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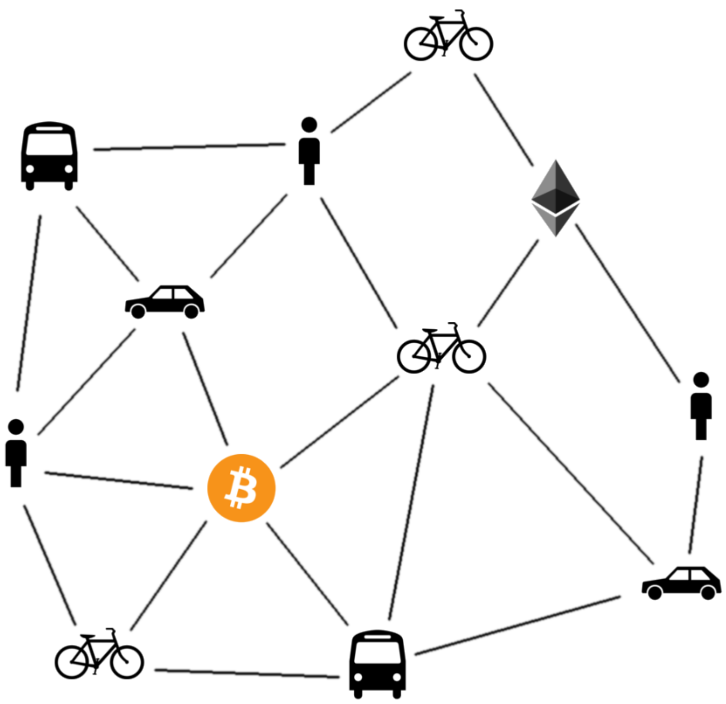

Exploring the role of blockchain technology in Mobility as a Service

Towards a fair Combined Mobility Service

Master's thesis in Complex Adaptive Systems &
Management and Economics of Innovation

Patrik Andersson
Joel Torstensson

Department of Space, Earth and Environment
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2017

Master's thesis FRT 2017:11

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Supervisor: Frances Sprei, Department of Space, Earth and Environment
Examiner: John Holmberg, Department of Space, Earth and Environment

Master's Thesis FRT 2017:11
Department of Space, Earth and Environment
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover: Mobility cluster with inserts of blockchain related figures.

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Abstract

Mobility as a Service is a novel approach to mobility. There have been several efforts to incorporate the approach by trying to bring multiple mobility providers (MPs) together in one platform. In most of these efforts, one organization has acted as a broker for all of the MPs and the customers. This broker might have vested interest and could be biased toward well established MPs. A new technology called blockchain provides a viable method of coordination of parties that do not trust each other without the need of a central authority. This report explores the intersection of these two developments, Mobility as a Service and blockchain technology, and asks: How can a Combined Mobility Service platform that benefits all of the involved stakeholders be designed? We explore both the technical viability as well as possible economic impact on MPs of such a platform by combining qualitative and quantitative approaches. By interviewing multiple stakeholders, the central requirements were identified. To investigate the socio-economic impact, an agent-based model was constructed that simulates the effect of user behaviour with and without the platform. These simulations shows that while it might not be very clear if the revenue of a MP increases by joining the platform, the existence of the platform will decrease the revenue of MPs that do not join if the platform gets sufficient network effects. The main result of the study is a simplified technical specification of how a platform could be constructed which provides a solid description of how it could be implemented. This specification takes into consideration the needs of existing MPs, but also maintains neutrality so that new MPs can join on an equal footing with the existing ones. While it does not take all of the technical possibilities into consideration, it can still be seen as a success since it suggests a solution to the main problem of combined mobility platforms. The simulations provide additional confirmation that this approach is viable. The next step in this research is to implement a proof-of-concept of the platform, showing its viability on a more practical level.

Keywords: Mobility as a Service, Combined Mobility Service, platform, Blockchain technology, agent-based modeling.

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We would like to put forward our gratitude and appreciation of how Challenge Lab (C-Lab) has provided us with life-long memories and knowledge. The people and the team behind the C-Lab has an extra special place in this acknowledgment because of their support in our work on this Master's thesis. They provided us with space, time and effort in making this the best experience we have had so far during our studies at Chalmers. Also special thanks to Andreas Hanning for providing an adult but loving vibe in the lab throughout every week.

Without the stakeholders involved in the project this report would not be what it is. So a big thank you for your participation, and to the respondents that took time off to be interviewed as well.

We would also like to thank our supervisor Francis Sprei. She supported us and gave us advice and feedback necessary to tie the two separate study backgrounds together when everything looked dark.

Last but not least we thank our fellow students in the lab whom have given us many laughs and good times.

Patrik Andersson & Joel Torstensson, Gothenburg, June 2017

Terminology

General terms and abbreviations

API Application Programming Interface, a set of procedures and tools for building software applications that interact with the features or data of another application or operating system.

Blockchain
a new type of decentralized database with a lot of interesting properties

CMS
Combined Mobility Service

Cryptocurrency
a digital currency issued on a blockchain

Ecosystem
A complex system or network of interconnected components.

FOT Field Operational Test

ICT Information communication technology

Intelligent Mobility
Using technology and data to create connections between people, places and goods across all modes of transport.

IT Information technology, is technology for processing, storing and exchanging information.

ITS Intelligent transport system, the interaction of Information Technology and Telecommunications to enable information to be used by the public and through private administration, that is applied to transport.

MaaS
Mobility as a Service

MaaS Provider
Stakeholder that designs and offers the MaaS value proposition.

MP
Mobility provider

Multi-modal
A combination of the use of different modes of transport in one trip.

P2P Peer to peer

Servitisation
The idea of aggregating products or services that adds value as a supplement to the original product or service.

Sharing economy
A model of peer-to-peer sharing to access a range of goods and services.

Smart contract
a small piece of code that lives and executes on a blockchain

Transport Operator
Stakeholder that provides transport assets and services.

Contents

1
Introduction

The world is increasingly becoming more complex as we are moving further into the 21st century. Our ability to forecast the future is decreasing and at the same time the need for action to solve global problems has never been greater. To approach these problems new kinds of tools are needed that gives a more holistic picture of the complex systems that we are a part of and that shows ways how to move forward.

The Challenge Lab (C-Lab) is a interdisciplinary space situated in the upper part of Johanneberg campus at Chalmers University of Technology in Gothenburg. This is a place where students from different engineering disciplines and cultural backgrounds meet and have the opportunity to take advantage of the diversity in knowledge they bring to the lab. It is also a neutral space where the triple helix consisting of academia, the public sector and the industry can meet on equal terms. This is an important feature of the lab since it enables the students to work in an environment that is providing a multifaceted point of view. In this environment the students are given the task to find new creative solutions to relevant problems. C-Lab enables students to work with contemporary societal problems using a method called backcasting. The focus is on enabling the students to learn how to specify problems and how their competences fit into the larger complex societal system. This year the C-Lab offered three themes. Namely; urban futures, mobility, and circular products and services. The chosen one for this report became mobility after a process of four weeks. During this time a wide range of topics where explored within the three themes using the backcasting framework. All students worked together until the last week where groups of two formed around specific research questions.

This report investigates the intersection between Mobility as a Service and Blockchain technology. Both of these topics are cutting edge and are being actively researched. The reason this topic was chosen is manifold. The current transport system is in need of transformation because it has a wide range of problems. Among them are pollution from fossil fuel, congestion, and health issues. Mobility as a Service is about integrating multiple mobility services in order to address some of these problems. Blockchain technology is a recent development in computer science and economics that brings a new way for parties with differing interest to come to an agreement without the need of an intermediary. This could have impact in most sectors of society.

The format of this report is divided in two separate parts, referred to as phase I and phase II. Phase I is mainly about the process of how the students came together as thesis pairs in the first 4 weeks and how the research question was produced. Phase II then focuses on answering the research question itself.

Phase I

2
Challenge Lab

This chapter describes how we worked in the Challenge Lab (C-Lab) during our first four weeks together as 16 students. During this time we developed a common understanding and discovered issues in the current system. From this understanding we constructed our research question that is explored in the second part of this thesis. This period will henceforth be referenced to as Phase I.

2.1 Background

C-Lab is an initiative that empowers students to play a larger role in the transition to a more sustainable world. It invites students to write their master thesis in an open space where co-creation and innovation takes a central role. The focus of the lab is to address the sustainability challenges that are present in today's society. Including social, economic, and environmental aspects. C-Lab also acts as a neutral space where students have a unique opportunity to get new perspectives on these important questions. The initiative for the lab was taken by Professor John Holmberg, former vice president at Chalmers university of technology, and it is now being run for its fourth year.

One of the major reasons behind the lab is the realization that traditional ways of linear problem solving are not appropriate when solving problems in today's society. Instead the inherent complexity and complicatedness of society, which is often referred to as wickedness[1], is acknowledged and more novel approaches are used to help induce transition into the system in the places in which it has become unsustainable. To accomplish this a tool called backcasting is utilized, which will be described in detail later in the report. Another major aspect that the lab introduces is that the students get to work with stakeholders from the *triple helix*. The three sectors that make up this concept is academia, the public sector and the private sector. Looking at problems from all of these three perspectives and talking to the respective stakeholders gives students a good overview of the situation in the region. Furthermore, connecting with the stakeholders is essential for the produced theses to have a real world impact. It also helps the students learn about working in real world scenarios.

As mentioned before the students are a central part of the lab, but the aim of the lab is not simply to help students to become better problem solvers. Instead the students are given space to become *change agents*, who take an active role in defining the problems at hand. John Holmberg stated it simply:

> “ The student is much more than a problem solver ”

2.2 Theory

In this section will go through the theory behind what was done during the first four weeks of the C-Lab. The focus is on backcasting, that acted like a framework in which the other theories where used. There are two major perspectives that these tools can be categorized as; *inside-out* and *outside-in*. Inside-out is done by introspection of yourself or your organization, with the goal of making an assessment of the current situation and where you would like to be. The opposite of that is outside-in, where the perspectives of outside sources are taken into consideration. Together they provide a good holistic overview of the problems we are facing.

2.2.1 Backcasting

Backcasting is an approach to combat complex societal problems[2]. In contrast to forecasting and scenario planning, which simply extrapolates from the current situation to predict the future, backcasting employs a method of defining a desirable future and how to reach it. Forecasting can be seen as problematic since the future it predicts might be undesirable, it can also be prone to errors in the long term since it is hard to predict complex relations that might cause large scale dissipation. While Scenario planning merely predicts contingency actions for alternative futures. However, Backcasting approaches these problems by using a process of four distinct steps[3]. Using these steps backcasting provides a radically different framework for solving problems since it gives us a way of understanding the holistic picture in which the problems are framed. Such a systematic understanding is essential to address the sustainability issues we are facing in the world today. To get a visual representation while reading about the four steps refer to figure 2.1.

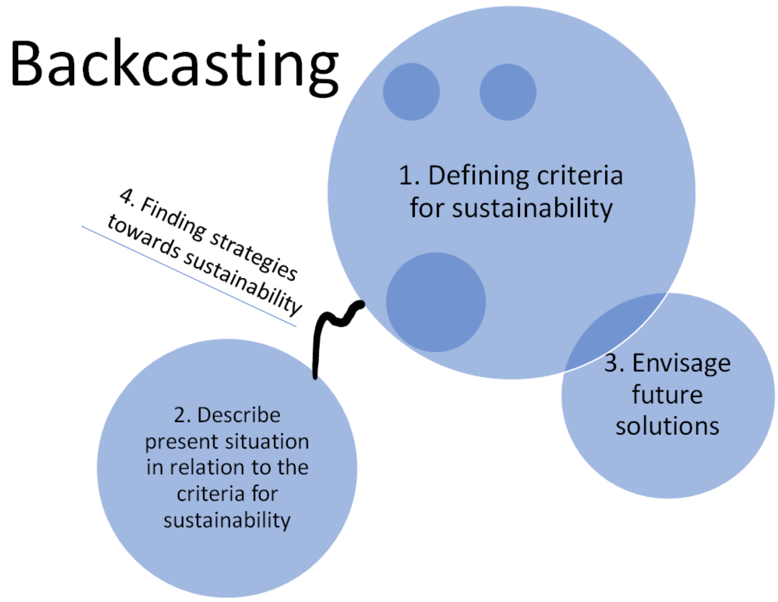


Figure 2.1: The four steps of backcasting adapted from Figure 1 in Holmberg[3, p.33]

2.2.1.1 Step 1 - Define a framework for sustainability

In the first step the goal is to define a framework for sustainability. It is important to specify a vision of what a desired future would look like. Without it, using only current trends as a guide, things could go in a negative direction and it would be hard to detect. The sustainability framework can be seen as a guiding pillar that helps us move forward. Making up this framework is a number of criteria. Some of the most fundamental criteria are mapped out by previous studies[3]. However, it is important for each project using backcasting to define this framework for that particular project. Both in order to get a better understanding of the criteria and to adopt them to better fit the current project.

2.2.1.2 Step 2 - Examine the current situation

Using the framework defined in the previous step the current situation can be investigated[4, 3]. What is the current situation like in relation the the framework? What are the ongoing activities and what competences exists? These questions should be investigated by taking each of the previously defined criteria into consideration. It is important to make this understanding as realistic and thorough as possible, so that the next step can have a solid grounding in reality.

2.2.1.3 Step 3 - Envisage future scenarios

By combining the previous two steps the third step focuses on envisaging possible futures. The vision could be quite broad but should be within the framework defined in step 1. Using the information from step 2 the vision can be made realistic. It is also important to look at the future role of the organization in which the backcasting method is used. The question is if the vision and mission of the organization are aligned with the criteria of the framework?

