Consideration of co-creation autonomous distributed system for MaaS

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Abstract

We propose a system that can collaborate highly even among distributed DBs and propose their functions. In Japan, transportation projects are done by the private sector, and there is a scheme that makes it difficult to develop one system with the same capital. For that reason, it is necessary to construct an advanced MaaS system with a higher degree of distribution and cooperation among subsystems. We named the system co-creation autonomous distributed system. This system can have “extensibility”, “high quality”, “reliability” and “maintainability”. After several field trials in Japan, we devised a function based on the result. We are currently developing the system and plan to quantitatively evaluate concrete effects through field trials using this system in the future.

KEYWORDS: information linkage, heterogeneous system integration, public transportation, service operability

Novelty of this research

The study suggesting the virtual linkage of the whole public transportation system in Japan is performed for the first time, and its diversification and dispersion is high especially in Japan. It is difficult to standardize, but the system architecture of public transportation having merits in its cooperation has never been examined before.

Utility of this research

We will make concrete proposals for constructing system concepts and system architectures when cooperating across information systems constructed by different ideas. We propose a sustainable and extensible MaaS system architecture, especially taking into consideration the system operability not only during development but also during operation after development and system expansion. Enabling the cooperation becomes possible especially in Japan where the degree of distribution of businesses is high and public transportation services are enriched, which is not only useful, but the standardization at the time of collaborating beyond national and transport modes in the future has already been completed and we suppose this concept can also be applied to subsequent expansion etc.
1. Introduction

Japan has a population of 120 million people and an area of 377,971 square kilometers. In particular, the Tokyo area with the capital has a population density of 6,123 people / square kilometer, and advanced transportation networks are in place to support highly developed economic cities. Also in other cities transportation is being maintained along with the road network. However, each transportation network has been subdivided into 150 models of railway operators, 800 bus companies and 15000 taxi operators in Japan, due to the circumstances of conversion from national government to a model operated by private sectors. Of particular importance is the competitive relationship between the private sectors. It is clear that one standardization and one integrated system are desirable for social implementation of MaaS. However, we thought about the methodology to realize advanced transportation system drawn in MaaS, even though its standardization and integrated system were difficult to achieve. However, we thought about the methodology to realize advanced transportation system drawn in MaaS, even though its standardization and integrated system were difficult to achieve. We will introduce the background from the next chapter, the situations in Japan, and the invented system.

Regarding the definition and system of MaaS, reference is made to the following documents.

• “Exploring the Opportunity for Mobility as a Service in the UK” Transport Systems Catapult (2016)
• Sampo Hietanen, Sami Sahala, “Mobility as a Service, Can it be even better than owning a car?”, ITS Canada

1.1. Difficulty of implementing MaaS model in Japan

Public transportation in Japan has contributed to the development of the Japanese economy by adjustment of the routes and improving services following the postwar reconstruction. During the development process, the problem of lack of state-owned railway operators and bus operators emerged, and privatization and division were attempted as countermeasures. It depends on the calculation method, however if we classify only by the capital, we will see that about 150 railway enterprises, about 800 bus operators and about 15,000 taxi operators existed that time which was pretty big amount in the world. There are various factors such as policy decisions of that time, but as a result, the management structure was improved by introduction of market and competition principles for the private business, and the user service was also improved. Therefore, when the profit decrease following the decline in number of customers, judgment is made by private enterprises, cost reduction measures and consolidation of routes are carried out. Even now, the metropolitan area can secure and survive profits, but some local public transportation systems are forced to withdraw due to the deficit or forced to abolish the line. Therefore, by revising the bill to revitalize regional public transport in 2014, as an administrative institution to support public transportation services of private enterprises, and creating opportunities to consider regional public transport, introduction of sharing mobility and regional on-demand buses by administrative organs are beginning to be considered.
1.2. The state of public transport information system in Japan

Since the above-mentioned public transportation business operates on a per-carrier basis, the information system is also basically developed independently. Below, we will describe the current situation and the presence/absence of the integrated system together with its scheme for each category of information system. As an integration scheme, we categorize the case as “broker” which is converted through an intermediary system or brokerage business and is unified, and “standardization” which matches specifications at the output part. In addition, this situation was surveyed in August 2017 from hearings and cases with major business operators, which showed the possibility of several cases not being in line with this result or there may be different circumstances at present depending on the business.

<table>
<thead>
<tr>
<th></th>
<th>Status of each information system</th>
<th>Status of integrated system</th>
<th>Integration scheme</th>
<th>API(External)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timetable</td>
<td>Dispersion</td>
<td>Yes</td>
<td>Mediation</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Operation information.</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Mediation</td>
</tr>
<tr>
<td>Electronic payment</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Standardization</td>
<td>N/A</td>
</tr>
<tr>
<td>Seat reservation</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Mediation</td>
<td>Yes (partially)</td>
</tr>
<tr>
<td>Information about location</td>
<td>Dispersion</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Congestion information</td>
<td>Dispersion</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Bus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timetable</td>
<td>Dispersion</td>
<td>Yes</td>
<td>Mediation</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Operation information.</td>
<td>Dispersion</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Electronic payment</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Standardization</td>
<td>N/A</td>
</tr>
<tr>
<td>Seat reservation</td>
<td>Dispersion</td>
<td>Yes (partially)</td>
<td>Mediation</td>
<td>Yes (partially)</td>
</tr>
<tr>
<td>Information about location</td>
<td>Dispersion</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes (partially)</td>
</tr>
<tr>
<td>Congestion information</td>
<td>Dispersion</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1.3. Regarding the utilization of public transport information in Japan

In Table 1, data output from a business operator is described, but it is possible to create more convenient data and information contents by making use of such information. Currently offered services and API offer cases.
1.3.1. Route search service

When designating the departure place and destination of the user, the shortest/lowest route is displayed. It is based on the basic planned timetable and does not correspond to the delay of the train. There is also a service to incorporate some operation information and to exclude the overlapping section.
Source data: timetable, operation information

API Provided Case: Yes

1.3.2. Operation information distribution service

The operating information of each company is displayed (normal operation, delayed, operation stops) in a list and push delivery etc. for smartphones. Currently, there are many undeveloped routes for railway lines and bus lines.

Source data: Operation information
API Provided Case: Yes

1.3.3. Real-time location information providing service

Providing location information of individual trains and buses. Provide the information about current section and time of delay to smartphone.

Source data: location information
API provided case: partly available

1.3.4. Real-time congestion information service

Provide congestion information on individual trains and buses. Although it is not so popular yet, there are cases where the service began around 2014

Source data: congestion information
API Provided Case: None

1.3.5. Congestion prediction service

Estimate the congestion degree of specified vehicles and routes from various data. Various methods including the approach from traffic flow prediction, log data utilization of real time data and coexist.

Source data: traffic survey results, real time log data, external data etc.
API Provided Case: None

1.3.6. Reserved seats comprehensive comparison/booking service

We can make comparison of the situation and reservation of the designated seats for multiple enterprises. It is mainly done by air and ferry, long-distance bus etc.

In Japan, traffic information is roughly classified into two schemes

1. Transport operators provide the service to users
2. Business is performed by enterprises other than transportation companies
Table 2 classifies the situation of traffic information service currently provided. This table is still at the stage of survey. Besides, in some cases, it is set to $\bigcirc$, so it is not based on all the circumstances and it judges only whether or not it is generally popular.

### Table 2. Status of Traffic Information Service in Japan

<table>
<thead>
<tr>
<th></th>
<th>1 Transport operators</th>
<th>2 Other than transportation operators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Railway</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timetable</td>
<td>$\bigcirc$</td>
<td>$\bigcirc$</td>
</tr>
<tr>
<td>Operation information</td>
<td>$\bigcirc$</td>
<td>$\bigcirc$</td>
</tr>
<tr>
<td>Electronic payment</td>
<td>$\bigcirc$</td>
<td>$\times$</td>
</tr>
<tr>
<td>Seat reservation</td>
<td>$\bigcirc$</td>
<td>$\bigcirc$</td>
</tr>
<tr>
<td>Location information</td>
<td>$\bigcirc$</td>
<td>$\bigcirc$ (partially)</td>
</tr>
<tr>
<td>Congestion information</td>
<td>$\bigcirc$</td>
<td>$\times$</td>
</tr>
<tr>
<td><strong>Bus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timetable</td>
<td>$\bigcirc$</td>
<td>$\bigcirc$</td>
</tr>
<tr>
<td>Operation information</td>
<td>$\times$</td>
<td>$\times$</td>
</tr>
<tr>
<td>Electronic payment</td>
<td>$\bigcirc$</td>
<td>$\times$</td>
</tr>
<tr>
<td>Seat reservation</td>
<td>$\bigcirc$</td>
<td>$\bigcirc$</td>
</tr>
<tr>
<td>Location information</td>
<td>$\bigcirc$</td>
<td>$\bigcirc$ (partially)</td>
</tr>
<tr>
<td>Congestion information</td>
<td>$\times$</td>
<td>$\times$</td>
</tr>
<tr>
<td><strong>Railway and Bus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Route Search</td>
<td>$\times$</td>
<td>$\bigcirc$</td>
</tr>
<tr>
<td>Integrated seat reservation</td>
<td>$\times$</td>
<td>$\bigcirc$</td>
</tr>
<tr>
<td>Integrated location information</td>
<td>$\times$</td>
<td>$\bigcirc$</td>
</tr>
<tr>
<td>Integrated operational information</td>
<td>$\times$</td>
<td>$\bigcirc$</td>
</tr>
<tr>
<td>Congestion forecast information</td>
<td>$\bigcirc$ (Not enough)</td>
<td>$\bigcirc$ (Not enough)</td>
</tr>
</tbody>
</table>

As it becomes clear from above, various information has been broadcasted in Japan, but it is necessary to convert and mediate individually by each business operator, and integrated services are often done by non-transportation companies, MaaS. In constructing the model, it is clear that cooperation between transportation companies as well as other than transportation companies is indispensable.
2. Preliminary research and organization of heterogeneous data integration

I referred to the following two papers as a Japanese articles.

