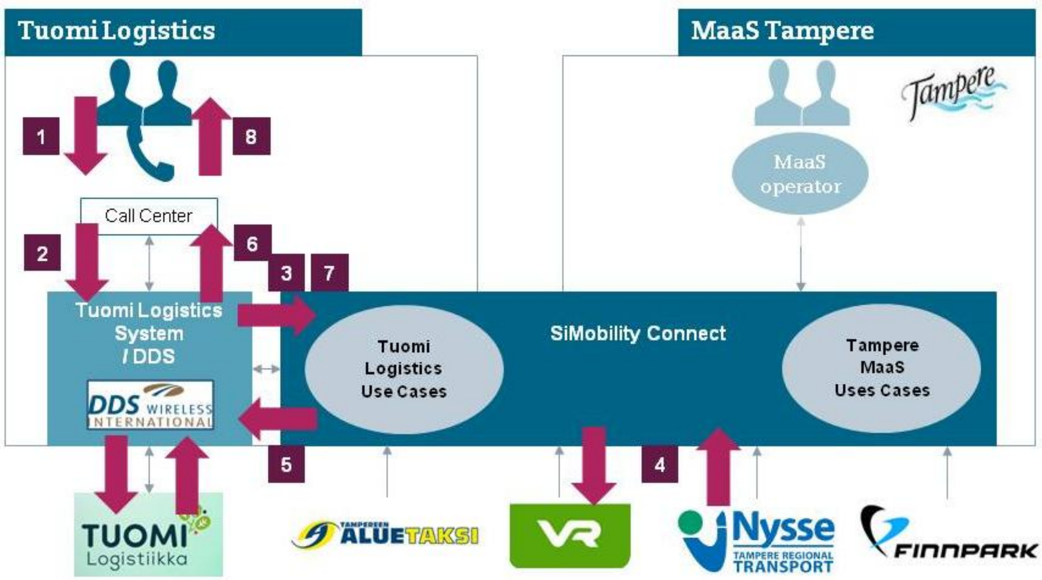

Figure 16: Description of Use Case 2

The interaction process between user and system is described by the steps below:

Route Search and optional booking

1. TL customer asks TL call center for trip (A, B, time, customer-mobility-needs)
2. If trip qualifies for MaaS, TL Call Center asks DDS for trip without mobility restriction
3. DDS queries CONNECT for trip (A, B, time)
4. CONNECT checks trip availability and price for PT / taxi trip
5. CONNECT returns to DDS availability, price, and modes
6. DDS provides route info (price, modes) to Call Center
7. If Call Center decides to use trip offering, DDS books trip with CONNECT
8. Call Center returns info (price, modes) to TL customer

This use case is expected to yield the following benefits:

- Tuomi Logistics has saving potential by offering cost-attractive alternatives (PT, taxi) to some of their customers. A suitable marketing campaign and incentive scheme may be needed to motivate TL customers to accept the possibly less attractive, but more cost-effective alternative.

- Those travelers who decide to perform sections of their trips via public transport may have saving potential, e.g. through the incentives provided by TL
- Through a reduction of the overall mileage driven by taxis to perform exclusive TL trips in favor of a combination of taxi and public transport, the City of Tampere and the local communities achieve a reduction of the overall environmental footprint.

5.4 Business Cases for the Tuomi Logistics operations

The benefits to be expected by the integration of the Tuomi Logistics and the MaaS operations as described above were estimated through an analysis of the transportation services offered by Tuomi Logistics in 2015 and their associated costs.

In particular, the benefits to be expected by Use Cases 1 and 2 were estimated as follows.

5.4.1 Business Case Use Case 1

In the year 2015, Tuomi Logistics offered about 400.000 routes to their customers, fulfilling about 350.000 trip requests.

About 275.000 routes – roughly 70% of the offered routes – could be used for offering shared services: these excluded routes with “on-the-fly booking”, routes with “no sharing allowed” restrictions and included only those with one or two passengers, thus having the potential to carry additional passengers in shared-taxi mode. These routes, with lengths varying from between 0-5 km to over 50 km within the Tampere region, had an overall cost of about 7.5 million Euro, with costs, obviously, varying with their length.

To estimate the saving potential to be obtained by opening the already planned TL routes to non-TL customers, in shared-taxi mode, the following assumptions and considerations were made:

- The use of TL routes by MaaS travelers increases with time, starting with a 20% of the available capacity in the first year and increasing to 40% after 3 years.
- The likelihood that 2 MaaS passengers book the same TL route is lower than the likelihood that 1 MaaS passenger books a TL route (i.e., the fact that a TL-taxi has additional room for 2 passengers doesn’t necessarily mean that 2 passengers are going to book that taxi route).
- The inclusion of one or more additional passengers to a preplanned route increases the route length and thus cost to TL.