2.2.1.4 Step 4 - Identify transition strategies

The final step consists of looking for strategies to fill the gap between the current situation and the future scenario. How can a transition happen that also take the sustainability criteria from the framework into consideration? It is important that all of the criteria are considered so that solving one problem does not create another one. When this is done a first thing that can be considered is if there are any low hanging fruits, quick fixes that have a good impact. Things that are more difficult to fix should still be considered in parallel though, since they probably have a larger positive impact.

2.2.2 Tools used within backcasting

As a part of backcasting a number of additional tools can be used. Some of the tools can be categorized as inside-out and some as outside-in. The backcasting step in which they are used within is also specified.

2.2.2.1 Self-leadership

Self-leadership is an inside-out tool that is used to get to know yourself better. The main goal of this tool is to get a better understanding of your own values and why you behave the way you do. This was integrated into step 1 of backcasting.

2.2.2.2 Multi-Level Perspective

The *Multi-Level Perspective* tool used to better understand how different aspects of society play into societal transformations[5]. It can be seen as an outside-in perspective to get a better understanding of the system as a hole.

2.2.2.3 Leverage points

In a complex system it is easy to get caught up in trying to come up with solutions without having any real understanding of how those solutions might actually affect the system. Therefor we need a tool to help us find places where change can actually happen. A *leverage point* is a place in which it is possible to intervene in a complex system with small effort to cause a large positive effect[6].

2.2.2.4 Dialogue

In order to start thinking together about problems more direct methods of communicating are needed. A dialogue is a tool that enables this[7]. Instead of talking **to** each other by preparing in advance exactly what to say, dialogues enables people to talk **with** each other, which is needed in order to solve problems together. This is done in an open setting where participants can face each other and relate.

2.3 Method

This chapter will explain the methods we used together. In short, moving towards a sustainable future by starting with the backcasting method then proceeding in order with self-leadership, systems thinking, understanding the current situation, and end with design thinking.

We started our journey in the C-Lab as change agents building upon the experience of the previous years students. This is one of the major reason the lab exist and is a way of reconnecting with stakeholders who have projects going on for longer periods of time than the students theses. It also helps students in finding where they fit into the processes and helps them become more skillful change-agents. The unique part of the lab is how we as students worked with the tools provided. We had the opportunity to look at the problems from a global perspective, think in longer terms, and work with what we got in new ways, much like an entrepreneur rather than students. As future change agents, we need to be able to identify and recognize the inevitable risk of doing nothing in a world of constant change. The methods we used gave us the ability to have an holistic approach rather than solving issues by sub-optimization. With questions on how we open-up and close down, in other words going from an abstract level of gathering information down to a concrete level of synthesizing information. Here fundamental principles of details vs. the trunk was used in the representation of a tree. Where the details is the leaves and the trunk is it's core and roots. As we started here at the lab we made our own coat of arms, which are our self-portrait of our values and interests, representation in form of a heraldic design of who we are and what we stand for.

From the previous years' sessions at the C-Lab, the students identified why this neutral space exist with three words:

- Transformation
- Integration
- Universality

These words symbolizes what the C-Lab is all about. Consequently the following will explain how they are used and what they refer to.

2.3.1 Leadership for Sustainability Transitions

Previous to this masters thesis, most of us took the introduction course ENM145 - Leadership for Sustainability Transitions. This course is not mandatory but quite central since it gave the students participating a chance to learn the theory presented in the previous chapter and test the methods used in Phase I. In the introduction course served Johanneberg campus at Chalmers University of Technology in Gothenburg as an incubation area in a case assignment guiding us through the backcasting segments:

1. Principles and values
2. Understanding systems
3. Solution envisioning
4. Transition strategies

The course followed the same pattern as Phase I, hence the following explanation of the method presented here covers the course. However, there is a difference, the distinction lies within the time available. In the course, we had about 2 months and the Phase I, duration was 4 weeks. In the course we also had the problem area of the campus already defined and presented to us, in Phase I we had to discover the gaps along with the aim of finding a research question from a leverage point. Note that during these four weeks, we have not proceeded to the final stages of backcasting as we did in the course.

2.3.2 Backcasting at the lab

The first step in the backcasting methodology was to to define a sustainability framework. Doing this in general has been proven difficult[8], it is hard to imagine what the future will be like. Another way to describe the process is to establish a future vision and have the basic shared understanding of the current situation. Sustainability is defined as:

> “ *Development that meets the needs of the present without compromising the ability of future generations to meet their own needs* ”
> *- Our common future[9, p.42]*

We cannot as a deduction of this continue with *business as usual* and thus get stuck in the way we are used to live our life. The earth we are inhabitants of has its limits and if we should be able to support over 10 billion people living here, we need to be careful. Minding the planetary boundaries[10] and by using the method developed by Holmberg & Robért[4] and diffused by The Natural Step, four principles have been defined.

This was evidently a tough task given to us because the criteria framework[11], had to be revisited a couple of times before we as a group of 16 students, was satisfied and reached consensus. This can be seen in parallel to how complex and complicated the world is and backcasting, when it is applied in this planning phase, acted as the scaffolding for conceptualizing and strategy formulation when facing wicked problems[4].

Following the first week, we put together a framework (see section 2.4.1) of sustainability criteria's and started to map out the current situation. In backcasting, the process starts with the target, the starting point is aiming to define what is the future vision or state that wants to be achieved. This was done in cooperation and co-creation in the lab, where we decided upon what sustainability is and what the boundaries are. These are the domains from which the sustainability criteria are derived from:

- Well-being
- Societal
- Economical
- Ecology/Nature

In Phase I our focus was on the backcasting step 1 and 2. As the theory section explained, step 1 is to look backwards from the future, to see what needs to be done to achieve the desired outcome and what should happen.

In Step 2 we payed attention at today's situation and looked forward on what is about to and will happen, describing the present situation in relation to the criteria for sustainability that we produced together in the lab. The second step in backcasting is consequently about the ongoing developments. The point of mapping out the current situation is to find the leverage points, where we as students and change agents can have an impact. As Meadows propagates[6] most people recognize where the leverage points are, but most fail to realize that there are more behind the scenes than they know of. Most of the problems we face today are increasingly complex and the feedback loops are not tied together in any traditionally logical way.

2.3.2.1 Outside-in

This perspective was used due to a shared vision is vital of how the outside perspective perceives the problem at hand. Furthermore, this way of approaching the problem is symbolic to how the C-Lab can be part of not only the solution, but also define the problem. By identifying and involving the stakeholders, sharing the future vision and confront them instead of supporting the current situation. This type of leadership requires dialogue[7].

2.3.2.2 Inside-out

As students we are part of the *elite* in society, we are empowering ourselves with education to become the leaders of tomorrow. This comes with a great deal of responsibility. From our experience we are rarely exposed to the ethical and moral issues during our studies to become engineers. One of the tools we used in the Phase I to tackle these was by understanding our own values. The logic for this is that change has to happen on the inside in order to happen on the outside. By knowing oneself and know what values one stand for, makes the students at the C-Lab feel grounded and self-confident to lead towards a sustainable future.

2.3.2.3 Self-leadership

It was clear in 2014 when The C-Lab was founded by John Holmberg that the lab aimed for the long-term[12]. To achieve this it had to be a place where students could grow as a person and build courage. Empowerment by education is only half of the journey, to get to know oneself better we had a workshop in individual strength assessment based on self-determination theory[13]. The way we do this together in the lab strengthens the trust between us and collaboration in this stage is important for the group dynamics. By listening, understanding, trusting and by co-createing in the midst of complex systems[14] we gained a better understanding of ourselves and our fellow students. At the lab we got to work with a team of international master students from a broad variety of backgrounds and master programs.

To better get to know our own values we had a workshop hosted by a representative from the organization Self-leaders. The workshop gave us an in-depth understanding of why and how we value what we do and how that causes us to act. Before the workshop we selected our top values and the first task was to present these values to other students in face to face dialogues of 15 minutes, which was a very good way to understand oneself. We also did an exercise called Strength deployment inventory (SDI), Develop by Elias Porter[15], to help us be aware of how our values relates to the values of others. To give a feeling of how it was to participate, here is a powerful quote from the workshop:

> “ The best leaders live according to their values. It makes people want to follow them. ”

The keywords from the workshop:

- Openness
- Emotion
- Reflection
- Dialogue

Furthermore, we talked about the importance of:

- Autonomy
- Competence
- Belonging

These factors are important in order to feel committed and trust towards the organizations we work in.

Another thing we learned from the workshop is that we live in a *V.U.C.A world.* This expression originates from the US army and if one write out the abbreviation it stands for Volatility, Uncertainty, Complexity, and Ambiguity. It symbolizes how dynamic and hard the world is to predict and forecast. Furthermore the interaction and causal connections are hard to define and a holistic perspective is necessary to understand the world today.

2.3.3 Systems thinking

Peter Senge defines the concept *systems thinking* in his book Fifth discipline as a way of thinking of the world as a hole, different system models can then be used to see the hole in different ways[16]. He also brings up the learning organization, that can enable an organization to find the time and place for leveraging their change actions in a rapidly changing environment.

The method we use in the lab is described as a multi-dimensional perspective[5], where we take a look at problems from four different dimensions presented in figure 2.2. Ranging from product technology systems, to product service systems, and sociotechnical aspects and the societal system that try to manage these complex and complicated issues[5].

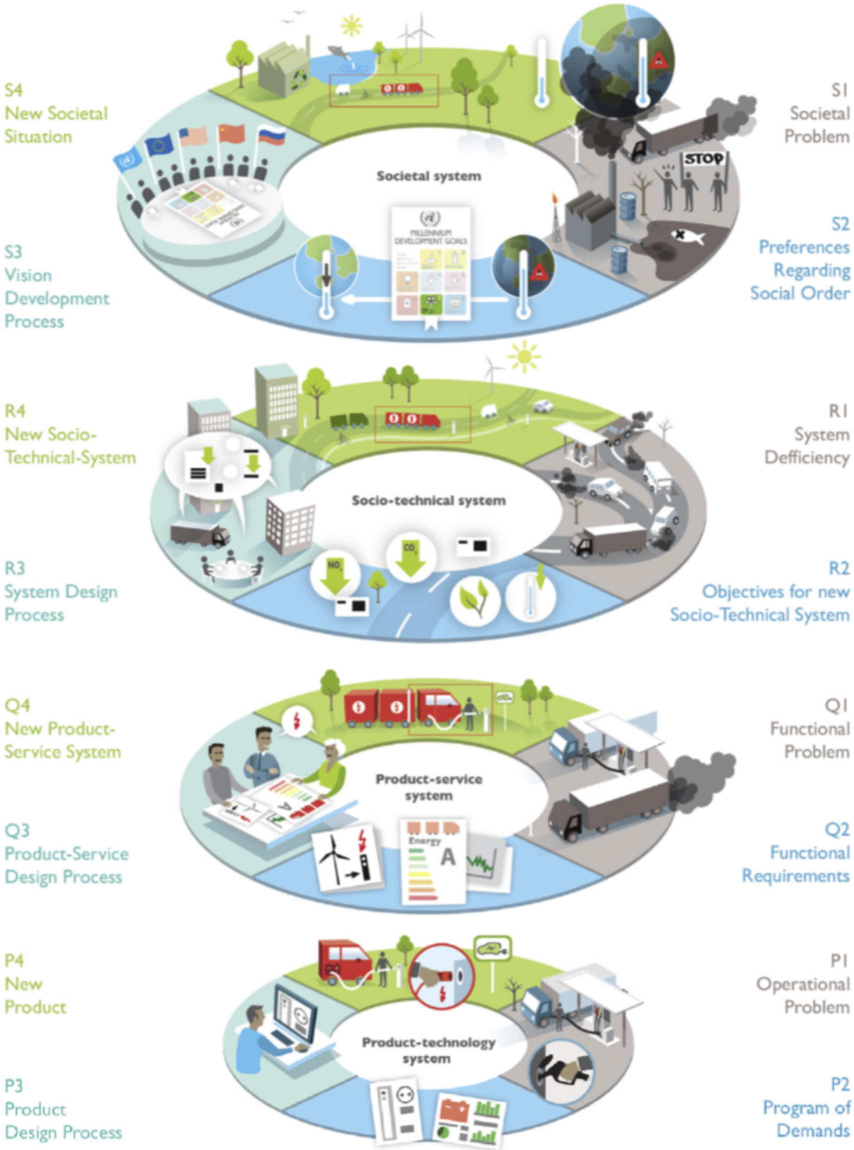


Figure 2.2: MDM cyclic visualisation - sustainable transport adopted from Joore and Brezet[17, p.100].

2.3.4 Understanding the current situation

The method used in the C-Lab to get a form or *situational awareness* is by inviting people in to the lab, presenting the current on-going work in the field of sustainability. Västra Götalands regionen (VGR), was one of these actors. We also use the knowledge we bring with us in to the lab, by adding these to whiteboards and in co-creation shares the interests in different topics.

It would be a general failure to not mention that we worked intensively with the whiteboards during the first weeks in the lab and definitely learned how to peal of a sticky note in the most perfected way.

2.3.4.1 Themes

This is the method to get to the conclusion in which area we want to work on our thesis, we use themes in the lab and this year we were able to choose from:

- Mobility
- Urban futures
- Circular economy and services

We then used these themes in cooperation and with the inputs from the stakeholders dialogues we started to put up sticky-notes on the whiteboards. The process was iterative and performed by breaking down the parts and putting them together. First define what the headline is and then going forward with the separate parts, finding the causal rational links between them. This part was done on the whiteboards where we had divided the themes on three separate boards. Then we used different colored sticky-notes to frame the different potential problem areas we should focus on as leverage points.