1. *Heterogeneous system cooperation function in IT infrastructure for smart city* (2014)
   It discusses the foundation for mutual cooperation of social infrastructure suppliers and demand side systems, devices and applications in the Smart City-based power field. In particular, not the value between DBs, resolve the incompatibility between DBs due to system change and specification change. Mapping between data classes and attributes in each data model, and transformation such as values / units define a transformation framework structure that can be commonly utilized. By registering a data synchronization job for each data item and setting it as processing for data synchronization as a job, we are not aware of the difference in update timing in data copy and synchronization between DBs of different systems.

2. *Common vocabulary base that promotes utilization of heterogeneous data and information linkage between administrative systems* (2015)
   A common vocabulary base with databases and various APIs to organize the notation, structure and meaning of terms, restrictions on notation etc as vocabulary data, to share data format. Store and provide vocabulary data maintained in a logical format independent of the data format in a format that is easy to use according to users and their uses.

The following is a summary of data processing methods from two articles


Data inconsistencies are classified into “single data source”, “multiple data source” and “respectively schema level, instance level”.

The following are defined as data cleaning approaches

1. analysis
   Analyze the data to decide which error or contradiction to remove

2. Define transformation workflow and mapping rules
   Perform numerous data conversion and cleaning procedures depending on the number of data sources, heterogeneity, data contamination
   First fix the single source instance problem
   Next, it performs schema, data integration and cleaning of inconsistency of multiple source instances

3. Verification
   Test and verify the accuracy and effectiveness of conversion workflow and mapping rules
   Analysis, design, verification may require multiple iterations

4. conversion
   Convert workflow, perform mapping and update data warehouse

5. Reduce data after data cleaning
Replace the original dirty data with clean data from which errors have been removed so that future data cleaning will not be repeated.

Examples of solutions for data inconsistency include the following.

1. **Split case**
   Unreformed fields often get values for multiple items, instance matching or deduplication is for France

2. **Validation and qualification of input instances**
   Check and fix data entry errors in each settlement instance. Perform spelling checks based on dictionary searches and correction of address data based on dictionaries relating to place names and postal vans

3. **Standardization**
   Convert attribute values to a consistent and uniform form. For example, convert date and time entries to a specific format, convert string data such as name to uppercase or lowercase.

As will be described later, in the state where the transportation company has independently designed in Japan and has not been standardized among the operators, “map data” “railway, bus time data, route data” necessary for navigation “operation information and position information “are distributed and generated, and assuming that specifications are different, the following problems are assumed. As a service to be realized, it is assumed that “path planning”, “real-time situation transmission”, “prediction such as delay and congestion”.

- Name mismatch of map information and time information
- Route search and train ID mismatch
- Duplicate use of train ID
- Difference between the operational station and the route ID and passenger information ID
- Data propagation delay
- Data inconsistency

**3. Challenge to cooperate with public transportation information gathered until now.**

The authors are working on the issue of cooperation beyond the scope of public transport operators since 2013. In cooperation with multiple operators in 2013 and 2015, the authors integrated real-time data and experimentally developed integrated applications and conducted social experiments.

The experiment purposes are as following
- Evaluation of the effectiveness of integrated services
- System problem extraction at integration

In addition to calculating the development costs and operating expenses of the integrated system and evaluating its effectiveness from the viewpoints of “Transportation companies”, “Regional administration”, “Users”, “Service providers” it became possible to realize the MaaS model we have drawn a roadmap for. As an object, we conducted experiments mainly on information provision service.
3.1. Regarding the demonstration experiment in Kashiwa city, Chiba prefecture in 2013

In accordance with Intelligent Transportation Systems World Conference 2013 held in Tokyo, Japan, we conducted a social experiment of public transport information cooperation using Kashiwa City, Chiba Prefecture as a field. Two railway operators and two bus operators entering a medium-sized terminal station called Kashiwa station, the University of Tokyo and the Kashiwa City Hall Traffic Policy Division worked together to provide smartphone applications and a large-scale gathering of customers feedback. We operated the service for 3 months and gathered feedback from 4000 people who used it. As a service, more than 80% mentioned the necessity of cooperation, and we could confirm such features of service as the increase of access logs at the time when public transportation was disturbed due to heavy rain and other factors.

3.2. Regarding demonstration experiment in Tokyo area in 2015

We carried out a large-scale demonstration experiment using a large terminal station such as Tokyo station and a station of a bed town such as Musashi-Koganei station as its field. Three railway operators, seven bus operators, the University of Tokyo, administrative agencies, etc. collaborated in order to evaluate the effectiveness and summarize the tasks. Approximately 3,000 people got used and got nearly 4000 evaluation results. For this collaborative service, we confirmed the intention to use more than 95%, and confirmed the high demand from the user’s point of view, especially in cooperation of public transportation in Japan.

3.3. Approach to open data

In FY 2013, together with the above verification, we also provided data to the open data study group in Japan and examined it. In cooperation with a system company, etc. that organizes data, we examined the data discrepancy and operation between each business operator.

3.4. Issues and analysis obtained from demonstration experiments etc.

Since standardization was not performed and cooperation schemes were not organized, problems on various services occurred and we were asked for correspondence. Analysis of these experiences and the current information system group gave the following subjects. Today, public and private open data initiatives are also conducted in Japan, providing data that can be output on best effort. When the system operation is performed and the system that guarantees reliability is defined as the main system and the system operation level is low and the condition when system operation is not guaranteed, reliability is defined as the subsystem, the current settlement system will require the main system output. Integrated services are being handled as the main system, but the information providing service is not provided by the subsystem, and the subsystem operation is used as the integrated system.

### Table 3 Classification of Main System and Subsystem

<table>
<thead>
<tr>
<th>Type</th>
<th>Each output system</th>
<th>Integrated</th>
<th>Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type(1)</td>
<td>Main system</td>
<td>Main system</td>
<td>None</td>
</tr>
<tr>
<td>Type(2)</td>
<td>Main system</td>
<td>Sub system</td>
<td>Conversion logic of integration part</td>
</tr>
<tr>
<td>Type(3)</td>
<td>Sub system</td>
<td>Main system</td>
<td>Operating output systems</td>
</tr>
<tr>
<td>Type(4)</td>
<td>Sub system</td>
<td>Sub system</td>
<td>All problems</td>
</tr>
</tbody>
</table>

The main system defines errors, master data, and discrepancies between data servers as managed states.
Subsystems are subject to data output, but may be affected by specification changes or system changes, and are not guaranteed.

Development time
• Difference in data specification definition
• Permanent data loss
• Difference in data ID and name

After development end
• operation
• Primary loss of data
• Difference due to change of ID or name of data
• Data specification change

The tasks at the time of data integration are roughly divided into the following two categories.
• Instance level: sequential tasks
• Schema level: challenges as specification

It is summarized in Table 4 below.

<table>
<thead>
<tr>
<th>Task event</th>
<th>Type of tasks</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>System development</td>
<td>Difference in data specification definition</td>
<td>Schema</td>
</tr>
<tr>
<td></td>
<td>Permanent data loss</td>
<td>Schema</td>
</tr>
<tr>
<td></td>
<td>Difference in data ID and name</td>
<td>Schema</td>
</tr>
<tr>
<td>Service operation</td>
<td>Date fault</td>
<td>Instance</td>
</tr>
<tr>
<td></td>
<td>Due to changes in data ID and name</td>
<td>Schema</td>
</tr>
<tr>
<td></td>
<td>Change of data specification</td>
<td>Schema</td>
</tr>
</tbody>
</table>

If we make an analysis from the business evaluation of these system architectures, we will see there is a situation when the integrated system is constructed as the main system and can not be the main system of the output system. As an example, if the main system of an individual business entity has already been constructed
and there is a requirement which can not be replaced by that specification, there is no motivation to fix the existing system for the purpose of cooperation with another system. Also, when constructing a system that integrates public transport as a whole within Japan, there are possibilities that the integrated system: main, output system: main will not be the same, depending on the process of establishing the system. From the above, in order to realize the Japanese MaaS model, in order to achieve sustainable and more advanced public transportation cooperation effect on the premise that the integrated system or the output system is the operation of the subsystem, its extensibility and altitude. It is necessary to share and realize among the stakeholders, including the theoretical construction of the system architecture including the conversion and including them in the roadmap.

4. System architecture, agent system created by receiving analysis results

If it is considered as standardization or one system, it will be as shown in Fig1(left).
However, since the MaaS system as an aggregate of subsystems has the same reliability as that of the main system, logic for solving several problems is required.

Basically, each server and system has a response function from an external agent. This function autonomously controls each distributed system. Since this is a concept that is most suitable for “co-creation” as this existing small system cooperates and does not constitute one large system, the author explains the system giving it the name of “co-creation type autonomous decentralized system”.