- A TL-shared taxi ride is offered to a MaaS passenger at a price lower than that of a regular taxi price. Several alternatives were considered and finally agreement was reached on a pricing scheme where the fee is dependent on the length of the trip and corresponds to a portion (either a third or half) of the corresponding taxi price. A percentage of the fare is to be retained by the MaaS operator.

The overall potential profit to be gained by this integrated operation was calculated by the overall sum of the net fares paid by potential MaaS passengers to TL while subtracting the additional costs to TL due to the extension of the routes.

Such potential profit, as shown in the figure below, can be increased by the decision to fulfill only those trip requests where the fee paid by the additional traveler is higher than the cost increase. Since this information is available within the TL dispatching system at time of booking, such decision can be taken automatically and it would carry additional profit increase.

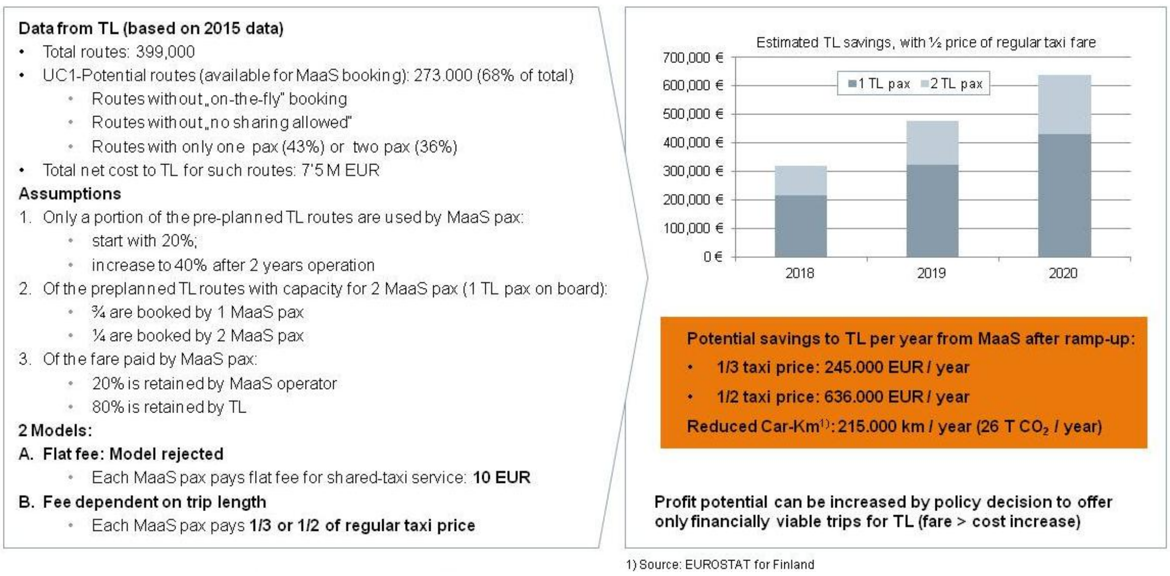

Figure 17: Business Case for Use Case 1

5.4.2 Business Case Use Case 2

The same data on routes performed by TL in 2015 to fulfill their customer orders was used. Of the about 450.000 trip requests (orders), only one third (about 155.000) was judged suitable to be performed by a combination of taxi and public transport. Several types of orders, such as those with the right to a low-vehicle, or those with wheelchair, or those with "no-front-seat" requirement were excluded.

To estimate the potential gain to Tuomi Logistics out of Use Case 2, the cost associated to the potentially suitable routes was compared with the cost resulting by using a taxi to the nearer public transport stop (assumed to be within a 5-10 km range) and using public transport to either the destination or to a stop close to the destination, finishing the trip by taxi.

Obviously, a combination of public transport and taxi is cheaper only for longer trips (at least trips longer than 10 km). For such trips, it is convenient to TL to offer such service to its customers and consider offering incentives to motivate the modal shift. In addition to the savings to TL, an overall reduction of the car-km driven was estimated, as shown in the figure below.