2.3.4.2 Dialogues

As students in the lab, we are also practicing our leadership skills by facilitating multi-stakeholder dialogues.

These dialogues are mainly to get insights on the themes and stakeholders was invited into the C-Lab space to be part of discussions, to help us comprehend what happens in the region. We had three sessions altogether and they where facilitated by us students. The discussions took place in the format of fish-bowls (see figure 2.3), with one inner circle and one outer. Where the stakeholders sit in a ring and talk, moderated by the facilitators that are neutral. The talks starts with the inner circle and the outer circle are only allowed to listen. Later the outer circle joins in to ask questions and to bring new perspectives into the dialogue.

2.3.4.3 Guest-lectures

During the Phase I we where visited by guest lectures to help us understand the current situation related to the second step in backcasting.

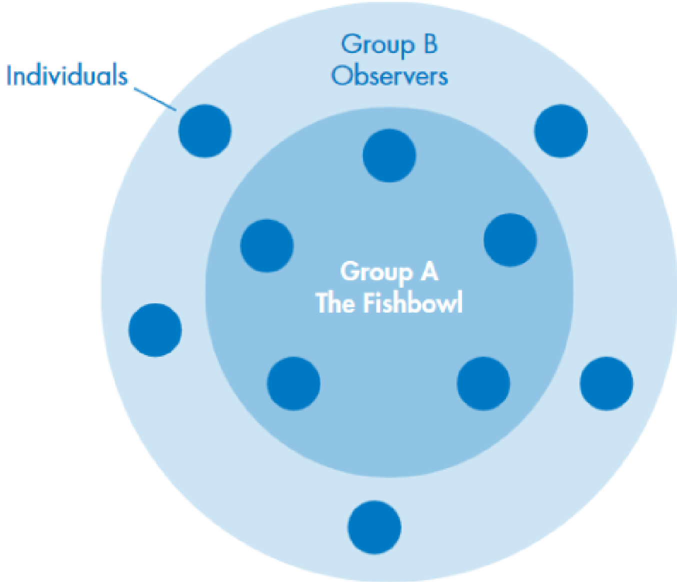


Figure 2.3: Fishbowl

- Anna Dubois, Vice President at Areas of advance of Chalmers university of technology. Presented Chalmers Open Innovation Systems (COINS), a long-term strategic project included in 5 out of 8 areas.
- VGR, also presented their report: *Strategiska vägval*[18], a climate strategy for growth and development that used the backcasting methodology to define 85 challenges in the region of Västra Götalands county. It has two perspectives, geographic and consumption. Targeting 2030 to be a fossil free and fossil independent region. This new report takes over where the old one ends, *VG2020* - a strategy for growth and development 2014-2020 with 4 themes focusing on the good life.

2.3.5 Design thinking

The process in the C-Lab is iterative and the method used is called *Design thinking*[19]. In order find the gap between Step 1 and Step 2 in backcasting, the approach is to have the concept of design in mind. This is relevant because emotions, the cognitive and physiological environment has to fit with the needs. Using design thinking usually means that the process is iterative, the same goes for the C-Lab. Here we used a generative bottom-up approach.

In the lab we are guided in design thinking by Örjan Söderberg, teacher and Head of MSc Programme for Industrial Design Engineering, div. Design & Human Factors, Product and Production Development.

Design thinking was used and integrated in:

- Individual gathering (methods: internet, 1-to-1 talks, VGR etc.)
- Leverage points

- The final challenge - Gap

Furthermore design thinking is closely linked with mapping. Where we open-up in an exploratory divergent way that is discovery driven and close-down in a convergent pattern that is delivery driven.

Dynamic Balancing is a natural part of design thinking, where relationships between regimes and actors are explored [5]. As the process is iterative, the innovative steps become incremental in design thinking. Additionally, in the C-Lab these are referred to *low hanging fruits*, the leverage points where we as change agents can interact.

2.3.6 Formulating a research question

By using the relationships we have and the combined knowledge we possess in the lab, one can argue that we work less as regular students with scientific methods and more comparable to entrepreneurs. This *entrepreneurial method* is refers to effectuation [20]

Patrik approached Steven Sarasini with questions during the coffee-break regarding UbiGo. The curiosity on the theme mobility was raised after a discussion that took place following the fish-bowl session on the theme mobility. What the main reasons are for subsidizing mobility services and why, if UbiGo was so successful, why did it not still exist? Joel picked up the idea on how the low level of integration between the different actors created silos of information.

2.4 Result

From the process described above we arrived at three main results. A sustainability framework, a thesis pair, and a research question. This section goes into details about these results.

2.4.1 Sustainability framework

The result of step 1 of backcasting is a sustainability framework that is our common agreed upon criteria for a sustainable future. It consists of four dimensions that each have a number of own specific criteria. All of this was compiled into figure 2.4. Important to note here is that these goals will be used as a reference point for creating and evaluating our solutions.

2.4.2 Thesis pair and research question

When the second backcasting step was started, one of the goals was for each of us to find a thesis partner. During the information gathering phase it had become clear that there was lots of momentum in new ways of coordinating mobility. UbiGo was put forth as an example of this, with both its strengths and shortcomings. Besides this, we also knew from more personal experience that blockchain technology had exiting new properties, and wanted to know if they could fit into the mobility space. We (Patrik and Joel) ended up together since we had a similar vision of what could be accomplished with these two leverage points combined. Patrik came in with the business perspective and had a good

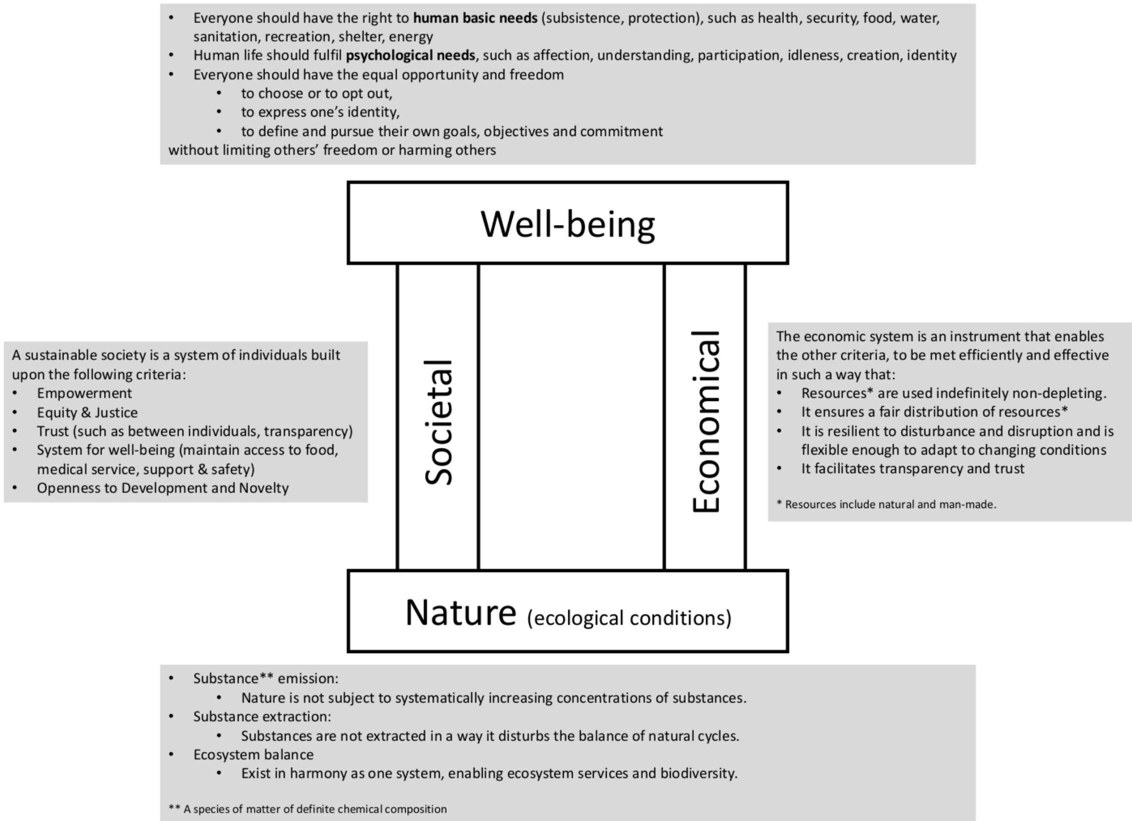


Figure 2.4: Common sustainability criteria

overview of how mobility worked. Joel contributed with a solid technological perspective with a good understanding of what could realistically be constructed. Together we started looking at Mobility as a Service (MaaS) and how that could be combined with blockchain technology to create a sustainable transport solution. To help us reach this goal we came up with one main research question:

> “ How can a Combined Mobility Service platform that benefits all of the involved stakeholders be designed? ”

2.5 Discussion

Overall Phase I has been a very interesting and exciting way of finding a research topic. Mostly because of the wide variety of differing perspectives within the group, which was nice but also challenging at times. The general structure of the backcasting process is something that we will take with us and hopefully be able to use in future projects as well where needed. Moreover the overall process opened the opportunity for lots of personal growth since lots of new perspectives allows for a revaluation of self, which was very appreciated.

2.5.1 Tools and method

In the course mentioned in section 2.3 we carried out all four steps of backcasting while in the first four weeks of the thesis we only did the first two steps, leaving the last two for the remainder of the thesis work. This gave us the chance to focus in the thesis pairs while still working in the backcasting process, which acts like a backbone for the more detailed work. It makes sense that the criteria and the current situation where evaluated in a larger group since more perspectives will be taken into consideration yielding a more holistic picture.

One shortcoming with the triple helix perspective is that it misses one of the most important parts of society, namely the civil society. The civil sector is what we all are part of in our normal lives outside of the workplace. One significant actor in this sector which gets a lot of publicity in the mobility space is Skjutsgruppen[21]. They are a group that helps each other travel around and do so without any financial incentives. So trying to represent, or at least highlight, this sector to the future iterations of C-Lab is essential.

2.5.2 Result

While it is important to take all dimensions of the sustainability criteria (figure 2.4) into consideration we also note that some of them are more applicable to our research. The one we think our work will have most impact on is the *societal* dimension, bringing trust and transparency. The economical dimension could also be positively impacted by our work. The two other dimensions will also be affected, ecologically MaaS could bring a reduction in car use if optimized correctly. It could also help the transition to new technologies go smoother, e.g. electric cars.

The research question captures something that is very important for sustainability but is easily forgotten in the mobility industry, and also other industries for that matter, namely the need for neutrality. Opting for a platform which allows for the inclusion of all stakeholders we believe mitigates the risk of having a few monopolistic actors that locks out environmentally smarter alternatives.

Phase II

3
Background

This chapter lays the foundation in which our investigation of the intersection between Mobility as a Service (MaaS) and blockchain technology takes place. The current situation is explored along with relevant strategies laid out by government. Also the essential concepts of Mobility as a Service and Blockchain are explained. Projects working close to or with the MaaS concept are described to make these concepts more tangible.

3.1 The current state of mobility

As cities around the globe have started to develop and grow to become metropolises for their citizens, numerous challenging problems have followed related to mobility and accountability. Many epidemiological studies point to the same cause, the number one problem related to mobility is the death of cancer due to emissions and pollution from fossil fuels[22]. In South America can the number be as high as 3 times more than car accidents and more than twice as many as aids and breast cancer combined in Brazil[23], in China 38% of the population suffer from pollution because they are living in areas classified as unhealthy[24].

The European Union (EU) have previously been most concerned about the biggest particles that come from wear and tear on the roads and brakes. These are measured by its size in particle microns "PM", 10 microns (PM 10), just as small that they can come into the lungs. But now there have been new rules for the smaller and more dangerous particles that are 2.5 microns (PM 2.5) large and there is now only 25 micrograms per cubic meter of particles allowed in the air by the European Commission[25]. Note, it is thus a measure of weight. The EU's limit value for these smaller particles is 250% higher than the World Health Organization WHO recommendations and there are estimates that it leads to 22,000 additional deaths a year and that the EU does not comply with WHO's guideline values. In addition, many researchers now suspect that it is the smallest particles that are most dangerous[26]. However, due to the fact that it is the size of the particle that matters, it is still like measure and compare the weight of feathers and lead. Therefore, a weight measure is not particularly sensible as the European Commission suggests, meaning a discrepancy between reality and science.

Meanwhile during the wintertime in Sweden, there is occasionally very bad air in Stockholm with high particle contents. For a day, the total distribution of particles should not exceed 50 micrograms per cubic meter, but the measured values can be as high as 105 micrograms of PM 2.5[27]. The reason is partly that dirty air has come from Europe and partly the dry winter streets are the sources and in some places it is worse than in Beijing nowadays[27]. This means that the problem we have here in Sweden is not an isolated problem related to our own environment.

There is an urgent need to reduce car traffic to reach the Swedish climate target. This is a must, according to the Swedish Transport Administration. The numbers of journeys by 2030 have to be down at the same level as the end of the 1990s, which represents a decrease of about 30% compared with the forecast for 2030[28]. The target also aims in a stricter sense at the same time for the journeys to be 80% fossil-free. Meanwhile the paradox is that We have *zero tolerance* for traffic deaths in Sweden, but in Gothenburg alone are people continuing to die of exhaust emissions and secondary causes of traffic[29].