Co-creation type autonomous distributed system.
A concept that makes it an aggregate of subsystems and regards it as a system having the same value as the main system. In the realization phase of the MaaS model, it becomes a concept to be utilized when commonality and standardization are difficult. Especially in Japan, even though it was a basic information system, this concept is thought to work effectively. It consists of five basic functions, and explains each function. Focus range is the present assumption as “coordination of plan data”, “cooperation of real time data”, and “improvement of operability of data cooperation/ analysis result”. Conversely, the pre-settlement system has been already standardized and made common in Japan, so it is out of the scope of the current situation, but in the future when cooperating with other financial services etc., it will be within the focus range. In addition, as there is a possibility of utilizing the road system and the map data in the information provision service, the range to be considered is specified according to Table 5 at this stage.
Table 5: Current scope of co-creation autonomous distributed system

<table>
<thead>
<tr>
<th></th>
<th>Plan (Static)</th>
<th>Realtime</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Bus</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Road</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Taxi</td>
<td>○</td>
<td></td>
<td>○</td>
</tr>
<tr>
<td>Map</td>
<td>○</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Ticketing</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>

4.1. Master data management

The master data management function makes requests from external agents to the columns of databases of each data server and application server, definition of data specification level, etc., and performs data acquisition and difference management. In particular, we focused on differences and correction mistakes in data groups with different update frequencies. As an example, in the case of railway system data, it is assumed that the new station name reflecting the latest data from the operator is shifted in reflection timing with the map type data maintained by original research. Also, similarly, the station name and section name of real-time data are always up to date, so inconsistency with map-related data for which update frequency is determined (in Japan, there is a point once a month) many occurred.

4.2. Propagation delay management of real-time data

As for real-time data of trains and vehicles, there is a delay related to the actual traveling position. Besides, in case you pass through the server, the magnitude of the error increases by that amount. For this reason, it is necessary to manage the data generation time and the time until the data is transmitted to the display side for confirming the consistency of the data including the transmission delay. Particularly when combining data coming from different lines and combining them as a service, it is difficult to establish as a service without this concept, and it is also an important factor when used as source data of statistical analysis and prediction information.

4.3. Sharing alerts during service operation

Alert management of server malfunction is performed in basic output system and cooperation destination system. However, depending on the level, operations may be performed without being shared by collaborators, especially when both the output system and the integrated system are assumed as subsystem premises, the tendency is noticeable, which leads to the situation when neither transport operator nor the integrated business operator notices that the erroneous data are continuing to be delivered. To solve this problem, we surveyed a method of distributing alert state from upstream to both data transmission and a method of collectively managing each alert in foreign agent. There are cases in which data connection is not made at the time of a server malfunction, but there is a task to enable server ③ from server ① → ② → ③ to notice the trouble of server ①. As the current assumption, it depends on the reliability design required for real-time data, but in some cases it is important for service providers even if the warning information is minor, so please put it in the data transmission route, including warning. If it is a critical level, it is assumed that it is acquired by the foreign agent and the operation system is taken.
4.4. Establishment of cleansing method at statistical analysis (cooperation with alert).

In this paper, we do not mention the prediction system by utilizing past log data and real-time data, but in general when data is statistically analyzed, data on error should be cleansed so as not to affect the prediction accuracy. In the case of predicting on the basis of a plurality of data, it is common to input them to the prediction engine with the entire amount data, but there is a need to define the period of error and the data group due to the above alert situation and master data difference using the function of cleansing the analysis data. It is assumed that this system reflects the data inside the external agent to the integrated analysis infrastructure.

4.5. Establish reliability measurement of predictive information

For information provision in public transportation area, information that can judge about the future will be rather important than information judging about the present. Therefore, the construction of the prediction system is important for the MaaS model, and dynamic demand forecasts such as when to hold events, whether there are any transportation troubles, whether it is reasonable to use public transportation for large-scale evacuation, etc are important. The reliability of the model predicting usage also becomes important in smart city viewpoint and ride-sharing service supply and demand. Therefore, in addition to improving prediction accuracy in the above cleansing work, logic for determining the accuracy of the prediction system by matching the prediction data with the actual data by the foreign agent is important. With this, convenience is improved for users who use the prediction system, and the service provider can examine the supply-demand balance based on the reliability and precision.

5. Summary

In the first chapter of this document we mentioned the current state of public transportation operators in Japan and the public transportation system. In chapter 2, we set the tasks and analysis to construct MaaS model and make it operational through demonstration experiment of public transportation cooperation and its result analysis. In Chapter 3, the idea of the system architecture to solve those problems and the current scope of coverage. The concept of MaaS is still in the stage when dissemination has begun even in Japan. As mentioned above, it is expected that many problems will arise especially during system development, such as the formation of transportation operators and the relation between traffic administration and private business operators. However, it can be said that MaaS’s “as a service” has the fundamental feature of the “transformation and system which is different in terms of physical division/difference but is regarded as one concept as virtual and service”. It is the domestic transport operator to demonstrate its effect. In this study, the scope will remain in the information and guidance information used for information provision and operation, but this concept will also be expanded when implementing more advanced MaaS models and public transport services and systems within smart city in the future. We will engage in further R&D on the assumption of the cooperation effect in the upper layer.
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Mobility as a Service: Comparing Developments in Sweden and Finland

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Abstract

This paper examines how institutional factors influence developments in the field of Mobility as a Service (MaaS). We draw upon neo-institutional theory in order to describe drivers and barriers of MaaS developments in Sweden and Finland. By analyzing similarities and differences across the cases, we identify a set of general implications for MaaS policymakers and practitioners. Developments in Finland demonstrate the importance of top-level support, of inter-organizational collaboration and of trust among key stakeholders. The Swedish case reiterates the need for inter-sectorial collaboration, particularly with regard to creating the right conditions for commercialization, and to involving stakeholders on both strategic and operational levels of the transport sector in developing the vision for MaaS. Lastly, we also assess the utility of the applied theoretical framework, and comment on the necessity of recognizing that both practice-based and structural changes are needed in order to facilitate institutional change.

KEYWORDS: Mobility as a Service; neo-institutional theory; drivers and barriers

1. Introduction

Since the concept of Mobility as a Service (MaaS) was introduced in 2014 (Heikkilä, 2014), the term has received much attention in the personal transport sector. During this period, Sweden (SE) and Finland (FI) have acted as global pioneers of MaaS. For instance, the 2014 pilot of UbiGo in Gothenburg (SE) is often referred to as the first in real-life conditions (Sochor et al., 2016), while the 2016 launch of Whim in Helsinki (FI) drew international recognition to the concept (MaaS Global, 2016). However, despite the pioneering roles taken by Sweden and Finland, developments in these two neighboring countries have arguably progressed along different trajectories. Hence, based on 31 stakeholder interviews, we analyze and compare the two cases. In particular, we investigate the role of institutions as key structures given their capacity to bring about differentiated outcomes, with the purpose of identifying a set of general contextual preconditions and stakeholder actions that enable societally beneficial MaaS to flourish. Overall, we aim to address the following research question:

How have institutional arrangements influenced MaaS developments in Sweden and Finland, and what implications can be drawn from these cases?

By developments we refer to a broad set of practices including past and present events and activities that can be related to advances of the MaaS concept. By implications, we refer to two things. First, we refer to a set of insights drawn from the two case studies that can benefit public and private sector practitioners with
an interest in promoting MaaS developments. Second, we refer to a set of theoretical implications drawn from the application and assessment of a framework developed in the Swedish project IRIMS (Institutional fRameworks for Integrated Mobility Services in future cities). Here our aim is to further refine the framework by abstracting conceptual insights, again from the Swedish and Finnish cases.

Our paper is divided into five sections of which this is the first. The next section outlines our research approach, including the IRIMS framework and methods. In section three we depict developments in relation to MaaS in Sweden and Finland, followed by outlining, in section four, formal and informal drivers and barriers that have influenced the two processes. In section five we propose general implications for other cities, regions and nations with an interest in MaaS, prior to discussing the applicability of the utilized conceptual framework. Lastly, we provide some summative concluding remarks.

2. Research approach

2.1. Conceptual framework

The IRIMS framework (hereafter IRIMS) (Mukhtar-Landgren et al., 2016, Karlsson et al., 2017) defines MaaS as an integrative concept that bundles different transport modalities into a single, seamless service as a means to provide tailored mobility solutions that cater for users’ travel needs. This includes considerations of both passengers and goods. IRIMS’ central focus is on the various institutional arrangements that act as both driving forces and barriers to the development and deployment of MaaS. IRIMS defines institutions as ‘regulative, normative, and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life’ (Scott, 2013, p. 56). Regulative elements of institutions are things such as laws that impose coercive control by either allowing or sanctioning certain types of activities. Normative elements refer to values and norms that are embedded in certain well-established roles, and exert control via ‘logic of appropriateness’ in certain situational contexts. Cultural cognitive elements are typically experienced as ‘rules of thumb’ among a collective. IRIMS divides these institutional dimensions into formal (regulative) and informal (normative and cultural-cognitive) categories.

IRIMS furthermore delineates institutional arrangements into three additional analytical levels: macro, meso and micro. The macro level encompasses societal institutional arrangements, including laws, policies, taxation and subsidies (formal) alongside culture, national identity and societal trends (informal). In practice, the set of relevant macro-level institutional arrangements includes things like transport regulation, the use of subsidies in public transport (PT), cultures of automobility that vary between countries, and the penetration of new sharing economy ideals. The meso level includes institutional arrangements at the regional and local levels that are embedded in public authorities and public and private service providers including: regional/municipal transport plans and directives, urban planning, and regional innovation grants (formal) alongside the roles and identities of local PT authorities (PTAs), local cultures of collaboration via innovation networks, and the logical components of existing mobility business models (informal). The micro level is that of the individual, referring to the proposed users of MaaS services, i.e. travelers. Institutional arrangements that are relevant at this level include a range of push and pull measures, such as congestion charging, taxation and investments that make certain transport modes more attractive (formal), alongside travel patterns and habitual behavior, self-images, subjective norms and social status (informal).