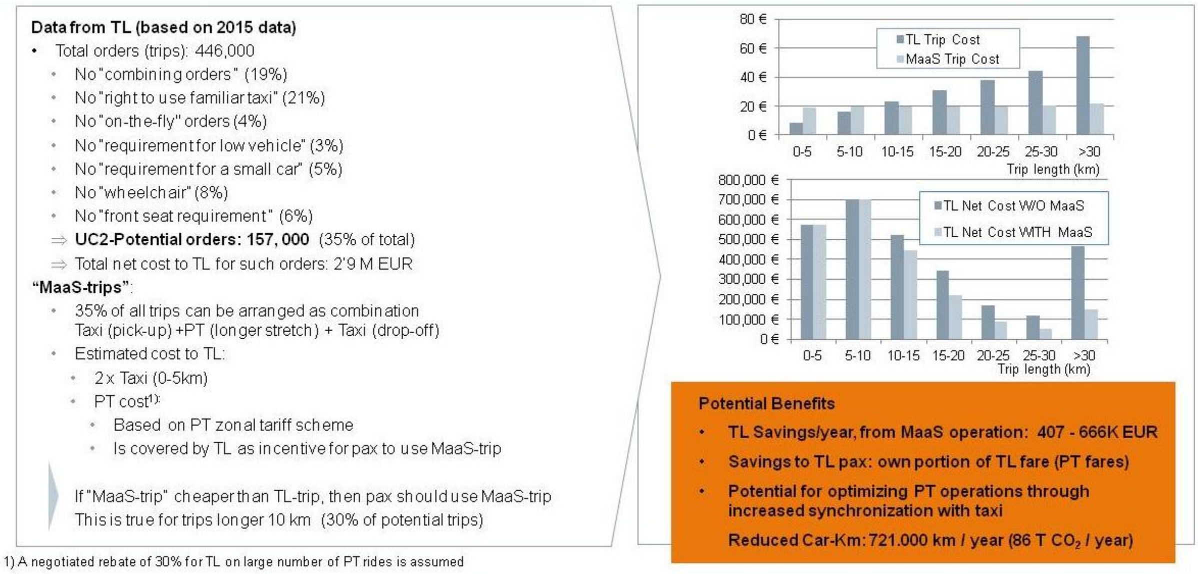

Figure 18: Business Case for Use Case 2

The calculations above for use cases 1 and 2 indicate that significant benefits, including both financial and non-financials, are to be expected by the integration of the Tuomi Logistics operation with a MaaS operation.

6 A Phased Approach

Considering the dynamicity of the mobility service ecosystem, it is recommended to develop the system architecture with a phased approach, which consists of incrementally integrating services and functionalities. This method offers the following advantages:

- It avoids to agree too early on a static end-result in a dynamic environment
- It enables the collection and analysis of empirical data on customer acceptance and service utilization
- The system increases incrementally at the same pace with the technical, functional and/or policy-related readiness of the various involved players
- It allows agreeing on terms & conditions for the use of auxiliary services with partners at the right time, to avoid starting technical specifications work before knowing legal requirements on business processes
- In general, it avoids working based on unverified assumptions.

Thus, the functionalities to be developed will be made available in successive phases as follows.

6.1 Phase 1

Phase 1 consists of the development of the basic interfaces between the various players, the customization of the B2B platform, of the smartphone app, and of the DDS dispatching system of TL, for the development of Use Case 0 and Use Case 1. This is due to the consideration of the above listed issues, including for instance that at time of writing no mobile ticket is yet available for the local public transport, or that a suitable marketing campaign must be carried out by Tuomi Logistics to inform their customers of the potential changes in travel options.

In particular, phase 1 will thus include:

- The customization of the B2B architecture, of the smartphone application, and of the DDS system
- The development of the following interfaces:
  - Digitransit for public transport and trains for trip planning
  - Local taxi API, for information, availability, and booking
  - Parking structure API for pricing, location, and availability
  - TL interface for availability and booking of TL preplanned trips

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6.2 Phase 2

After the development and successful testing of phase 1, phase 2 consists of the consolidation of the proposed services and extension of the developed interfaces. This includes essentially the development of the functionalities for payment of the offered services (e.g. mobile ticketing on public transport and trains, smart-phone payment for taxis and parking structure, all within the same MaaS smartphone application) and the extension of the TL operations to include Use Case 2.

In particular, phase 2 will thus include:

- The customization of the B2B architecture, of the smartphone application, and of the DDS system to incorporate the payment functionalities and Use Case 2
- The extension of the interfaces developed in Phase 1) to enable the execution of the following functionalities:
    - Generation of a mobile ticket (Public Transport and Train) and transmission of the “proof of travel evidence” to the smartphone app via the B2B platform
    - Automated payment of a taxi service (including the pre-planned TL services in Use Case 1) and of a parking service via the smartphone app, e.g. through a confirmation by the traveler of the performed service

6.3 Phase 3

After the development and successful testing of phase 2, the system in Tampere is likely to be continuously expanded both through the addition of additional transportation services (e.g. additional shared services, further modes, such as via air and via water) and through the extension of the geographical coverage, e.g., via additional long-distance services or the integration with other Finnish MaaS systems. Furthermore, additional functionalities such as the development of mobility packages tailored to different user segments, and further Use Cases are likely to be developed.