Another important part of mobility are connected to the freedom and well-being of people. Part of this is the ability to move us around and enable us to travel freely. As history can show us the concept of mobility has transformed a number of times. The first revolution was the introduction of the railroad. Considered as one of the biggest innovations of human history[30]. Then came the car as fast replacement to the horse. Since then the infrastructure and the modes of transportation have been developed further to where we stand today. People has started to travel longer distances not only on their holidays but also in their everyday life. This has provided us with a complex mix of solutions to serve the citizens needs. As a result, We now face new challenges related to negative impacts on our environment with pollution and greenhouse gas emissions, inefficient use of resources, congestion problems such as traffic jams, noise pollution in the soundscape and increasing costs of supporting the infrastructure. Altogether affecting the factors of well-being in our cities by building psychical limits in our environment and institutional barriers with lock-in effects that requires long-term investments and maintenance.

Ten years ago during the financial crisis, history showed us that reduced car dependency is possible[31]. On the other hand, another negative issue was raised later. Namely, that cars are used less efficiently and stand still most of the time, one solution to this is sharing pools, and this development is closely linked to the growing sharing economy, which in short means utilizing resources more effectively by swapping, renting, giving, lending, collaborating or otherwise sharing for example homes, vehicles, clothing, tools or other assets[32]. Reduced dependency on cars is, in many aspects, the most sustainable way forward not only in Västra Götaland but also globally[33]. Reduced car dependency contributes to fewer emissions, noise and congestion. In order to reduce car dependence, other modes of transport must become more attractive and incentives should be introduced to the current stock of cars for them to be used more efficiently.

3.2 Strategic aim 2030-2050

Sweden must have near-zero emissions of greenhouse gases by 2050[34]. The Swedish region of Västra götaland (VGR) and the city of Gothenburg aims to be fossil independent by 2030. This is an ambitious climate goal and VGR furthermore have a strategic aim for Gothenburg to be a thriving place, providing well-being and with a suggested vision named *the good life*, a road-map how to achieve has been produced. The proposal aims to improve the health, increase the social and economical opportunities, and contribute to the regional development[18]. The Strategic road-map is a joint proposal for

Västra Götaland to reach the target of a fossil-independent region in 2030. The proposal has been developed in a broad process, and actors from industry, municipalities, municipal federations, universities, and others have had the opportunity to participate and comment during the process. The proposal has been published and presented during the summer and autumn of 2016 and the results of the referral will be presented in the spring of 2017. The road-map has twelve initiatives within four focus areas:

1. Sustainable transports
2. Climate-friendly and healthy food
3. Renewable and resource-efficient products and services
4. Healthy and climate-friendly housing and facilities

The main focus in this report is towards goal 1. - Sustainable Transports: Climate friendly, everyday travels that enables more people to walk, bike, and use public traffic more often[18].

3.2.1 Sustainable Development Goals

There are 17 Sustainable Development Goals (SDGs), adopted in September 2015 and part of the 2030 Agenda for sustainable development. The SDGs are relevant in the context of mobility together with the Paris climate agreement that was adopted as a separate process, with ambitious targets to stabilize global warming at less than 2 degrees Celsius. The agreement applies from 2020 onwards. The SDGs that are of relevance for this report are:

(a) SDG No.9 **(b)** SDG No.11 **(c)** SDG No.12

Figure 3.1: The relevant SDGs

> “ *The Sustainable Development Goals (SDGs), otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. These 17 Goals build on the successes of the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities. The goals are interconnected – often the key to success on one will involve tackling issues more commonly associated with another.*

”

- *UNDP[35]*

3.3 Mobility as a Service

The term Mobility as a Service (MaaS) came about as as new mobility solutions such as on-demand, connected, and autonomous vehicles started to emerge. These new transport services bring new challenges by having an unpredictable impact on urban mobility. Another concept that has sprouted from the same area is combined mobility services (CMS) which Holmberg et. al. argue is an subset to MaaS[36]. CMS is not just one mode of transport but a combination of which are delivered in one service. This multi-modal model is a product of years in development and a convergence of different technologies that now reached a point of maturity to finally be implemented in a unified system.

In Scandinavia, Finland and Sweden have been the grounds for experimenting with new mobility solutions. The term *Mobility as a Service* originates from Finland where it was first mentioned in a masters thesis[37], which included the following definition:

> “ *Mobility as a Service (MaaS) - a system, in which a comprehensive range of mobility services are provided to customers by mobility operators.* ”
> *- Sonja Heikkiläs[37, p.8]*

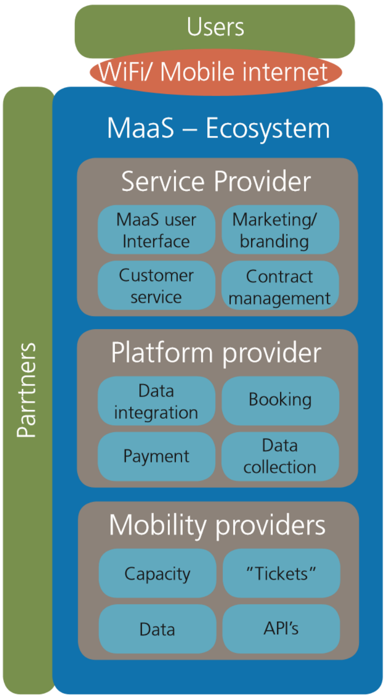
But as recent as in the end of 2015 there is no consensus about the definition of the term[36]. Hence are Combined mobility service (CMS) and Integrated Mobility Services (IMS) sometimes used in place of MaaS[38].

The MaaS concept has been tested in Finland thanks to Sampo Heitanens initiative to create a movement by starting the company MaaS Global in 2015. The company calls their product *Whim*, and it was launched in 2016[39]. From there the EU have supported a collaboration and research program called ERTICO, where the *MaaS-Alliance* network have been established. *MaaS-Alliance* is a public-private partnership (PPP) aiming towards a single market MaaS solution based on a multi-modal monthly or pay-as-you go subscription business model, and a data platform with user account and payment solutions[40].

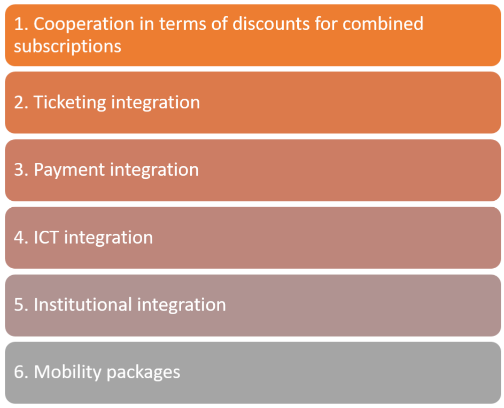
Common to all the definitions is the idea that by linking together various transport services to easily accessible and comprehensive mobility solutions it becomes possible to create a competitive alternative to the privately owned car. So the expectation on MaaS is that it can reduce the use of privately owned cars in most urban areas[36]. In theory you can ask yourself: Why should I own my car if it is both smoother and cheaper to consume the transport need *as a service*? To create a complete MaaS solution different parts are needed. In addition to all the mobility providers (MP) and their separate services that are to be integrated, an IT platform that manages this information, booking, payment, etc. is needed. Some argue that a party that acts as a service provider (sometimes also mentioned as a MaaS operator), selling the entire service to the end customer is required as well[41]. The figure 3.2a gives an overview of the different roles in the MaaS ecosystem and how they relate to each other.

3.3.1 MaaS Ecosystem

The framework presented by Emma Lund at Trivector measures how advanced the capabilities are in the MaaS ecosystem by the level of integration between the different providers.[41]. The most advanced MaaS integration are the ones that uses the subscription model with multi-modal alternatives included (See item no.1 in figure 3.2b). The paper leaves out information of how these services should be negotiated, which is of interest to find out.



(a) The MaaS ecosystem adopted from E. Lund[41, p.2].



(b) Differentiation of MaaS services made depending on integration levels adapted from MAASiFiE[42]

Figure 3.2: Two frameworks describing MaaS

The figure 3.2a depict a simplified model of how the MaaS ecosystem looks like and the different parts. The *Service provider* is the front-end that users experience(demand-side). The *Platform provider* maintains the core components in the MaaS platform. The platform sponsor supports and mediates basic necessities such as the IT system with the integration of data, and payment services etc. *Mobility providers* are those offering the mobility services included in the overall MaaS service, such as public transport operators, car sharing operators, taxi and bicycle pools (supply-side).

3.3.2 The case of UbiGo

In the last couple of years there have been numerous efforts to build a combined platform to integrate different MPs in a MaaS solution. One of the most notable being UbiGo. The UbiGo Field Operational Test took place in Gothenburg between 2013-11-01 to 2014-04-30 as part of the GO:SMART project with 70 users. Featuring a front-end app and a smartcard, UbiGo packaged multiple MPs in the city of Gothenburg into a single product

[43][42]. It aimed to provide sustainable travels in the region by reducing the need of owning a car in the city. In addition it also provided compensation to participants that did not use their private vehicle, up to a fixed limit[42].

UbiGo was a success in that it was very convenient and liked by the users involved. The service convenience came from the business model, which was a *subscription*. Payments where collected in a single invoice that worked as a punch card ticket with a finite number of credits to use. The credits was replenished each month with the possibility to top up as well anytime. By having a subscription participants in the project could use credits for using the public transport system, bike sharing, taxi, or car rental / sharing fleets. These services where accommodated and brokered by the people behind UbiGo, something that was a manual and tedious process. A good analogy and representation of this can be a travel agency. They also had a 24/7 customer service line the users could call anytime. The behaviour of several actors can be studied in the UbiGo project, along with the business model the company itself[43]. The experiment was ended and evaluated, and in terms of reduced car usage it was regarded as a success[43].

The intention was then for UbiGo to automate and digitize the processes and start as a regular company. However they failed to do this due to several circumstances, one of them being that many of the MPs where uncomfortable with the idea of giving so much influence over their services to a company that they had little or no control over. Hence this gave the UbiGo company very much power, although the legal status of UbiGo was unclear at the time[42]. This is a result of how the negotiation process works; UbiGo buying mobility services in bulk. In line with the above, what can be observed is that there is demand for a central platform for MaaS, or what some call CMS. One of the unresolved questions is why any MP want to join the service network and what happens when the CMS provides a diverse array of alternatives. This is the starting point to why this report is produced.

3.3.3 Samtrafiken

The organization Samtrafiken, owned by 38 transport companies is the facilitator of mobility services in Sweden. In early 2017 they released a white paper called: Swedish Mobility Program. The report does not include information about whom MaaS services are meant for and what the services will look like, however they conclude that MaaS will not be of interest to all customers and that all customers will not be interested in the same services. The most interesting part in the report is that the major challenge is that there are major changes ongoing both in different transport solutions (horizontally), and in the value chain towards customers (vertically). New actors appear with disruptive business models and new technical solutions, changing the landscape on a continuous *linear* basis. Notable in the report is a new definition of the concept of *public transport*, that is going from passenger transport with scheduled traffic to the following wording:

> “ Public transport = Passenger transport with shared resources. ”

A flirt to what the transformation could bring to the future maybe. In figure 3.3 the possibility is that Samtrafiken wants to take the role of the *Integrator*. They see themselves as the most neutral actor in the space.

The most important mission of Samtrafiken at the moment is to coordinate the *Re-*

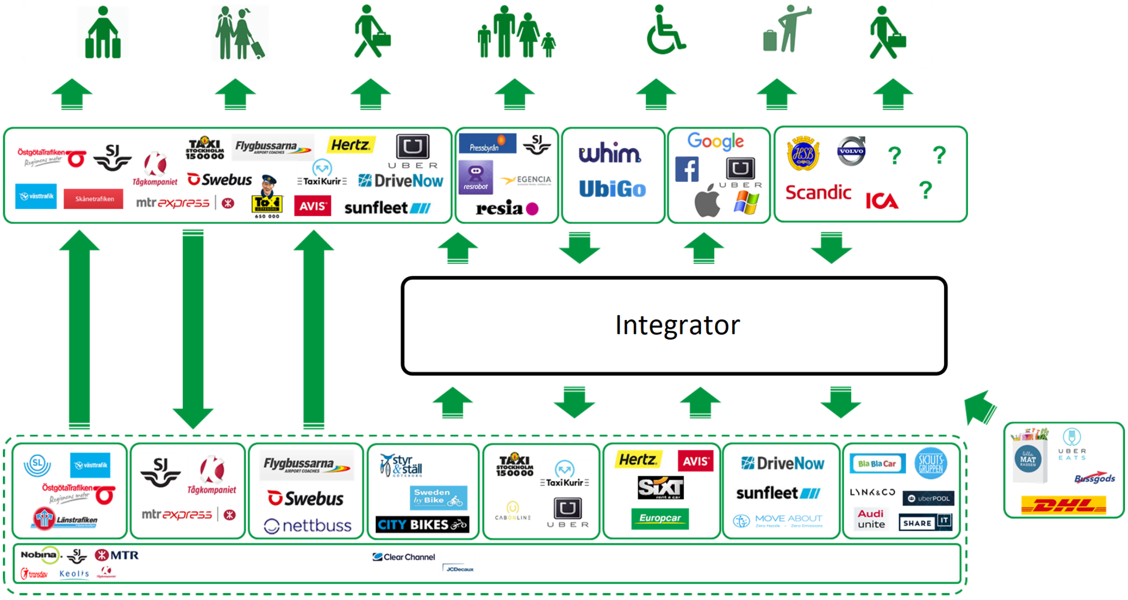


Figure 3.3: Mobility as a Service actor network adopted from Samtrafiken[44, p.4]

splus system, a national ticket cooperation[44]. Resplus mediates about 5 - 6 million trips per year, worth about 2 billion SEK. It is estimated that 2/3 of these trips are combined with at least two carriers involved. This means that Resplus is Sweden's largest ticket cooperation. However, in relation to the number of public transport journeys per year, this is a modest number of trips, as booked public transport trips account for only about 3% of all public transport journeys made in Sweden. Most of the trips are purchased as period cards at the respective Public Transport Authority.