Despite the use of Scott’s definition of institutions, IRIMS focuses more on the rule-like features of institutions that constrain and enable practices. However, Scott’s definition of institutions captures their rule-
like features (structures) alongside activities, actions and rituals (practices). This more nuanced understanding acknowledges that the rule-like features of institutions are intertwined with the practices they depict as legitimate – institutions also encompass ‘routines, procedures, conventions, roles, strategies, organizational forms, and technologies around which…activity is structured’ (March and Olsen, 1989, p. 22). Hence institutions can be divided into two realms – institutionalized structures and the material realm of practice. The two realms are deemed ‘mutually constitutive’ (Meyer et al., 1994), such that in processes of institutional change, there are adjustments in both realms.

As a consequence of IRIMS comprising a meso level, it acknowledges one type of practice that, alongside the structural aspects of institutional arrangements, is critical the development and diffusion of MaaS. That is, to realize the development of MaaS, there is a need for business model innovations that are based on a new set of inter-sectorial collaborations. Hence, IRIMS notes the importance of collaboration in new business ecosystems (cf. Moore 1996). IRIMS characterizes collaboration as ‘a process where various stakeholders from different public, private (and/or public/private hybrids) as well as civil society organizations (i) combine capacities, recourses and expertise and (ii) work together with the common goal to implement a solution or policy or to solve problems of an inter-organizational character’ (Mukhtar-Landgren et al., 2016, p. 13).

2.2. Research gap

Until now, little work has been done to identify the way in which institutions influence collaboration in emerging MaaS ecosystems. It is, however, increasingly understood that MaaS necessitates the creation of new roles and associated responsibilities (i.e. practices), such as that of a MaaS operator and integrator (cf. Smith et al., 2017a). Here the question of who takes the role of MaaS operator is a particularly sensitive issue, since some existing transport service providers view MaaS as a potential threat in terms of brand, image and customer relationships. Hence a discussion has emerged regarding roles in the ecosystem, and scholars have noted that different models for ecosystem collaboration may emerge in different contexts (e.g. Holmberg et al., 2015; Kamargianni et al., 2016). In these different models, a common theme is the discussion of the division of roles between private actors and public organizations. For instance, Smith et al. (2017a) outline three ways in which MaaS developments may evolve: via market-driven activities; as a result of state interventions; or as part of public-private collaborations. Regardless of the scenario in question, there exists bidirectional influence between collaboration (a practice) and institutional arrangements (structures). That is, practices are enabled and constrained by existing structures but also have the potential to transform those very structures. Yet IRIMS is silent on the interactions between changes in structure and practice, and how these may influence MaaS developments. In this paper, we examine the relationships between structure and practice, and comment on their relevance for MaaS developments.

2.3. Method

We performed 31 interviews with 34 key stakeholders in Sweden and Finland during the period September 2016 to February 2017. We utilized a semi-structured interview guide to organize the interviews around the three institutional levels recognized in IRIMS – macro, meso and micro – focusing on identifying perceptions of institutional drivers and barriers in relation to the development of MaaS. The interviews lasted between 43 and 112 minutes (average 69) and the respondents consisted of public and private actors directly involved in MaaS developments. The sample is described in Table 1.
In order to analyze the data, we first coded and clustered transcriptions of the interviews inductively in two parallel processes. This resulted in two initial lists of institutional drivers and barriers, one for each case. Then, we applied the IRIMS framework to sort and compare these results. From this exercise, we generated a table describing similarities and differences across the cases in terms of institutional arrangements. Lastly, we revisited individual quotes to decompose and clarify our findings.

3. Background - MaaS developments in Sweden and Finland

Brief summaries of past, present and planned developments in relation to MaaS in Sweden and Finland are described below and laid out in Figure 1, although neither the descriptions nor the figure can capture all relevant developments. Moreover, it should be noted that (i) MaaS developments in Sweden and Finland are entangled, and (ii) both cases are strongly affected by external developments.

3.1. Developments in Sweden

In the Swedish context, the concept of customized, multimodal mobility packages was initially proposed in 2011 within an R&D project entitled ‘The flexible traveler’ (*Den flexible trafikanten*). The project, which examined business opportunities associated with multimodal services and sought to initiate processes for their realization, concluded that the conditions were in place for services that provide metropolitan citizens with comprehensive, reliable, customized and usable mobility services that reduce costs, increase flexibility, and contribute to sustainable everyday travel (Boethius and Arby, 2011). The business concept was further developed between 2011 and 2014 in a two-phased R&D project named Go:Smart (Strömdahl et al., 2014). The second phase of the project comprised a well-documented six-month pilot of a multimodal service in the Gothenburg area, called UbiGo (e.g. Sochor et al. 2014, 2015a,b, 2016).

Concurrently, several actors within the Swedish PT sector were realizing that entirely new approaches to how PT is organized and delivered to citizens might be needed in order to meet the widely adopted goal of doubling the market share of PT within Sweden (Grönlund, 2017). For instance, the current regional PTA (*Västra Götalandsregionen* – VGR) in West Sweden first proclaimed their support for such a goal back in 2006 (K2020, 2009); and later based their regional transport strategies around achieving that goal (Bokeberg et al., 2015; Efraimsson, 2012). However, by 2011, several reports were published at both regional and national levels that demonstrated the discrepancies between existing PT budgets (including the one in West Sweden) and the budgets needed for achieving this goal (e.g. Legerius, 2012). Consequently, key persons at VGR, among others, adopted the view that PT must aim to better attract private investments, which was the basis for their keen interest in the outcomes of the abovementioned R&D projects.

The success of the UbiGo pilot, which ran in 2013-14 under the Go:Smart project, had two main results. First, a company was launched early in 2014, named UbiGo AB, that aimed at continuing the service with

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Table 1. Respondent sample

1 However, at that point they were not the regional PTA – a position they first acclaimed on January 1st, 2012 when PT responsibilities in West Sweden were reorganized and a new PT law was introduced in Sweden.
its existing customer base, then further expanding the service. Second, VGR commissioned its operational company, Västrafik – that had participated in the UbiGo pilot as a transport service provider – to conduct a pre-study to evaluate the legal conditions and potential implications of taking different roles in forthcoming developments. However, this move created uncertainty regarding the relationship between Västrafik and external MaaS operators, which contributed to UbiGo AB being closed down in 2014. UbiGo Innovation AB, a new company with the mission of refining and relaunching the piloted service, replaced it later the same year. Currently, UbiGo Innovation plans to relaunch the UbiGo service in Stockholm as part of a EU-funded R&D project (civitas.eu/eccentric).

For Västrafik, the pre-study led to a decision at the end of 2014 to initiate a procurement process (Frey, 2014). Accordingly, in the spring of 2016, they invited prospective bidders to discuss potential conditions for a service concession agreement regarding a MaaS for West Sweden. After reviewing the response from the participating companies, Västrafik concluded that offering their tickets for resale, without any additional investment on their part, would fail to drive MaaS developments in a direction that would fulfill the doubling goal (Smith et al., 2017b). First, since the investment costs for MaaS operators would be disproportionate (especially if aiming to develop nation-wide offerings) and, second, because a role as transport provider (and nothing else) would leave Västrafik with little opportunity to govern the trajectory of MaaS.

As a consequence, Västrafik teamed up with other regional PTAs in the ‘Swedish Mobility Program’ (SMP). SMP, which is managed by Samtrafiken2, aims at developing a national integration platform for transport-related services, i.e. a portal giving MaaS Operators access to transport service data and tickets to include in their MaaS-related offerings. SMP also aims at establishing Samtrafiken as a national MaaS integrator; to co-ordinate a joint business agreement; and to initiate, operate and participate in pilot activities related to MaaS (Samtrafiken, 2017). At present, the integration platform is scheduled for launch in West Sweden in April 2018 and in the counties of Stockholm and Skåne in 2019, if Samtrafiken manages to receive funding for its development and operation.

SMP has also succeeded in promoting the MaaS concept to several key actors. One such actor is the regional PTA in the county of Stockholm (Stockholms Läns Landsting – SLL). In 2016, SLL made a strategic decision to enable MaaS developments in the county of Stockholm, positioning itself as a transport service provider in the MaaS ecosystem. In practice, this decision means that SLL envisages that third parties should take the role of MaaS operators. SLL has made short-term plans to make a selected range of tickets available for third-party resale through deep linking. During 2017, SLL plans to initiate and participate in MaaS-related pilots and to analyze legal, business, technical and time-related aspects of permanently enabling third-party ticket resales. In 2018, SLL also plans to approach politicians with a more detailed implementation plan for MaaS (Palmbeck, 2016).