7 Operation and Technical Support

The Tampere MaaS architecture is made available as a "managed service", with the complete technical operation managed by the system developer. In this way, an optimum prerequisite is provided for Tampere to functionally develop the solution with short innovation cycles, and to flexibly implement the associated requirements in the different extensions by means of new partner services and extended functionalities.

7.1 Hosting

The complete sales platform is operated at a thoroughly selected cloud provider. Thus, maximum scalability can be achieved for when the number of transactions increases and the functional requirements rise.

The solution concept follows the fundamentals of a service-oriented architecture (SOA). The data center (DC) is certified according to DIN ISO/IES 27001 and located in Europe, and offers synergies and cost advantages for Tampere.

7.2 Technical Support

The service concept is generally structured so that the providers of the B2B and B2C levels assume the technical service responsibility for respectively the mobility platform and the B2C level as a 2nd Level Support (Technical Support Center) and as a 3rd Level Support (R&D Experts). The MaaS operators will be responsible to provide Fist Level support to their end-customers.

The Technical Support Center (2nd Level) coordinates the necessary resources and measures depending on the priority of single errors. Through the ticketing system, all messages, the current status reports about the work progress up to the final closing of the ticket are documented at regular intervals. The 3rd Level Support is included after a first analysis of a disruption provided by the 2nd Level Support, in order to solve arising problems as quickly as possible.

The 3rd Level Support generally comprises all measures enabling the stable technical operation of the mobility platform, and which cannot be provided by the after-sales service or the 2nd Level. Planning and execution of the software maintenance is under the responsibility of the 3rd Level Support.

Within the scope of the 3rd Level Support, the respective development team makes the tested and released software updates available at regular intervals. These eliminate software errors, and continuously implement minor improvements regarding operability and performance.

The operation model for the technical support is shown in the Figure below.

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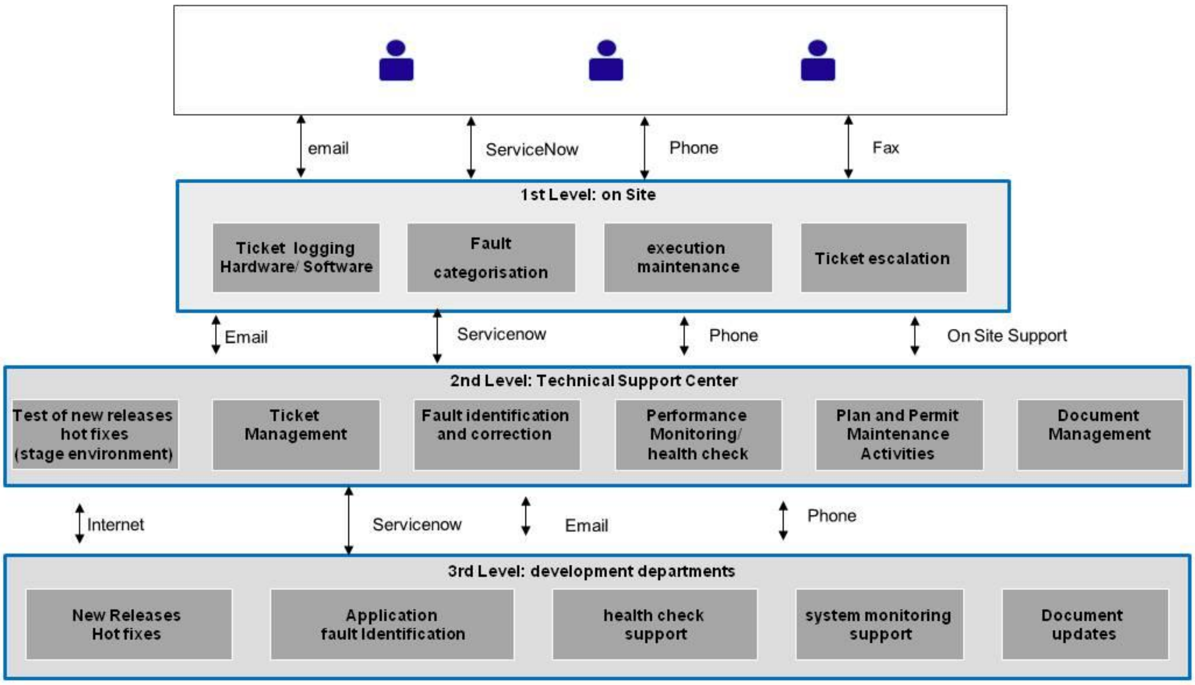

Figure 19: Technical Support Model

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8 Appendix

8.1 DDS Transit API

The enclosed file describes the documentation of the current interface provided by DDS Wireless for interacting with the B2B platform.

DDS_Siemens_Mobility_platform_interface