3.3.4 Other projects and research programs

Other than the efforts by Samtrafiken there are several efforts looking at using MaaS. Some of them are focusing only on mobility and others want to integrate MaaS into urban development projects.

The **EETICO** network has initiated an ITS Europe partnership. They have a project called MAASiFiE which can be seen as the origin for many of the MaaS projects in Europe[42]. Within this project the goal is to analyze trends within MaaS, develop business models, investigate interoperability issues, etc. It also tries to coordinate this within the scope of the *Single digital market* strategy[45].

UITP is the International Organization for Public Transport. The report by Holmberg et al[36] disclosed that the UITP supports the MaaS concept and proposes that public transport should play an active role. By this, they mean that public transport may become a future MaaS operator, and if this role is taken by a private sector operator, it could pose a threat to the transport industry. By taking public transport into the role of a MaaS operator, they can control and subsidize where there is a need while working to maintain the benefits of public transport today.

Drive Sweden that started in 2015 is one of Sweden's strategic innovation programs, funded by the Swedish Energy Agency and Vinnova. They are looking at the future of mobility in Sweden. Their objective is explore the possibilities of integrating self-driving vehicles and MaaS with a CMS platform. including real time traffic management[42].

SAMS is a project called Sustainable Accessibility and Mobility Services (SAMS) consisting of partners from industry, academy, and public sector. Their vision is to transition to sustainable mobility services in urban areas by 2030. The project is funded by MISTRA.

DenCity is a project by Lindholmen Science Park and includes the concept *easy to B* or *easy to be* (EC2B). It is a pre-study from lead-partner Trivector and sponsored by Climate-KIC. Additionally focusing on MaaS as part of the accommodation offering in a dense urban environment. The project takes place in Frihamnen, Gothenburg. It involves a lot of diverse stakeholders, and among them is Drive Sweden.

3.4 Blockchain technology

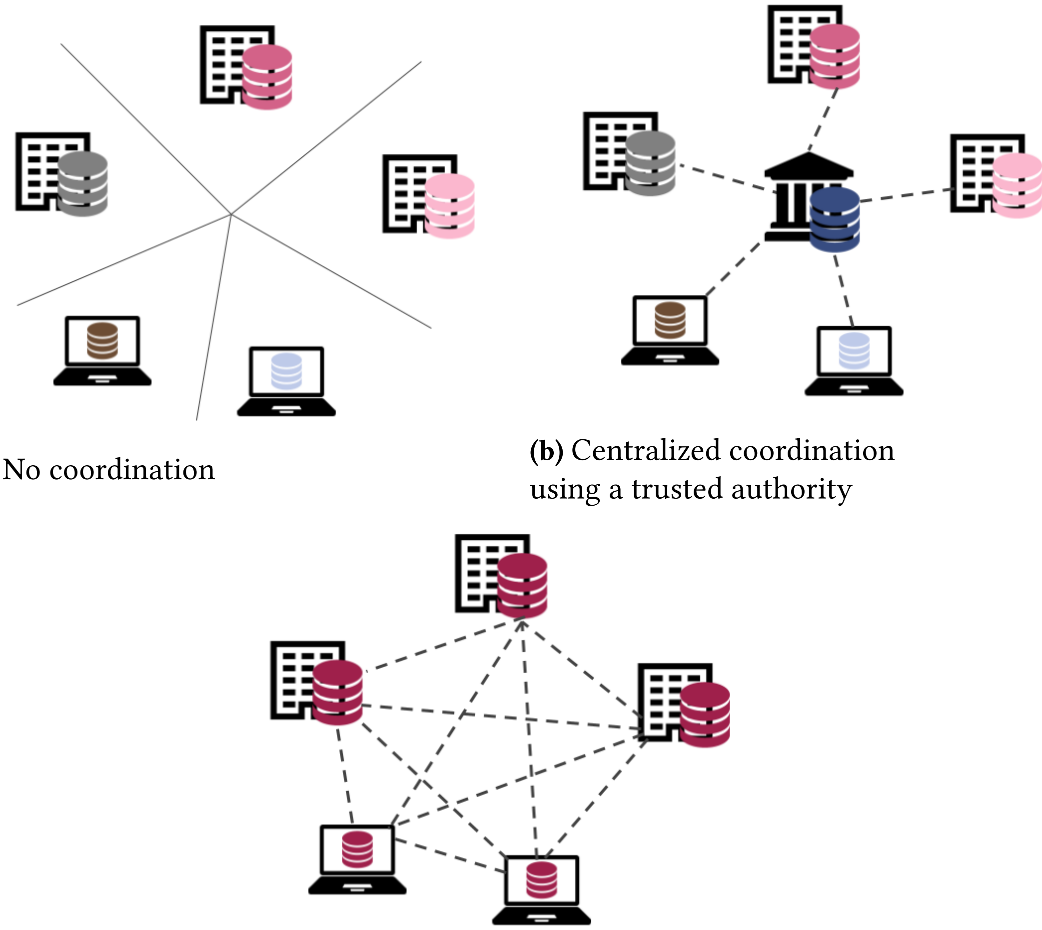
Blockchain is a new technology that has just started taking of. It originated from a small community of cryptographers but is predicted to have impacts on many sectors in society.

3.4.1 Blockchain technology in context

When the internet began in the late 1900s it was only a place where it was possible to exchange ideas. What became available was essentially only forums where people discussed their interest and websites for organizations that wanted to show what they did online as a new form of advertising. This early internet could not handle payments since there was no way to send confidential information such as credit card numbers. The next step of the internet was taken when something called https was created. Https basically made it possible to send data fully encrypted between a client (your computer) and a server (a companys computer). Credit card information could now be safely transmitted over the internet and the age of online payments thus began. As we know today this completely changed the way we as humans do business, online payments are now commonplace and most people in the western world could not imagine not being able to buy anything they want online and have it being delivered in the next couple of days.

Https is quite simple in cryptographic terms, and over the years a lot more sophisticated cryptographic tools have been developed. Most of these tools have had slim to none adoption on the internet. That is until blockchain technology came along. Now there is a hole new set of utilities available to expand the reach of the internet. If https gave the internet access to payments, blockchain and its set of surrounding cryptographic tools gives the internet access to the whole of the financial sector while also providing the means of verifying real world transactions such as the shipment of a container. The *internet of payments* is now surpassed by the *internet of agreements*.

Another way to understand blockchain technology is to look at how organizations an people store data. Traditionally networked computers all have their internal representation of the world stored as data (see figure 3.4a). This data may have different formats making it difficult for two organizations to cooperate and integrate since the



(a) No coordination

(b) Centralized coordination using a trusted authority

(c) Decentralized coordination using a blockchain

Figure 3.4: Three different modes of coordinating data in an internet connected system

data needs to be converted between these two different formats. Furthermore a user interacting with three different organizations online will have to provide their data three different times in order to register that data internally for each organization. The traditional way to mitigate this problem is to introduce a trusted intermediary (figure 3.4b). This central authority has their own model of the world and enforces that on all involved entities. This model is used by banks e.g. You can change the number in your bank account locally on your computer, but no one will honor that since it is the banks model of the world that is the correct one. This has some obvious drawbacks since the central authority might have vested interest and corrupt people within that organization might use the power to their advantage. Unfair systems might also easily be perpetuated in such a system. When using a blockchain we get a system similar to what is depicted in figure 3.4c. Here all entities participate in a network on equal terms. Because they are part of this network they have a shared model of the world which makes interaction between two parties more seamless. All transactions that happen in the network are public and participants can choose to only observe the transactions that they are interested in. In this system there is no central authority that can be corrupted, instead the network has to agree on updates that happen.

3.4.2 History and trends

The idea of a blockchain was first conceived of in a project called bitcoin. It came about in 2008 when an pseudonymous entity, that went by the name Satoshi Nakamoto, posted a paper in an online cryptography community[46]. The paper described a system for *electronic cash*. One of the main inventions behind this system was a new way in how to structure sequential data and how to come to consensus about what had happened in what order. This is achieved through a mechanism of financial incentives which forces participants to act truthfully as long as they don't have over 51% of the capacity in the network. New transactions that happen in the network are gathered into a data object called a block. When this block is created it links to the previous block, forming a chain of blocks. There are a lot of technical details here, but we choose not to dive to deep into them in this thesis. The most important aspect to remember is that bitcoin introduced a way of using mathematics to coordinate between economical actors with a differing set of interest, something that has only been possible to do with law and court systems before.

Bitcoin inspired lots of similar projects which features modifications and improvements to the original bitcoin protocol. The most notable of these being Ethereum. Ethereum uses the concept of *smart contracts* which allows for arbitrary business logic to be encoded and executed in the blockchain. This opens up for multiple parties with differing interest to come to agreements without the need of any trust in a third party. Using this mechanism developers can build applications that are completely decentralized and censorship resistant, something that has been very hard using previous internet infrastructure.

Businesses are now also starting to pick up on this technology which originally only had attracted enthusiasts. Some companies came together to create a project called Hyperledger, which seeks to create framework for deploying something called private blockchains. Private, or consortium blockchains as they are sometimes called, are different in that they don't have global consensus where anybody can join the network and contribute. Instead they rely on a set of organizations that together have ultimate authority. But it is not only businesses that have started looking at blockchain technology. Governments are also exploring the technology. EU are looking seriously at it[47][48], and Dubai aims to have 99% of their governmental transactions on a blockchain by 2020[49]

3.5 Scope

Due to the increase of complexity on both the number of actors offering services and the way people are using mobility services, the issue under investigation is how to mediate these services on a neutral platform and how the network effects ties together such a collaborative ecosystem. Moreover the specification of how this can utilize the innovative blockchain technology and why. The intersection of MaaS and blockchain is completely unexplored and could potentially be quite large. Therefore this section specifies a more particular aim and adds limitations.

3.5.1 Aim

Our main aim can be summarized in the following sentence: How can a combined mobility service platform that benefits all of the involved stakeholders be designed? By using UbiGo as a starting point, the current status of MaaS in Gothenburg can be mapped out. Using this information requirements, concerns and demands that the stakeholders could have in relation to a central platform can be specified. By using this information, connecting to stakeholders, and exploring the new technology in and around blockchain we aim to bridge the neutrality gap that we think was not fulfilled by UbiGo. In order to accomplish this we create a technical specification for inspiration on how such a platform could be implemented. We have a good reason to believe that we as students can interact and retrieve the data necessary from the stakeholders, due to our neutral position. The outcome of this project will be a valuable contribution, with a unique perspective, to the field of MaaS and its relation to blockchain technology.

3.5.2 Limitations

The first limitation in this report and distinction is the separation or transportation of goods and people. Where this report only treats the latter. MaaS potentially includes all transports where a good or a person is moved from point A to point B, and any combination of these. While there is likely to be many synergies between freight and personal transport they are today quite separated. Including both of these aspects into our research would mean that the scope becomes quite huge. We have therefore decided to limit the research of this thesis to only include personal transportation.

There are a lot of details that could be specified in a CMS platform. One example is multi-modal transport integrations, allowing travelers to go with multiple transport modes on one journey. Instead we will focus on letting the user choose between single mode journeys between point A and point B. Another example could be a smarter ride sharing systems where users are grouped together riding different parts of the journey together to minimize the travel costs. This could become quite complex pretty quickly. Therefore we will focus on a service that focus on single user journeys (or multiple journeys together). However, we think that such functionality could probably easily be added on the MPs side, or as a future extension of a simpler platform. So our main focus is on specifying the general structure of a platform bringing together the stakeholders selection of services in one application. Once this basic component is figured out more advanced extensions could be added. Furthermore the limitations regarding the stakeholders participation in our project are assuming that they are located in the area of Gothenburg. This could impact the generality of our proposal, however in general MPs are similar enough to make this study applicable in most other medium to large cities.

4

Method

In this chapter the various methods we used throughout the thesis are explained.

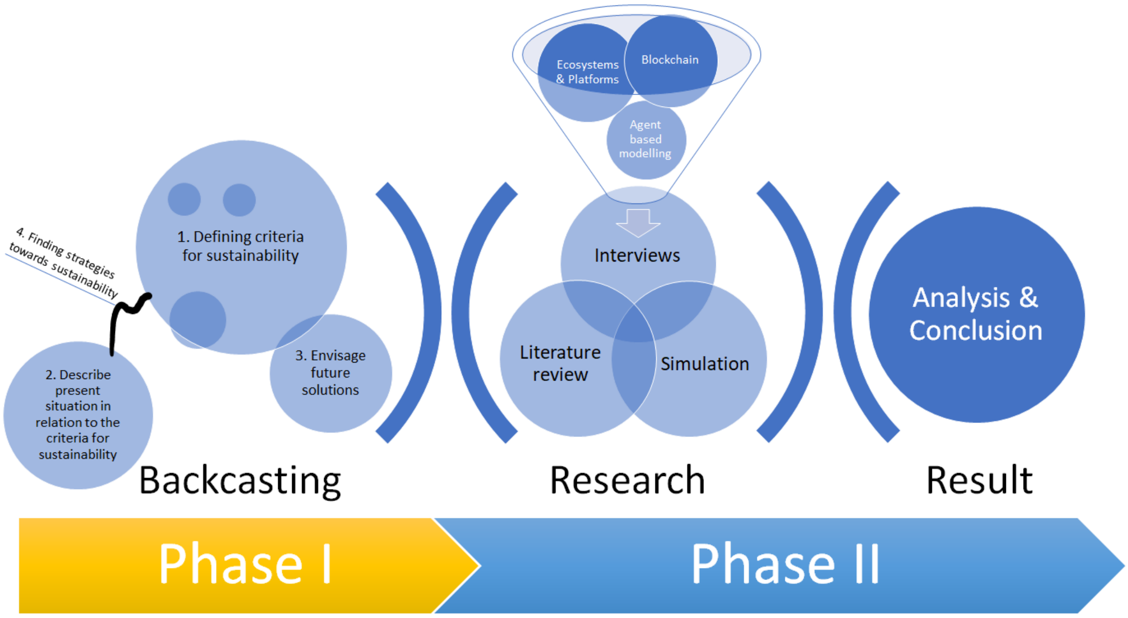


Figure 4.1: Design of the study

4.1 Design of study

Taking of where the Phase I ended, our objective is to conduct research within the field of Mobility as one of the three themes at The C-Lab this year. The purpose is to find sustainable solutions to the complex challenge that Mobility is facing in Sweden and in the city of Gothenburg. To accomplish this the topics chosen to perform research on is blockchain technology and MaaS, both of which are still in its infancy. Most of the sources dates from 2014 onward on the topic of MaaS, putting the research at the edge of knowledge and interdisciplinary integration of two separate fields.