At the national level, MaaS is a salient issue for the Swedish Ministry of Enterprise and Innovation (Näringsdepartementet). In 2017, one of their collaborative groups (samverkansgrupp) proposed MaaS as a key priority for solving the transportation challenges of the future and established a working group in order to explore potential actions for promoting its development (Näringsdepartementet, 2017). These initiatives led to a national roadmap for the development of MaaS in Sweden (Pernestål Brenden et al., 2017), and a program for overseeing the suggested actions (kompis.me). The roadmap coordinates other strategies, such as SMP and the Swedish Transport Administration’s (Trafikverket) action plan for Intelligent Transport

2 A joint venture that aims to support coordination of PT in Sweden.
Systems (ITS) (Andersson et al., 2014), in which MaaS is again recognized as a prioritized area. Moreover, the national roadmap for MaaS features in the Swedish Transport Administration’s proposed plan for the development of the transport system in Sweden between 2018 and 2029 (Kalander and Haraldsson, 2017). Lastly, the Swedish Energy Agency (Energimyndigheten) plans to initiate a program aimed at boosting MaaS developments called ‘Challenge from Sweden’ by the end of 2017.

3.2. Developments in Finland

In 2009, the Ministry of Transport and Communications (Liikenne- ja viestintäministeriö – LVM) decided that a major reform of transport market legislation was needed if the public goals for the Finnish transport sector were to be met. The same year, they also authored Finland’s first national strategy for ITS. Among other things, the strategy proposed that an increased use of ITS could realize a versatile transport system that guides citizens towards using environmentally sustainable, economical and safe modes of transport, but that this development required a modern, customer-oriented transport policy (LVM, 2009). Hence, LVM initiated the ‘Transport Revolution’ program, which aimed at developing an entirely new approach for transport policies and policy implementation (Tuominen and Kanner, 2011).

In recent years, the abovementioned ideas have been concretized into proposals. Major legislative modifications have been brought together in a unified act, which LVM has labeled the ‘Transport Code’. Key objectives of the Code are to ‘promote the creation of new service models, ease market entrance, dismantle national regulation that limits competition and reduce the level of public guidance’ (LVM, 2016a, p. 1).

The first phase of the Code, which mainly concerns road transport, was adopted by the Finnish Parliament in April 2017 and will enter into force on the 1st of July 2018 (LVM, 2017). This phase has two parts. First, it aims at lowering permit requirements and tearing down silos between transport markets through deregulation. For instance, the current PT license will be replaced with a passenger transport license; any type of vehicle will be allowed to be used as a taxi, and limits on the number of taxi licenses as well as price regulations for taxis will be removed (LVM 2016a,b). Second, it focuses on enhancing the use of open and interoperable data interfaces. The Code will oblige incumbents as well as new entrants to the transportation market to provide their operational data as well as their single tickets for third-party resale and use. The underpinning idea of the Code is to take advantage of digitalization and enable both the development of better and more agile transport services, and the integration of them into MaaS offerings. LVM proposes that these changes will streamline the public role in personal transport, with the concrete goals of achieving a 10% savings in publicly subsidized passenger transport from 2017 (LVM, 2017).

The development of MaaS is closely coupled with LVM’s work on reforming transport market legislation. The idea of creating multimodal mobility packages was, in the Finnish context, first promoted at a LVM think tank in 2012, and LVM has since used the idea of MaaS as the crown jewel of their envisioned future smart transport system. Several members of the think tank began promoting MaaS – ‘the Netflix of transportation’ – all over Finland, but it was first when MaaS was introduced as a key topic at the ITS European Congress in Helsinki in 2014 (Heikkilä, 2014) that it began receiving international attention (e.g. Hellmann, 2014; Wile, 2014).

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3 The idea was presented by Sampo Hietanen, then CEO of ITS Finland, who later became CEO of Maas Finland Oy, subsequently MaaS Global Oy.
In the beginning of 2015, LVM and the Finnish Funding Agency for Innovation (Tekes) launched a joint program for the development of MaaS. As a first action, Tekes published a call for MaaS operators. Eight pre-studies were funded, and in the end several MaaS-related pilots were performed around Finland during 2015 and 2016. The telecom giant Telia Finland Oy (previously Sonera) developed a MaaS application called Reissu, and conducted two pilots, one for commuters in the city of Hämeenlinna and one for tourists heading to the ski resort Ylläs, before selling the brand to the Finnish company Semel Oy in December 2016. Tuup Oy, a start-up company, launched the first version of a MaaS application in 2016. So far, it enables purchasing PT tickets in Turku and hailing taxis in some areas, as well as exclusive access to Kyyti, a taxi-pooling service that currently is available in Oulu, Turku and Tampere. Sito Oy, a Finnish consultancy firm, piloted a MaaS application, Kätevä, in Seinäjoki between November 2016 and April 2017. The service provided three types of mobility packages that combined local buses, demand responsive transit and taxis. Sito Oy is currently analyzing the results of the pilot.

Still, it is the activities of MaaS Global Oy (previously MaaS Finland Oy) that has received the most attention. In May 2015, 23 organizations partnered to cooperate in the establishment of a company that could take the MaaS operator role. In the end, eight of the organizations invested in the idea and in December the same year MaaS Global was registered as a company. In June 2016, MaaS Global publicly launched its first service, Whim, and began offering it to pilot customers in a beta test in Helsinki from October the same year. Whim customers access regional PT, car rentals and taxis via different subscription packages. PT access was enabled through a business agreement with HSL, the regional PTA, which allows MaaS Global to resell their single tickets. In 2017, MaaS Global raised additional venture capital, and is currently preparing to expand to Amsterdam, NL, West Midlands, UK and Singapore, SN.

In addition to LVM and Tekes’ joint MaaS program, another public actor, Export Finland, has launched a growth program for MaaS, aimed at helping Finnish MaaS-related ventures to attract international investors and to and seize global business opportunities.
Figure 1. Key events in the development of MaaS in Sweden and Finland
4. Results – Institutional conditions

4.1. Macro-level conditions

In Finland, there is an ongoing political movement towards deregulation and increased market orientation. For instance, when entering office in 2015, the current government proclaimed that Finland will be ‘a land of solutions’ (Sipilä, 2015). The government identified three means to achieve this vision: digitalization, experimentation and deregulation. Regarding deregulation, LVM has been investigating a reformation of the transport market for almost two decades and recently succeeded in getting the first phase of the Code through parliament. As a result, there is a strong likelihood that the existing, heavily regulated PT and taxi markets will be opened up. As such, MaaS seems likely to be market-driven in Finland (cf. Smith et al. 2017a).

In Sweden, the PT market has already undergone several phases of deregulation since 1989 (Jansson and Wallin, 1991). The most recent change was in 2012 when, among other things, the rail market was deregulated allowing commercial operators to deliver rail travel on any regionally governed route (Transportstyrelsen, 2012). Ringqvist (2016) notes a tendency towards transport regulation following regulatory cycles with four stages: (i) regulated public monopoly; (ii) competitive private supply; (iii) private sector area monopoly; and (iv) regulated private local monopoly (cf. Gwilliam, 2008). Accordingly, there does not seem to be any shift towards further deregulation in the Swedish transport sector, why the development of MaaS might be more likely to follow a public-controlled or public-private route, compared to the development in Finland (cf. Smith et al. 2017a).

In Finland, communication and transport are governed by the same ministry (LVM). This has enabled the Finnish government to make structural links between transport and ICT. This is not the case in Sweden. Also, the struggling Finnish economy and the nation’s long tradition within ICT and digitalization are key to LVM’s interest in MaaS. Since the global financial crisis of 2009, Finland has had one of the poorest performing economies within the Eurozone (Khan, 2015). During this period, ICT and digitalization have been the biggest contributors to national economic growth. Much of the human capital from Nokia has moreover remained in Finland since the telecom giant’s collapse. Hence, LVM has substantial incentives for keeping ICT and digitalization in focus when looking for new recipes for future growth (Leviäkangas, 2016):

> After Nokia had sold its mobile phone [technology] and it looked quite grim for the Nokia group itself, we still had a lot of resources in Finland that were interested and knowledgeable in this area [ICT]. So, it is also an institutional explanation, why just Finland; there was a technological and mental maturity to address these problems. And there was some time, people had time. – IP3 Finland (translated)

The development of the Finnish Code has been closely coupled to MaaS developments. Several Finnish respondents noted that LVM in general, and the minister for transport and communications in particular, have paved the way for MaaS development in two ways. First, by communicating a ‘national’ agenda that seeks to enable MaaS development, drawing attention to the concept, and making it easier for start-ups to find investors and to convince transport service providers to jump on the bandwagon. Second, by proposing the deregulations and regulations required to drive the development, such as requiring transport service providers to make single tickets available for resale. Several private sector respondents in Finland also expressed that they felt included in policy developments, suggesting that Finland’s small and centralized nature may be beneficial for such inclusion. These respondents noted that many stakeholders from the transport and communication sectors, including the politicians and civil servants at LVM, know each other well and have strong formal/informal ties, given regular informal meetings.
In contrast, the Swedish government has only recently become interested in MaaS, and existing regulatory institutions have, until now, been perceived as an obstacle that constrains public actors’ action space. This is particularly the case for PTAs (cf. Smith et al., forthcoming). Also, MaaS developments have, so far, mainly occurred in Gothenburg, whereas most government agencies are situated in Stockholm.

Further, MaaS is supported by different rationales in the two countries. In Finland, MaaS is typically motivated by the idea that public spending on transport must be streamlined and that economic growth will result from cross-industry collaborations and sound market competition. In Sweden, MaaS interests are rather the result of the goal to increase the modal share of sustainable modes in general, and PT in particular.