Methodology, short and simple: Interviews was used as a method of getting information from real world MPs. Simulations was used to determine the impact of a central mobility platform could have on different MPs. A literature review was performed to construct an analysis of the result that was produced by synthesizing the data to finally extract a conclusion.

To understand the main drivers of how ecosystems and platforms work, the ontological considerations derived from postmodern philosopher Jean-François Lyotard are used as a corner stone. He argued that a *causal collapse* of centralized authority in the future could be enabled by digitalization. This statement describes the current regime transition toward change in mobilty[5]. Something that Lyotard puts forward as a prevailing central authority that now gets challenged by new technologies such as peer-to-peer networks (See section 5.1.1) and knowledge becoming a commodity in abundance.

The epistemology in regular Management perspective is based on reductionism instead of the holistic view, where parts are broken down and quantified on its own. Analyzed separately and then put together. This is a clear distinction to what is done in the C-lab. Simply put, in order to understand the dynamic aspects of how mobility ecosystems behave and what happens when blockchain technology is introduced, complex adaptive systems theory is blended with the theory of innovation systems in this thesis. Hence, the following is a summary of the methods that has been used to produce a contemporary picture of the current situation.

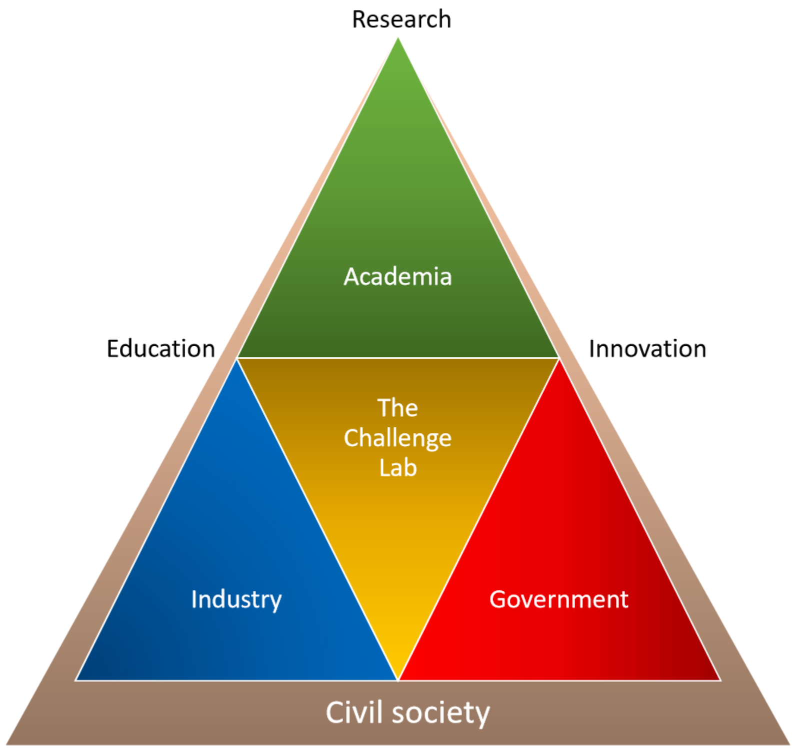


Figure 4.2: Triple helix expansion

The method of using stakeholders is taken from the meso-level, which is a framework in the IRIMS project, and adapted for this thesis[38]. The framework includes public institutions on the regional and local levels, private organizations, public/private hybrids and not-for-profit civil society actors[33]. Figure 4.2 portraits how we build upon the triple helix model and added the civil society in our work[50].

4.2 Literature review

To understand the concept of MaaS an extensive literature review has been conducted. As the concept of MaaS is still not fully defined, a general explanation is provided. Furthermore the report uses data from various sources on MaaS, e.g. a framework the MaaS ecosystem (See figure 3.2a).

Previous primary publications of blockchain technology have carefully been considered due to the background of the publication. E.g. the original paper on Bitcoin does not derive from the academia. The consequence has been that secondary sources had to be used in order to put the technology in the context of MaaS. Considerations that cover all of the material used focused primarily on making it relevant to combine the two topics. The fact that no formal research documents with the keyword *blockchain* could be retrieved from the library in Chalmers own database, portraits how new this field is in academia. Albeit there are some previous reports on basic and advance level published on Chalmers. Furthermore, there are some publications from the Swedish research institute (RISE) on both the topics.

The literature dealing with the topic comes from electronic sources searched on the internet. Search services used for this have been Google, Google Scholar and Summon. Keywords used where related to the subjects, e.g. *MaaS*, *Blockchain*, *Bitcoin*, etc. Sources that have been submitted have been made partly through direct searches in search services but also backward search, which means that the researcher studies references from a relevant article that deals with the subject.

4.3 Interviews

In order to get a better picture of what is happening at the moment in the MaaS space we conducted interviews with various stakeholders. This was to get a better understanding of what stopped UbiGo from taking off, and also to get the perspective of the stakeholders in what they would want out of a combined mobility platform. We also asked about current ongoing projects and what stakeholders think about combined mobility services. Important to note is that different stakeholders probably have different criteria. As a second part of the meeting we introduced the concept of a blockchain platform from a mobility perspective and how it can mitigate the coordination problem in the current paradigm. The interviews focused on the individual being interviewed, giving them space to reflect freely on the different topics. This yields a qualitative point of view, but also a quite honest one. The interviews mostly took place face to face, but some where over conference calls. Stakeholders ideas and initial reactions was recorded and used to generate our result. The main questions that where posed to each interviewee was roughly the same. All interviews followed this outline:

- Knowledge on Mobility as a Service
    - How do you define mobility as a service / combined mobility services?
    - What is your opinion on UbiGo?

- What is your opinion on the broker?
  - What are the platform requirements for you to join?
  - Is neutral broker possible?
  - Regarding transparency and data sharing, how open are you?
- Introduce blockchain
  After we had given a briefing of how blockchain technology works we asked some general questions about what they thought about it and what potential they saw with it within their organization.

The stakeholders that where interviewed where firstly the participants in the UbiGo and DenCity project, but there are also other stakeholders that where included as well. For example a start-up here in Gothenburg that was of interest for us, but that was not around when the UbiGo pilot was run. Another bonus with the interviews was that we where able to try to get the stakeholders engaged in our vision of a neutral combined mobility service platform. The interaction with the stakeholders provided us with the multi-level *Outside-in* perspective of the step-2 in backcasting methodology (See section 2.2.2.2)[5], which is a great complement to the other research approach of modeling the system.

4.4 Simulating a CMS

In order to get an understanding of what could happen when different types of CMS platforms are introduced in a market, a simulation was created. This simulation uses Agent-based modeling to simulate how users, MPs, and CMS platforms interact under certain circumstances.

4.4.1 Agent-based modeling

A complex system is something that consists of many parts that often have quite simple behaviour, these simple parts give rise to very variable and sometimes chaotic behaviour when they interact with each other. They are also very interdependent meaning that if you change one part of the system the outcome of the system might be very different. Transport and traffic can be thought of as a complex system where the parts are MPs, users of their services, cars, pedestrians, etc. Understanding that small changes to an individual part could have large impact on the overall system means that using regular analytics methods to learn what happens in this system is not possible.

To predict what could happen in a transport system we can instead use an agent-based model[51]. The agent in such a model is a part of the complex system. In the transport case this could be MPs and their users. The agents are then given a set of rules which they have to follow. They can then make decisions that try to optimize for their personal preferred outcome. Agents can also be influenced by the environment that may also change, or be different in different iterations of the model. The agents acting in the environment give rise to complex behaviour. If the agents are similar to the agents in the real world they will give a good prediction as to what could happen if some aspect of reality changes.

Since we are investigating how a central mobility service platform can be built an important aspect to take into consideration is how the stakeholders are affected economically by such a platform. Using an agent-based modeling approach we can make predictions of how the stakeholders could be affected by different forms of platforms. We would begin by making a model of how users interact with the stakeholders in the current system. This would be an abstract model taking only the most important parameters into consideration. In this model users have preferences for specific services and/or might not know about all of the services. We then introduce a central mobility platform into the model, and see how this affects the stakeholders' profitability. In the most basic form of this stakeholders have two options: join the platform, or not. The agents in this model are simply the users that have options to use the different mobility services. This simple model can then be iterated on in order to be more realistic. Of course there are many different aspects to take into consideration when making the model, and which parameters to include was decided during the iterations of the project.

4.4.2 Modeling the system

An agent-based model was created to simulate what would happen if a CMS platform is introduced. The model was build with the programming language Python and its extension NumPy for more advanced numerical calculations. The main thing that was investigated was how the user adoption of different MPs would be affected by introducing a CMS that was controlled by only a few providers, as well as a CMS that was more open and not directly controlled by any of the MPs.

The system was modeled by having a static number of MPs. Each of these have a set of specified areas that they provide their services within, e.g. a small taxi provider might only operate within a small physical area of the city. The agents in this model are the users of the mobility services. Each agent has some areas that they prefer and they will want MPs that gives them access to those areas, they also have a set of MPs that they know exists. In the beginning of the simulation all of the agents are initiated with a set of random MPs, this means that some agents might have all the MPs that they want, some might only have MPs that they do not want and some might not have any MPs at all. The component for a CMS can either be disabled or enabled. When it is enabled it can either contain a subset of the MPs or all of them. This could be seen as an analog to a CMS that is controlled by a few MPs vs an open one.

Once the simulation has been initialized with the data above it will run for a set number of iterations. Each iteration the following two things will happen: All agents will choose a MP that they will travel with, if they know of any that provides an area that they are interested in. If the platform is enabled the agent is just as likely to know about it that as any other MP, but if the platform is chosen the relevant provider in the platform is chosen. The choice of each agent is recorded in a list that later will be used for visualisation of what happens in the model. The second thing that happens is that agents discover new MPs. If an agent knows MPs that cover all the areas that the agent want they wont discover any new ones, since they are not looking. In most cases the agents wont have all their wanted areas covered, then they discover new MPs at the rate of 0.01 per iteration. Agents might discover MPs that are useful or useless for them. Network effects (See section 5.1.1) are programmed into the discovery mechanism. This simply means that MPs that lots of agents know about are more likely to be discovered. Once these two steps have been carried out a new iteration is started and they are carried out again, this repeats for the specified number of iterations.

An additional feature is that agents can choose to prioritize environmental friendly MPs. This feature can be enabled by specifying which MPs are so, a percentage of the agents will then always choose the environmental alternative if they know about it. In this model the percentage is set to 30%. The reason for implementing this feature is to investigate how the CMS affects the agents ability to choose environmental alternatives instead of regular ones.

5
Theory

In this chapter we will go through the theory behind the work we have carried out during this thesis. In the spirit of Backcasting (Section 2.2.1), the theory is used to envisage future solutions, and builds the theoretical ground needed to think of the gap and *Start with the end in mind*[52]. This refers to Step 3 in backcasting (Section 2.2.1.3), envisaging possible future scenarios.

5.1 Platforms

The word *platform* has one meaning in the dictionary, this definition differs from the one used in this report. The report depicts a version adapted from the architectural environment concept of platforms, that has emerged together with the development of computers[53]. Furthermore, the theory of platforms in this report derived from the research in innovation from various sources. The argument that MaaS business models require new business ecosystems represent the need for unique presentation of platforms [38]. Hence, a display of what the meaning is for freedom, abundance, innovation and distribution follows.

> “ *We are witnesses to the next revolution beyond multidivisional organizations and beyond the invisible hand. It is the ability in an environment of immense resources, immense plasticity and powerful information systems to make and break micro-economic relationships with enormous subtlety and velocity. We are entering an age of imagination.* ”
> *- Moore [54, p.22]*

The term *invisible hand* is a metaphor for how, in a free market economy, self-interested individuals operate through a system of mutual interdependence to promote the general benefit of society at large. It was introduced in 1776 by the Scottish enlightenment thinker Adam Smith in his book *An Inquiry into the Nature and Causes of the Wealth of Nations*. Furthermore More states that:

> “ *An economic community supported by a foundation of interacting organizations and individuals are the organisms of the business world. The economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders. Over time, they co-evolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies.* ”
> *- Moore [54, p.26]*

5.1.1 Network-based markets

The strength of platforms comes from the network effects of connecting people, enabled by ICT infrastructure and the complementary development of e-commerce. Online marketplaces mediates suppliers with their customers in a more direct way, peer-to-peer. In this type of market self-reinforcing relationships or positive feedback loops develops, called *network externalities*[55]. This is because the value of goods and services increase by the amount of people using it. There is a difference though between *hardware* and *software*, because hardware has an expected lifetime and life cycle. Both are subject to scale economies, whether in amortizing the total costs of production (such as upfront R&D) or in demand-side economies of scale through positive network effects[55]. Software can easily be replicated and used many times without any ware and tear with increasing returns, when the increase in production result in lowered marginal cost[56].

Two-sided market places also called two-sided networks, are economic platforms having two distinct user groups that provide each other with network benefits. These two different groups of customers that platform have to get on board to succeed need to have incentives, there is a "chicken-and-egg" problem that needs to be solved[57]. In the context of mobility it can be vehicles with drivers on one side and customers willing to pay on the other. Two-sided market places can be characterized as being closed or open systems that determines the degree of involvement through third parties. Both sides have to consider:

1. *Homing costs* are expenses (adoption, operation, opportunity costs) that arise when users are affiliated with a platform. Homing costs include any kind of investments/costs incurred due to platform affiliation. It basically consists of three cost components. First is upfront cost: search, initial investment and training. Second are on-going costs: membership fees, maintenance cost. Finally, exit costs include salvage value of hardware/software and termination costs[58].
2. *Switching costs* are high when users made significant and durable investments to a certain platform and into complementary assets (homing costs), thereby creating a hurdle to switching to an alternative platform. As a result, they are faced with a lock-in effect [59].
3. *Network effect* which can further be distinguished as same-side network effects and cross-side network effects[58].

Same-side network effects increase or decrease the value of one side of the platform. If we take game consoles as an example, users value a certain console if it has many users and a variety of games to offer, creating an incentive to exchange with other users, which is a positive same-side effect. For other platforms, however, a negative same-side effect can occur when there are too many of its own kind on a platform, making it unattractive to show affiliation[60].

Cross-side network effects are apparent when users value the other side of a platform, e.g., when advertisers are attracted by a popular website such as Facebook (positive cross-side effect), whereas too many ads create a negative effect on the reader side. To lower the hurdle for one side, most platform providers subsidize one side, to ensure that network effects have a chance to take effect[57]. If a two-sided network has been able to create a strong installed user base, the money-side gets mostly attracted to obtain value from these users. i.e usually the incentive consist of one side, often the demand-side is subsidized by the supply-side, the business model of Facebook is based on being compensated for exposure, generated traffic and / or generated sales[58]. The effects mentioned above are related to the external effect often referred to as *barriers to entry*[57].

5.1.1.1 Current strategies on network markets

In order to cope with the effects described above the platform sponsors or *the market makers* need to consider[57]:

1. *Bundling and Envelopment*, Platform owners with first mover advantage should be careful when the threat of being enveloped is evident. Platform owners can be enveloped when competitors enter (or sneak in) into their market and offer the same functionality by bundling it with their existing products, and at the same time, having essentially the same customer relationship [58][61]. Bundling is when two or more single products or services are offered as a package [59]
2. *Complementary assets*, the platform design decides how complimentary products are distributed. The strength of creating a *complete package* and a *one-stop-shop* for the customers should not be underestimated[62]

The platform design is important in software and *as-a-service* solutions, where two or more technologies compete for adopters and the provision of specialized complementary products [63][60][64]. Thus, for a platform with scale economies and a need for complementary innovation, the platform sponsor need to expand the total value created by the value-network rather than just maximizing their share of the existing value[62]. This is sometimes explained as *growing the pie*. This term referees to competition. What should be done in the business negotiations is rather something called *slicing the pie*. In the review of open standards strategies of computer producers, the author to the following article: *How open is open enough? Melding proprietary and open source platform strategies* concluded:

> “ *These various strategies reflect the essential tension of de facto standards creation: that between appropriability and adoption. To recoup the costs of developing a platform, its sponsor must be able to appropriate for itself some portion of the economic benefits of that platform. But to obtain any returns at all, the sponsor must get the platform adopted, which requires sharing the economic returns with buyers and other members of the value chain. In fact, openness is often used to win adoption in competition with sponsors of more proprietary standards.* ”
>
> *- West [64, p.3]*

De facto standard is explained as *in fact* or what happens in reality / practice[65]. *De jure* is the formal legal term of recognition by an authority and protection by law could be enforced[66].

Furthermore, the platform sponsor needs to carefully manage the suppliers of complementary assets because they will deliberate exploit the weaknesses of the platform to gain competitive advantage, i.e. getting ahead and staying ahead by innovation[60][61]. The competition can focus on:

- *Cost leadership*, of having lower prices than others
- *Differential strategies* to produce services that stand out in the crowd
- *Focus strategies*, supplying a special product to exploit the market

In standard wars there is three tactics that are recommended[60]:

1. Building alliances
2. Exploiting first-mover advantages
3. Managing consumer expectations

The sponsors main goal of using these strategies is for the platform, to become the *dominant design* and once this standard emerge, new variables of competition sets in[63][61]. The difference is that instead of competing on design, competition is about price. Were the dynamics of scale economies and learning curves, and how to exploit the market sets in motion.

5.2 Open innovation

To understand the concept of open innovation, one must first understand that the definition of innovation is separated from invention [67]. In the context of this report, the term invention is the theory behind blockchain, that is already brought to the market in some use cases today. One example is known as *Bitcoin*[46]. However, the meaning of innovation is much broader than invention, meaning not only one thing that exists in theory or on paper but rather consist of available processes, products and services, creating new value [67]. Clayton Christensen defined innovation as something that creates new value, new markets or value-networks. His thesis is that innovations that upsets the current state is called *disruptive innovations* if they have significant impact [68]. As part of this he also uses concepts as Sustaining, Evolutionary and Revolutionary innovations.

5.2.1 1.0

The theory of open innovation started in 2003, when Henry Chesbrough coined the term ‘open innovation’, in his book *Open Innovation: The New Imperative for Creating and Profiting from Technology*[67]. The figure 5.2 depicts to the left in picture how closed the innovation process was before open innovation was introduced by Chesbrough. The concept of open innovation concerns a systematic process where ideas can pass to and from different organizations and travel on different external exploitation vectors for value creation, as can be seen in the middle of figure 5.2. Open Innovation was based on the idea that not all of the smart people in the world can work for your company or organization and that you also have to look outside the organization for ideas. At this point Open Innovation was still seen a linear process which had an emphasis on licensing of technologies, joint ventures and spin-offs.

There is a dispute between the theory of Open innovation (Chesbrough) and User Innovation (Von Hippel). The main argument between the separation of the two are defined as:

> Open Innovation = value capture, User Innovation = value creation

The theory by Chesbrough are limited in tapping into the knowledge of the users in the sense of presenting prototypes and letting the customers co-evolve products rather than letting them be the source of new innovations, calling them co-producers instead[67]. This can be seen as the traditional top-down approach in figure 5.1.

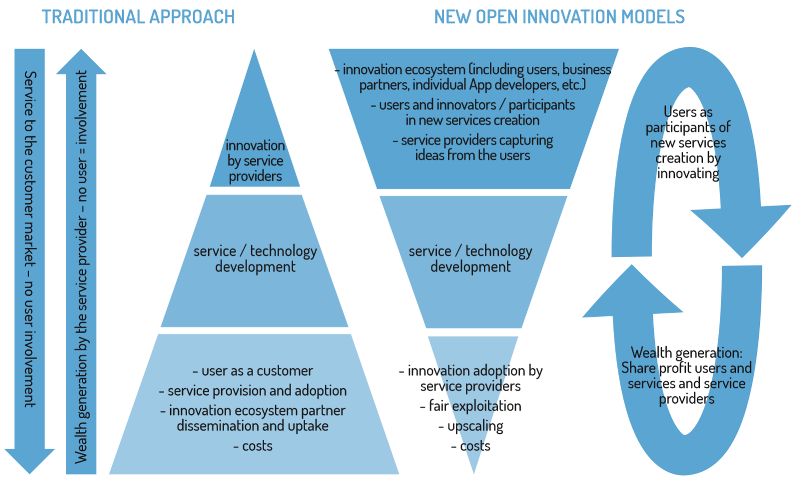


Figure 5.1: *Reverse Innovation Pyramid* adopted from Figure 2 in Curley & Salmelin[69, p.6]

5.2.2 2.0

There is a new non-linear paradigm in innovation called open innovation 2.0 (OI2). This new version of the open innovation model depends on a Quadruple Helix Model, where government, industry, academia and the civil society cooperate. Users likewise turn into a fundamental piece of the innovation procedure[69]. The idea of OI2 was stated by the European Commission in 2015[69]:

> *OI2 can help drive development of shared value solutions which can drive changes far beyond the scope of what any one organization could achieve on its own. OI2 is based on principles of integrated collaboration, co-created shared value, cultivated innovation ecosystems, unleashed exponential technologies, and focus on adoption.*
> *- Curley [70, p.1]*

The core in the evolution of OI2 lies in the importance of innovation ecosystems as the figure 5.1 depicts. Furthermore, OI2 redefines disruptive innovations and describe them as exponential technologies with extraordinarily rapid adoption[69]. OI2 can be defined as something that transcends these silos of verticals and creates a horizontal environment, this *organized chaos* can be seen to the right in the picture, referring to *Innovation network ecosystems* in figure 5.2.

Von Hippel introduces a concept called distributed innovation, where the knowledge move across the boundaries, in and out of the firm in both formal and informal

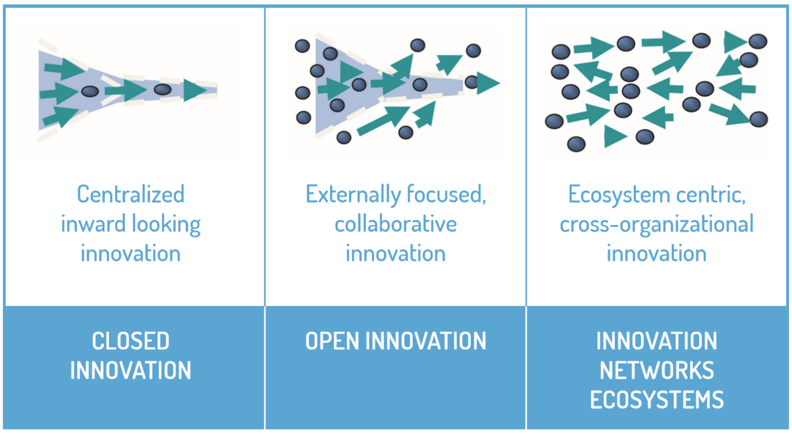


Figure 5.2: *The evolution of Innovation* adopted from Figure 1 in Curley & Salmelin[69, p.3]

ways[71]. The research done by Professor Eric Von Hippel at MIT argues that lead users sometimes develops innovation well before the market recognizes the need[71]. And typically the lead user develop this innovation before the S-curve takes off (see 5.3.2). Furthermore, the lead user provides guidance in decision making later on, and thus place an important role in the process of diffusion of innovation[72].

OI2 is about involving the lead users, in co-creation. The figure 5.1 shows this by putting users on top instead of consider them as just customers. Some of the best examples of a platform created in this way is the Linux ecosystem. What started as a hobby project of one person quickly developed into a global open source software project, with people and organizations all over the world contributing to the development of the system. The Linux Foundation was started around this movement in order to facilitate tools and training etc. to the open source community.

5.3 Transition towards a MaaS platform

The authors of the report *Towards an open ecosystem model for smart mobility services - The case of Finland*, Thomas Casey & Ville Valovirta are raising an important aspect of interoperable systems and vendor lock-in in MaaS from a systems perspective. They identified that the current services operates in closed and fragmented environment[73]. This model has created a situation in which innovations do not diffuse between cities and sectors, economies of scale are not reached and markets do not grow to their full potential. They conclude that interoperability and modularity are key success factors. The report draws upon the theories of open innovation and open source. It presents a challenge for the future success and scalability of these services. It defines how the network of actors providing the services, i.e. the value-system, can evolve from a closed vertically integrated state to an open horizontal state. The report states that the future of MaaS is at a crossroad with two possible paths.

“

- *Firstly, a centralized path. Where centrally controlled public services are liberalized and follows possibly the same path as in the evolution of the 1st and 2nd generation mobile communications*
- *Secondly, a decentralized path. Featuring fragmented and isolated services that are loosely coupled, similar to the evolution of the Internet*

”

- Casey & Valovirta [73, p.6]

Furthermore, the definitions used in the report are adopted as:

“

- *Centralized services with a strong public interest, i.e. where the public sector and regulated services play an important role, and*
- *Decentralized services operated by private actors with a larger degree of freedom to operate*

”

- Casey & Valovirta [73, p.7]

From the report a framework used to model the dynamics of value-systems from a techno-economic point of view has been adopted (See figure 5.3). This model has four value-system states[73].