What does Västrafik want to achieve with MaaS? To develop a service that is as useful as possible for the customer. That it should be…that we should be able to reach new customers with this service – those we do not reach today. We have a doubling goal [for PT’s market share], which we think this service can help us achieve. – IP4 Sweden (translated)

Finnish respondents argued that the organization of PT in Finland is an institutional barrier to MaaS. In contrast to Sweden, Finland does not have regions. Hence, the responsibility for PT and PT subsidies is either on the state or municipal level. In Finland, single tickets are not subsidized, and each municipality has the responsibility for subsidizing its ‘own’ residents’ PT passes. Hence the PTA in the Helsinki area (Helsingin seudun liikenne – HSL), which is governed by eight municipal political bodies, must keep track of their customers’ places of residence when selling other types of tickets than single tickets. In Sweden, all types of PT tickets and passes are subsidized at the regional level, regardless of the traveler’s place of residence.

4.2. Meso-level conditions

During interviews, several Finnish respondents noted the importance of a set of key players, described as ‘MaaS champions’. These actors are positioned in many of the most influential roles within key public and private organizations such as the LVM (both politicians and civil servants), within leading start-ups and at the City of Helsinki. The development of the Code, which is tightly coupled to MaaS development, has been characterized in terms of cross-sectorial discussions between MaaS champions. Finnish respondents also noted the importance of both informal and formal gatherings, and declared how fortunate they were to experience such an open and collaborative climate:

The new minister set up [a] sort of think tank for new mobility [with] high-level people from public and private sectors [and] research. And [the future CEO of MaaS Global] took this idea in there and it really got a flying start in that think tank. …With all that feedback it drove him further. He became the CEO of ITS Finland so it was easy for him to start pushing it more and more, and at the same time the ministry really picked it up, because they saw that this could be something, and then [they proposed] this law [the Transport Code]. We need to be thankful for our ministry because they have been really pushing; they are really one of the main key drivers in the background. – IP4 Finland

In contrast, Swedish respondents did not mention a consistent set of key players (although the CEO of UbiGo Innovation was mentioned during several interviews), and Sweden has, until very recently at least, not created a similar climate of formal/informal collaboration to facilitate cross-sectorial discussions. Further, many key actors in Finland share a vision for MaaS development, whereas very few Swedish respondents spoke of such a phenomenon in Sweden. As a result, there is arguably more tension and mistrust between certain public

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Phrase used in Swedish: combined mobility (kombinerad mobilitet).
and private actors in Sweden than in Finland (Smith et al., forthcoming). In Sweden, this is highlighted by the UbiGo pilot, which, despite its success, was followed by a lack of consensus over the next steps, and both VGR’s decision to initiate an innovation procurement procedure and Västrafik’s subsequent actions have been heavily criticized by some of the other actors involved in the development of MaaS in Sweden:

They [Västrafik] lack knowledge and self-awareness. Then it’s also a natural reaction. If you were [situated] in a development department and loved what you did, and someone asked: Should we outsource this assignment to an external consultant or would you like to do it at the department? ...It was a bit like putting a wet blanket on the whole [development of MaaS in Sweden]. – IP10 Sweden (translated)

Analysis of the meso level highlights two major barriers that are consistent across each case. First, the fact that the PTAs do not allow for third-party ticket resales is seen as a major obstacle to MaaS, both in Sweden and Finland. Although HSL has developed a contract to release single tickets, so far only signed with MaaS Global, and several PTAs in Sweden plan to provide their tickets through the SMP platform, PTAs’ unwillingness to cooperate is often portrayed as the main decelerator to the commercialization of MaaS. Respondents also cited technical issues as part of the problem, such as a lack of reliable open data and the non-existent standardization of interfaces. Respondents argued that the PTAs’ obstinacy on the ticket resale issue is primarily related to a protectionist mindset, risk aversion and organizational inertia. That is, PTAs do not want to risk market shares and customer relations, and are slow at adapting to changed circumstances, which is generally due to the nature of publically administered bureaucracies. Several respondents were of the opinion that PTAs are afraid of losing monopoly positions and losing control of the transport sector:

That’s the biggest problem in transport, everybody thinks that ‘we have to be in power’. When I talk to the train-sharing monopoly they say; ‘yeah, we need to control the customer, we need to control this market, we need to control’. Look, you can’t! – IP9 Finland

Second, uncertainty regarding MaaS business models was probably the most heavily discussed barrier in each case. Respondents argued that MaaS business models that promote sustainable travel and are beneficial for different transport service providers are the cornerstone of MaaS’ future success. This includes the division of roles and responsibilities among incumbent actors and new entrants. Several respondents noted the importance of one key factor linked to MaaS business models – costs associated with marketing new services (and brands) to increase visibility and attractiveness among potential users:

If you want to create a sort of a global, or even a regional service, you would need to have a visible brand that you build on. That’s a very...challenging game, because you need to create a lot of awareness among the users, you need to do a lot of marketing, and we saw that it’s easy to get visibility with these kinds of things, but to really gain those customers and keep them, well that’s a big challenge. – IP7 Finland

4.3. Micro-level conditions

Neither Swedish nor Finnish respondents professed much knowledge about end-users. Rather, respondents saw the need for further pilots to learn more about users’ attitudes, preferences and behavior. In both cases, respondents debated whether or not potential users are ready to adopt MaaS. More skeptical respondents questioned whether current problems in the form of congestion, parking hassles and transportation costs are adequately significant to motivate a shift towards servitized solutions. They also claimed that mental models favor sticking to private car use, and that it is very difficult to compete with the ‘mobility insurance’ that owning a private car provides. Skeptical respondents argued that it will take a long time to change user preferences, and that Finland having the oldest car fleet in Europe is indicative of Finns’ resistance
to change. In contrast, more optimistic respondents claimed that the private car is an ill-suited and costly solution to everyday mobility needs, which many users would rather be without. Further, these optimistic respondents mentioned that the penetration of smart phones; decreasing interest in driver's licenses among younger generations; and the general success of servitized businesses are good indicators of the readiness of the market.

5. Discussion

Our study utilized the IRIMS framework to identify a set of institutional conditions that act as drivers and barriers of MaaS developments in Sweden and Finland (summarized in Table 2). A comparison of the two cases highlights structural differences that, when considered in terms of their historical importance, have led to different paths for MaaS in Sweden and Finland. It is interesting to note that MaaS developments in Sweden initially preceded those in Finland, yet one might reasonably argue that Finland has seen more tangible and recent MaaS-related action. Our analysis reveals several reasons for this. At the macro level, in Finland, the reformation of the Transport Code, combined with the development of a strong vision that is shared by a wider collective of key actors (MaaS champions) situated within key organizations in the public and private sectors, has been a strong enabler of MaaS development. The creation of a vision that identifies MaaS as a source of a new potential growth trajectory that unifies the ICT and transport sectors in Finland, in the context of a dire need for economic renewal, is supportive of these developments. Hence, we argue that the political climate (deregulation of the transport sector) and prevalent challenges (enabling growth within ICT and streamlining public spending to offset the economic downturn) have been successfully matched with the proposal (MaaS) in Finland, thus opening up the needed window of opportunity for policy change (cf. Kingdon 1989). In contrast, Sweden does not have the same need for economic renewal, as the economy has escaped the downturn relatively unscathed. Moreover, Sweden does not have a unifying vision for MaaS; nor does it have formal networks based on strong informal ties; and there is a lack of MaaS champions in key positions. Rather MaaS in Sweden is increasingly framed as a means to assist PT growth.

The difference in the underpinning rationales for MaaS in the two countries is arguably an effect of incumbent PT actors having a more front-seat role in the Swedish MaaS development, compared to the development in Finland. Naturally, PT actors are more focused on improving the existent PT regime and fulfilling incremental growth goals. This can be contrasted to start-ups, innovation agencies and government ministries who are keener on revolutionizing the transport sector and fulfilling visionary targets such as replacing the private car as the go-to solution for mobility. Notably, no representative of the incumbent PT actors was mentioned amongst the group of Finnish MaaS champions, and the Finnish PT sector has had little involvement in either the preparation of the Transport Code or the creation of the MaaS vision in Finland. Hence, one may anticipate that the Finnish development of MaaS might soon face similar disagreements regarding the roles of private and public actors, as has been the case in Sweden (where PT actors have been involved in the development of MaaS since the UbiGo pilot). For instance, although Whim was launched more than a year ago, MaaS Global is still to succeed in convincing HSL to provide more than (unsubsidized) single tickets. As a consequence, MaaS Global has not yet been able to go beyond offering Whim to a group of pilot users.

The two cases highlight a similar set of formal institutional barriers at the meso level. MaaS ecosystems, though emerging, are largely disjointed and there is an air of protectionism and risk aversion among transport service providers (particularly PTAs), resulting in an unwillingness to allow third parties to resell tickets, a lack of open data, and as a natural consequence, uncertainty regarding the viability of emergent MaaS
business models. In both cases, uncertainty regarding the size of the MaaS market and its potential is the result of a lack of knowledge regarding users and their willingness to adopt MaaS as a genuine alternative to private vehicle use.

<table>
<thead>
<tr>
<th>Formal</th>
<th>Informal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro</td>
<td></td>
</tr>
<tr>
<td>The revised Transport Code (FI) +</td>
<td>Optimistic shared vision (FI) +</td>
</tr>
<tr>
<td>The existing regulatory system (SE) -</td>
<td>Lack of a shared vision (SE) -</td>
</tr>
<tr>
<td>Public funding of pilots (FI + SE) +</td>
<td>Presence of MaaS champions (FI) +</td>
</tr>
<tr>
<td></td>
<td>Lack of MaaS champions (SE) -</td>
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<tr>
<td></td>
<td>Drive for economic renewal (FI) +</td>
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<tr>
<td></td>
<td>Drive for sustainability in transport (SE) +</td>
</tr>
<tr>
<td>Meso</td>
<td></td>
</tr>
<tr>
<td>Lack of channels for ticket resales (FI + SE) -</td>
<td>Cross-sector collaboration (FI) +</td>
</tr>
<tr>
<td>Lack of viable business models (FI + SE) -</td>
<td>Public-private divide (SE) -</td>
</tr>
<tr>
<td>Lack of data &amp; standards (FI + SE) -</td>
<td>Risk aversion in ecosystem (FI + SE) -</td>
</tr>
<tr>
<td>Private investment (FI) +</td>
<td>Informal networks among key actors (FI) +</td>
</tr>
<tr>
<td></td>
<td>Lack of trust and social capital (SE) -</td>
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<tr>
<td>Micro</td>
<td></td>
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<tr>
<td>Uncertain market potential (FI + SE) -</td>
<td>Existing user habits (FI + SE) -</td>
</tr>
</tbody>
</table>

Table 2. Summary of influential institutional arrangements (drivers denoted “+” and barriers “-“)

5.1. Practical implications

While our case studies reveal several conditions that are highly contextual, they can also be used to identify a set of generic institutional arrangements that influence MaaS development. That is, policymakers and practitioners with an interest in promoting MaaS developments should focus on the following:

1. Engaging a broad set of strategic and operational key stakeholders that have the mandate and discretion to govern MaaS within and beyond their own public/private sector organizations;
2. The creation of formal and informal networks based on geographical proximity to the centers of power and which are conducive to the creation of trust and social capital;
3. Creating a strong vision for MaaS that tackles sustainability problems in local/regional/national contexts;
4. Using and iteratively revising this vision to create a climate of open innovation within the MaaS ecosystem, where risks are translated into business opportunities for transport service providers;
5. Supporting pilots and implementations with financial capital from the public and private sectors;
6. Experimenting with new institutional arrangements (e.g. the redistribution of subsidies for PT) that are conducive to MaaS developments and sustainable travel behavior;
7. Learning as part of an interactive, co-creative process that aims to develop MaaS services and associated business models that are attractive to users.

These implications are not an exhaustive list; nor are they separate from one another. Rather, they should be seen as a set of interacting institutional arrangements that can be combined to support MaaS development. For example, the creation and iterative revision of an overarching vision for MaaS, based on the developments of services and incentives for sustainable travel behavior (i.e. shifts to more sustainable modes such as car sharing, PT, cycling and walking) may be key to overcoming protectionism and risk aversion among different types of transport service providers. That is, if it can be shown through pilots that MaaS will attract new users from the current private car segment, then transport service providers will likely see MaaS as an opportunity to attract new users rather than see their offerings and their brands as potentially cannibalized
by the collaborative approach that MaaS entails. It is indeed important to remember that the development and deployment of MaaS is not necessarily a goal in and of itself. Still, long-term commitments from PTAs that go beyond piloting might be needed in order to attract private investments. Hence developing MaaS offerings that both encourage environmentally sustainable changes to travel behavior and build upon viable business models may be key to unlocking the potential of the MaaS ecosystem.

The set of institutional drivers and barriers outlined in this paper occur at the macro, meso and micro levels, and despite linkages between these levels, it is clear that no single actor can govern a transition to a MaaS-based transport system in any given setting. Rather, our findings advocate a multi-stakeholder approach to governance, where networks of actors (MaaS champions) must act in concert to bring about the necessary institutional changes. Further, an understanding of institutions as consisting of both structures (legislation and policies, networks and roles, norms and culture) and practices (the creation of visions, experimentation, collaboration, changes in travel behavior) is required for effective governance, such that the development and diffusion of MaaS, as a radical innovation, must be seen as a process of institutional change. Hence in the next section we explicate a set of theoretical implications that may further inform practitioners.

5.2. Theoretical implications

From our analysis, it is clear that the IRIMS framework is useful for identifying the structural elements of institutions that influence MaaS development. However, one major shortcoming of IRIMS is that it obscures the practice-based elements of institutions, i.e. institutionalized roles, norms, behavior and cultural understandings that must change in order for MaaS to flourish. In order to give analyses of institutional effects practical utility, it is necessary to consider how a transition to MaaS may be governed, and a theoretical framework that includes both the structural and practice-based elements of change processes is required. To this end one may draw on the literature on institutional entrepreneurship (e.g. Battiliana et al., 2009) to examine how collectives bring about institutional change. Alternatively, one may draw insights from transition theory, and particularly transition management (Kemp and Loorbach, 2007a; Loorbach, 2010; Loorbach et al., 2010; Loorbach and Wijsman, 2013; Rotmans and Loorbach, 2008) Broadly, this framework espouses a long-term approach to sustainable transitions, based on strategic, tactical, operational and reflexive activities. Strategic activities are collaborative, multi-stakeholder processes, which aim to ensure that long-term visions are shared and embedded among collectives. In contrast, tactical activities serve to link individual actor strategies to the shared long-term visions created via strategic activities, aiming to overcome short-termism within different societal sectors (e.g. politics, business). They also aim to tackle the difficulties in implementing solutions by acknowledging complex sources of inertia within regimes, and directing activities such as corporate political action and lobbying towards the reformation of such structures. Operational activities aim to link everyday activities such as innovative experiments to long-term visions, broader policies and change agendas. Reflexive activities include the ongoing monitoring, assessment and evaluation of policies and practices as a means to revise overarching visions and plans where necessary (Kemp and Loorbach, 2007b; Loorbach, 2010, 2007; Rauschmayer et al., 2015; Rotmans and Loorbach, 2008; Voß et al., 2009). Our findings show that these types of practical activities are central to MaaS development. Theoretically, this implies that frameworks such as IRIMS can be further developed to include elements of practice that can, together with structural changes, bring about institutional change. Practically, one could draw on transition management by, for instance, anchoring the approach among the multiple stakeholders that are key to governing MaaS developments.
6. Concluding remarks

Despite similar pioneering roles in relation to MaaS, developments have arguably progressed along different trajectories in Sweden and Finland. In Sweden, MaaS is primarily discussed as a tool for enhancing the attractiveness of servitized transport in order to meet growth goals for sustainable transport modes in general, and for PT in particular. In Finland, MaaS is rather seen as a new transport paradigm that can enable growth within ICT and streamline public spending to offset the economic downturn. As a consequence, Finnish developments have, until now, been more market-driven, compared to those in Sweden.

By analyzing and comparing MaaS in Sweden and Finland, we have identified a set of formal and informal institutional arrangements that enable and constrain MaaS development and deployment. The analysis illustrates that macro-level institutions (e.g. public funding of pilots) as well as meso- (e.g. risk aversion among key actors) and micro- (e.g. uncertain market potential) affect the prospect of developing viable MaaS offerings that contribute to societal goals. The analysis furthermore reveals differences (e.g. level of trust among stakeholders) and similarities (e.g. lack of data and standards) across the two cases.

Based on our findings, we suggest both practical and theoretical implications. For instance, on the practical level it is vital to engage a broad set of key stakeholders that have the mandate and discretion to govern MaaS within and beyond their own organizations, in order to promote the development of MaaS. This group should aim to create a concrete yet fluid shared vision for MaaS that tackles sustainability problems on both local and national levels. In order to create a vision that is both aligned with societal goals and with the goals of the key stakeholders in the emerging MaaS ecosystem, the group must include both stakeholders on strategic and operational levels of the transport sector, i.e. a mix of representatives for relevant governmental agencies and new entrants to the transport sector (e.g. MaaS start-ups) as well as incumbent public and private transport service providers. On the theoretical level, as practice-based and structural changes are needed in order to facilitate institutional change, both must be encompassed within applied analytical frameworks, e.g. IRIMS.

Lastly, the cases in this study are situated in a limited context in that they comprise a similar set of institutional arrangements. Further studies are needed in order to examine the influence of institutional arrangements in more divergent settings, for instance in countries where PT cannot serve as the backbone of personal urban mobility.
References


Transport system planning in Helsinki region –dealing with big potentials and big uncertainties

TAPANI TOURU HRT Helsinki Region Transport

Introduction

The Helsinki Region has a long history of regional long-term transport system planning. The planning will guide the regional transport policy and the development of the transport system as a whole. It is a common view of the 14 municipalities, how the region should be developed, created by professionals from HSL, municipalities and state (HSL, 2015).

The planning process has developed into its current form in stages. The recent major development step has been the stronger linkage between the regional land-use, housing, and transport system planning. The Helsinki Region land-use, housing and transport planning (MAL 2019) is fundamental for the region in order to increase its competitiveness and drastically decrease its emissions by affecting to the need and modes of transport. The planning process can be said to be state-of-the-art. However, as uncertainties have increased drastically after the anticipated paradigm shift in mobility has entered the game the planning process needs to be developed too.

Mobility as a service (MaaS) and development of technology hold great potential but also great uncertainties. These uncertainties especially in the operational environment must be taken into consideration in the long-term planning. It is also wise to admit, that there is no accurate information about the speed and magnitude of the anticipated paradigm shift. Thus depending strongly on i.e. certain speed or adaptation of some new solutions means taking big risks. It is important to make resilient plans that can adapt to different futures.

MAL 2019 planning process possess a philosophy of realism and resilience. This means, that in the short span of planning, target year 2030, the focus will be in ”certainly needed measures”. However, in the long term planning, target year 2050, focus will move to a consideration of possible future scenarios. By looking at different scenarios it is still possible to define some measures, that are ”more probably needed” than others. In short term, it is important to keep in mind not to ruin potential for any possible measures in the farther future.

Regional and national targets and goals guide the planning process. Goals set in the MAL 2019 process include ecological, social, and economic sustainability and competitiveness of the region. These goals create the base for planning. Key challenge among the goals is to decrease CO\textsubscript{2} emissions 39 percent from 2005 level by year 2030. This target is set by EU-commission and has been approved by Finnish government. This means that Helsinki region transport emissions need to decrease by 50% by year 2030.

Regional MAL-planning consists of studies, planning, and collaboration to find the best combination of measures to meet the set goals. MaaS, and different services considered to be under the concept, are taken into consideration as measures to meet the goals.

Second chapter presents briefly the methods and material for the paper. Third chapter presents the main findings from the case studies carried out in Helsinki Region. The final chapter presents some conclusions of the main findings.
Methods and Material

Helsinki region transport system planning is based on knowledge acquired from previous planning rounds. The information and contents are updated and added with relevant studies which will be carried out in the next round of planning. Among the studies carried out in MAL 2019 process thus include:

- “New transport technologies and services”
- “Shared mode simulation”
- “Public transport trunk network and land-use”
- “How to reach the target to decrease CO2 emissions”

The above mentioned studies are carried out under the supervision of Helsinki region transport system planning specialists using Emme-transport modeling tools and professional analysis. Key findings from these studies are described in the following chapter.

Review of the Studies

Based on the goals set in global, EU, national, regional and local levels, the key question when carrying out these studies is, how to decrease the CO$_2$ emissions in the most efficient way. This is considered in all studies. The impacts on emissions will be key priority when choosing measures in planning phase. Other set targets are more of a guiding nature. Then as an end result, the plan will consist of measures and policies that lead to less emissions and achieve the goals in the best way possible.

To get an idea, how new transport technologies and services could help the region to meet the goals, a study (HSL 2017) was carried out as part of the process. The key questions of the study were:

- What kind of new technologies and services are out there?
- What kind of potential do they have?
- What kind of risks are included?
- What kind of measures should be implemented as first steps?
- How to manage long term risks?

Fourteen different services or technologies were studied and they were divided into five different categories. The categories in the analysis were sharing, automation, traffic management, home delivery services and motive powers.

To study the concept of sharing, a ride-sharing market model was introduced in the Helsinki region. The study revealed the highest potential for ride-sharing to be in the relatively long trips made from the more densely populated satellite centers outside the metropolitan area. The short average trip distances and good availability of public transport reduce the potential in more urban areas. An interesting result in the model was that 2/3 shared ride users come from public transport. This is a significant risk that needs to be acknowledged as this modal shift can lead to more mileage, hence more emissions, congestion and other harmful effects (HSL 2017).

To study the possible impacts of automation on travel times, a scenario with an increase of 20-30 % to road capacity was applied in the Helsinki region morning peak (Fehr & Peers 2017). As a result, it was revealed that the areas that benefit the most from automation are near the arterial roads outside the outer Ring Road (Kehä III), mainly in the areas where the level of public transport is not very high. (HSL 2017)
Some of the new services and technologies add new options to transportation, which facilitates people who do not own cars and reduces the need to own one. Many of the services and technologies also support the more efficient use of resources, such as vehicles and infrastructure. However, some of them may lead to a development that does not meet the society’s objectives, for example increase to the mode share of cars. The most significant risks are related to privately owned automated vehicles, but also the other services based on cars (i.e. car sharing, ride-sharing) may decrease the share of walking, cycling and public transport as was seen in the ride-sharing results.

As a result, suggestions were made based on analysis and impact assessments:

- The impacts of different organizing and business models of ride-sharing need to be evaluated and meaningful services may be advanced by introducing pilot projects or trials. The requirements to infrastructure need to be further evaluated in relation to other modes of transport.
- To make sure that automated vehicles will be shared it is important to focus on the right models to achieve this. The trials should be connected to ride-sharing trials. The impacts of automation on urban sprawl need more attention.
- Dynamic pricing is recommended as a tool to manage the externalities of transport and to address many of the threats related to the new services and technologies.
- The new formats of cycling, such as bike-sharing and electric bikes, are advanced by investing in cycling infrastructure and expanding the city-bike system.
- Expansion of the charging network of electric cars is also recommended.

Another study done in the Helsinki region was carried out by OECD/ITF. The study of “Shared mobility – Simulations for Helsinki” (2017) answered to a question “what if different shares of current mobility would be done by shared vehicles”. The entire mobility of the Helsinki Metropolitan Area was simulated for one working day, including the current modes and different adoption rates of the new shared services. The simulation provided a detailed array of indicators that allowed the measurement of:

- Impacts on the city and the transportation system, such as decreases in CO₂ emissions, parking space required, car use, congestion, changes to accessibility and the extent of modal shift.
- New shared services performance, both from a user perspective (travel times, waiting times, access times, number of transfers) and operator or production side (number of vehicles, occupancy, depot location and sizes, costs).

Nine different scenarios were preliminarily studied. Out of those most influential is a scenario, where all trips made by private cars are substituted by shared mobility and public transport kept as it is. Reduction in vehicle kms, CO₂ emissions and congestion compared to baseline is more than 30%.

However, Helsinki region was interested in studying more in-depth scenarios that could describe the situation after first steps of implementation. The results show that public transport is an important part of transport system. These new modes would give benefits, compared to current system, in areas, where there is currently poor public transport as a result of low population density.

The findings from the OECD/ITF study show that compared to current situation, it is very difficult to improve accessibility and thus get benefits from areas that have good public transport service. In conclusion, public transport seems to be the correct mode for masses in these areas.

Another study was carried out to find out, how land use and public transport should be developed together. In the study, accessibility with sustainable modes was compared with land use density. The study showed...
that there is a lack of accessibility in the municipal centers outside of the metropolitan core. These are areas, where it is not economically viable to run efficient public transport service but still have some population densifications. Another key finding from the study is that in the metropolitan core, the accessibility enables still much more densifying, compared to preliminary land use data collected in MAL 2019. These results will guide further MAL 2019 planning. Densifying land use in existing rail corridors is one key starting point as this has good impacts on set goals.

The land-use data collected from municipalities show clearly, that the idea of densifying in rail corridors is well adopted. By the year 2050, approximately 80% of the population in the region is located in 30 biggest centers that are also trunk network node points. This kind of densification creates good potential for better public transport and enables walking and cycling. On the other hand, this densification means that space will be altogether scarcer. In addition, it is ever more important to zoom the focus on the attractiveness of city centers and local emissions. This means, that modes that have low space efficiency and create local emissions, should not be promoted in city centers. The extra space needed for cycling network, attractive pedestrian areas and for new kiss-and-ride services that will decrease emissions can be obtained from parking. This will be made possible for example with shared mobility modes, studied in the OECD/ITF simulation that decrease the need for car ownership. The most efficient all around tool for decreasing car usage is pricing.

There has been substantial amount of discussion about climate change. However, the actions which have an effect on climate change have not been as substantial. The study about “measures needed to meet the climate targets by year 2030” (HSL 2017) was done to obtain a clear understanding of the scale of measures needed. The results show that no single measure tested was able to decrease emissions enough. A combination of congestion charging, increase of parking costs, drastic increase of electric vehicles, the increase of public transport and cycling, and improvement of heavy transport fuel efficiency could altogether lower the emissions enough. The challenge is how to enable these measures now. The positive notion however is that the needed measures already exist.

**Discussion and Conclusion**

The results of MAL 2019 planning show that there is a need for strong public transport and i.e. good cycling network in any given future of mobility. According to MAL 2019 philosophy, investments in node point improvement and in public transport trunk and bicycle network are surely effective. How large these investments should be is another question entirely. Nevertheless, there recognizable risk, that insufficient investment to public transport can lead to less resource efficient travel patterns. This in turn could lead to undesired land use development. Hence, it is necessary to keep investing to public transport in order to keep it attractive to the general public, maintain functionality of the transport system and control emissions. Development of public transport oriented land use simultaneously improves possibilities to use bicycle or walk on daily trips.

From the transport system planning perspective, which is guided by goals of sustainability, it is clear that MaaS or any other transport trend should not compete with traditional sustainable means of mobility, as long as they do not prove to deliver better results. Competition can deteriorate the current transport system and lead to undesired impacts. If the big volumes using public transport currently would start choosing undesired and less sustainable travel patterns the impacts would be very negative.
Instead of competing with public transport and other sustainable modes of transport, the focus for developing MaaS and other new technologies and services should be clearly in developing them first as feeder services. This should be done especially for areas that currently lack services, i.e. the outerskirts of Helsinki region. This is of course a challenge from business perspective, but from societal perspective, that would be the right thing to do. At least in short term. Making it attractive to use sustainable modes of transport in areas where private car is the only real option currently would make a big difference. It is most important that people learn new sustainable ways for their mobility. This change in attitudes is much needed in order for the MaaS services to succeed. While Maas has a novelty value, it can make the change in attitudes happen. Nevertheless it needs to be stressed, that the new travel behavior patterns should take us towards more sustainable societies. Decisions of development and regulation should be based on sustainability, not for example freedom of movement. The problems that high adaptation of private cars has caused must have taught us something.

The reports of the studies mentioned in this paper can be found (in finnish) from 
https://www.hsl.fi/mal/julkaisut