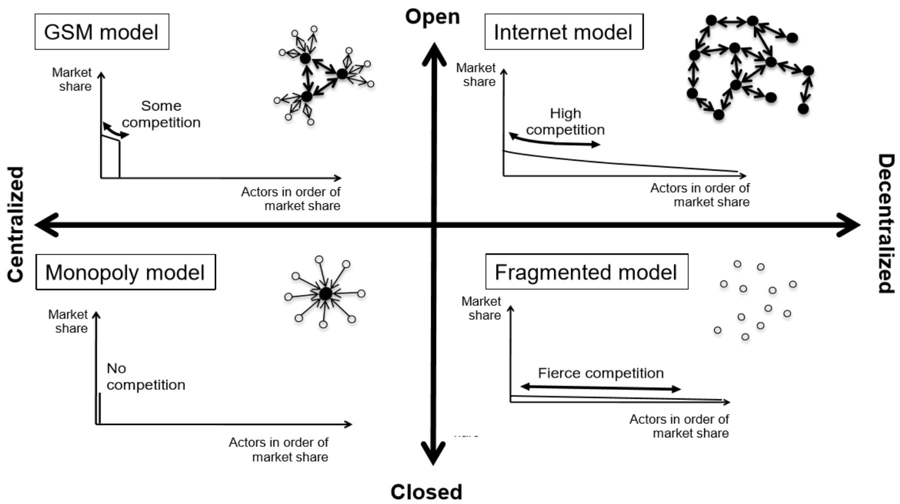


Figure 5.3: Four value-system states adopted from Figure 1 in Casey & Valovirta [73, p.8]

Open solutions to platforms:

- The *GSM model* in the left upper corner of the quadrant in figure 5.3, is regulated *de jure*, with a limited tightly connected actors that can operate under a licensing model[62]. The model is named after the GSM standard for telecommunications
- The *Internet model* in the right upper corner of the quadrant in figure 5.3, is an open and decentralized solution. The loosely coupled actors are able to provide a *de facto* standard platform in a democratized way. This is the model that companies

such as Uber are using, often referred to as *Sharing economy platforms*

Closed solutions:

- The *Monopoly model* in the left down corner of the quadrant in figure 5.3, is centralized with highly regulated *de jure* verticals. Where one single provider has all the control over the platform and the technical components. Is is resistant to change and slow to adapt to the environment
- The *Fragmented model* in the right down corner of the quadrant in figure 5.3. Isolated actors that operate with proprietary incompatible systems. Fierce competition and isolation result in the *Tragedy of the commons*[74], with low efficiency in use of resources, due to low level of coordination

5.3.1 Multi-level perspective

The diffusion of innovation is not triggered by any single factor when it comes to socio-technical system transitions, but from innovative processes at various levels in the figure 5.4. The interaction between technology and society can be defined in three levels and are distinguished as regime, landscape and niche[5]. This can be used to understand how new niches develop and can affect the current regime of how society is using a certain technology. The landscape represents how trends and technology is formed and used in the current system but this is challenged by the niche, representing a new addition to the mainstream solutions provided by the current regime.

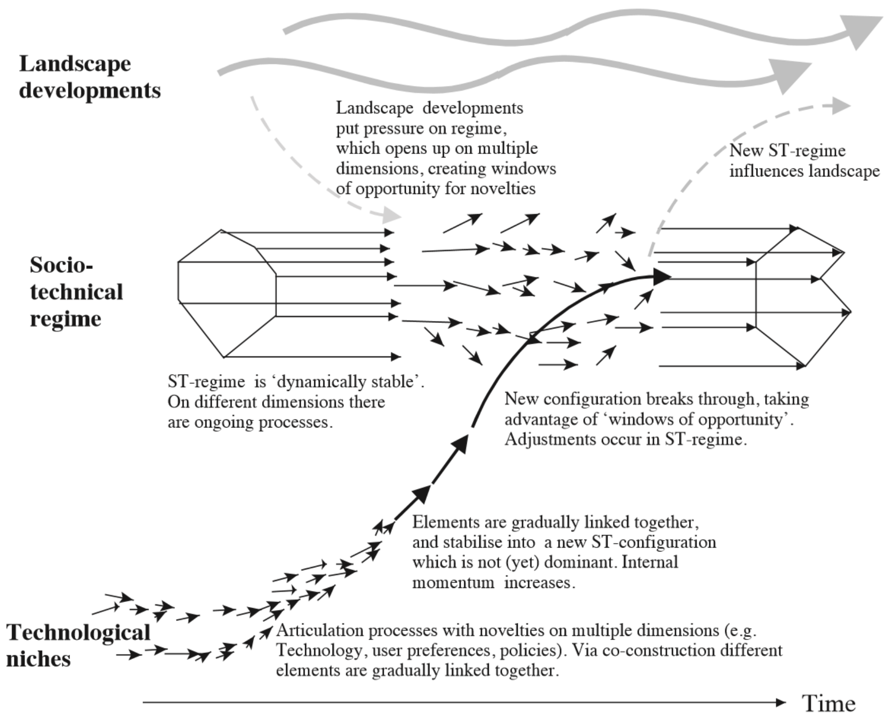


Figure 5.4: A dynamic multi-level perspective on system innovations adopted from Figure 4 in Geels[5, p.685]

5.3.2 S-curve

Diffusion of new technology is epidemic and have an s-shaped pattern. The development in MaaS, enabled by ICT has been investigated and the framework called s-curves has been further developed by Clayton Christensen to define architectural changes[53]. To explain the diffusion of innovation from the theory by Rogers[72].

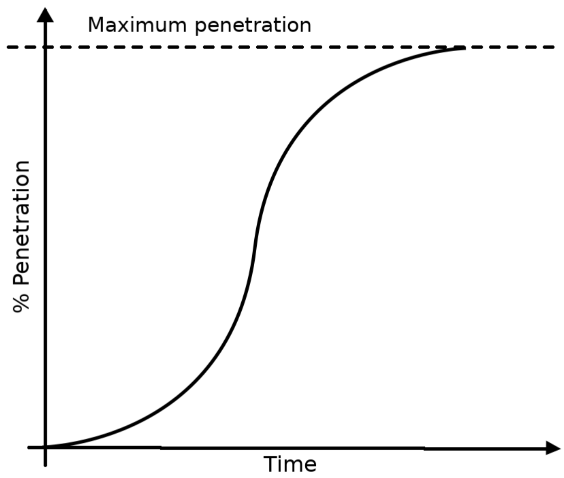


Figure 5.5: S-curve

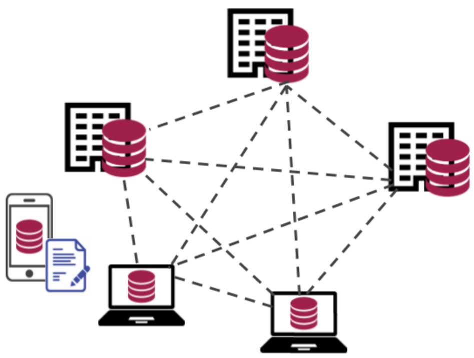
The innovation S-curve normally speaks to the substitution of new innovations towards old ones at the business level. As found in Figure 5.5, the size of change in the penetration of an platform or process relies on upon the development of the innovation. In the initial stages, the rate of penetration is moderate, yet when time passes by and the innovation turns out to be better comprehended, controlled and diffused, the rate of penetration change increments. In the early stage, the platform approaches the rate of development in an exponential pattern.

Drastically new advances are seldom formed and brought into market by incumbents. The reason is that the main firms regularly neglect to spot new fruitful opportunities and rather they are just attempting to fortify and refine their innovations in a incremental way[53]. It is usually the regularly new market participants and start-up companies, who create and bring these innovations by seeking unmatched or underserved needs. This theory refers to a jobs-to-be-done perspective[75].

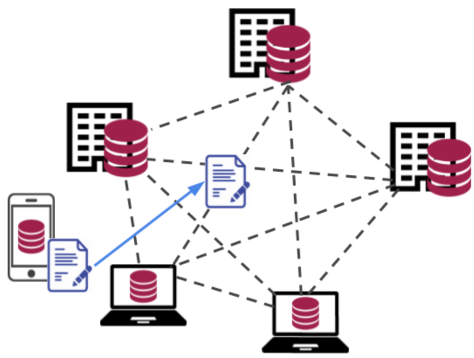
> “ *If I asked my customers what they want, they would answer: I want a faster horse* ”
> *- Henry Ford on incremental innovations vs. radical innovations*

5.4 Smart contracts

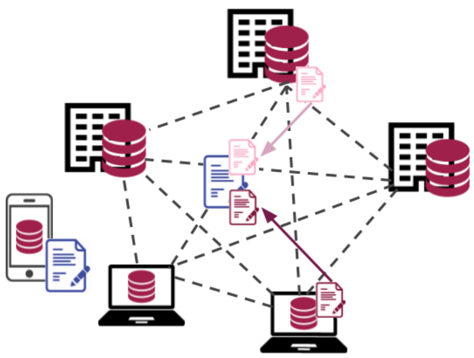
The digitization enables online commerce and digital contracts in network-based markets[62]. Contracts in a digital environment do not act like contracts in the analog world. The main reason for this is that computers need specific instructions on what to execute, thereby they can not consent to any terms that not has been specified, as humans can. This is the difference between a normal *contract-as-a-consent* and the *smart contract*, the theoretical discussion is whether the latter is really contractual. The categorization of which Smart contracts fits in are *Machine-made contracts*. This can also be divided into two parts, the first one where the computer act as an *agent* in the network, negotiating the terms. A second feature is called *Electronic enforcers*, where a term is enforced autonomously. An example is where a 30-day license is issued and when the days are over, the contract terminates autonomously. This second feature is often referred to as *digital rights management*.[76]. By using smart contracts, rules can be specified between multiple parties. Unlike traditional contracts that require a court and law system to be first negotiated, ratified and enforced. The rules in the smart contract are then guaranteed to execute as coded without any manipulation from the participating parties. Once a smart contract has been created it can not be changed, this gives its participants a guarantee of what will happen. Smart contracts can also hold value in the form of cryptocurrency and other digital assets, these funds can then be released on different conditions. Data that participants put into a smart contract can not directly be trusted because the data might have been altered to get an financial advantage. So to get real world data into a smart contract oracles are used. An oracle is basically a third party that inputs real world data into the blockchain. These can either be trusted or have an incentive mechanism that makes it expensive to lie.



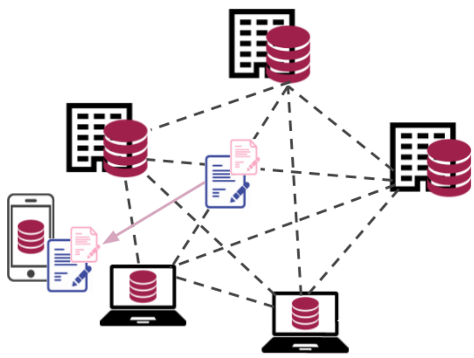
(a) User creates contract



(b) User sends contract to network



(c) Providers creates counteroffers



(d) User accepts one offer

Figure 5.6: Visual representation of a smart contract being used to order a service

There are multiple examples of smart contracts in use today. One notable is Etherisc[77] which is a flight insurance application that you pay a premium, and if your flight is delayed you will get a payment. Other early examples includes lending circles and other financial instruments, but also decentralized social networks such as Akasha[78], and new forms of organizational tools such as Colony[79] which aims to make organizations more flat. One very clear example of the use of smart contracts is a demo created to solve a problem in the music industry. Music artist and instrumentalist generally have to wait for getting payed for their work about a year after they have released a music work. This delay is mostly due to slow bureaucracy. With smart contracts however the artists can specify exactly how much each performer and producer contributed. When a person then pays for listening to the song, the money gets automatically distributed according to the percentages set in the smart contract. In the demo an artist called Imogen Heap released[80] a song only available for purchase using cryptocurrency.

In figure 5.6 an example process of using a smart contract to order a service can be seen. In 5.6a the user creates a contract for a service it wants fulfilled. This contract also contains the payment for the service that will be automatically released once the service is carried out. The user sends the contract to the blockchain network (5.6b) and all interested participants can see it. Participants that wants to provide the service make counteroffers to the initial contract (5.6c). The user accepts the offer that it prefers (5.6d). Both parties now have more certainty about the outcome of the agreement. If the service is fulfilled the provider will be guaranteed to get a payment and with the accepted contract the user knows that the provider is very likely to deliver the service.

With all of the things above considered it seems rather clear that smart contracts will enable a lot of new types of applications as well as make old business processes more efficient. To get an understanding of how the code of a smart contract might look check out Appendix A.

6
Results

In this chapter the views gathered from the stakeholder interviews are presented and summarized. After that requirements for a CMS are presented that draws upon the information in the interviews. With those requirements as a start the role that blockchain technology could play is presented. Along with that a simple explanation of how a CMS could be constructed in this context. What follows next is the agent-based simulation of how such a platform in different configurations could affect the market outcome for different MPs.

6.1 Interviews: Stakeholders perspectives

During the thesis we interviewed 9 independent stakeholders that where all MPs. One of these was a civil society movement organized as a non-profit, two where public organizations and the other seven where for profit companies. Some of these had participated in the UbiGo pilot and the rest at least knew about it. In addition to that two more technically oriented people where interviewed, but their interviews where more casual in order to get some more general information about the situation in VGR.

Among the stakeholders that where interviewed most had a quite similar **definition of MaaS/CMS**. Most agreed that the definition is kind of loosely delimited, but includes some kind of service that combines multiple smaller services into a more cohesive experience for the user. It could include a planner that allows the user to travel with multiple services in one journey. Some think it should be approached from the users perspective, by removing the need for them to own their own vehicle. Another thing that some think should be included is the option to define how you travel, so e.g. if you want your ride to be environmentally friendly or if you want the scenic route. Some see MaaS as one actor bundling lots of services together in one price tag while others think it should be more open and not controlled by any specific actor, more like an open marketplace. Most interviewees agree that it should represent an holistic picture, but one stakeholder thought it was more aimed at the service sector at the moment.

The **views on UbiGo** held by the stakeholders vary, and not all of them knew that much about the project. One of the highlighted problems with UbiGo was that most of the users in the project where already *sold* on it, that the reason they participated was that they already liked the idea. This would mean that the positive feedback it got could potentially be scewed. Many stakeholders found it hard to find their role in the project, especially public actors. Private actors had more of a difficulty seeing the reason to join the project and would only join if the platform had already taken off somewhat. Most stakeholders seemed to like the idea of having a CMS but didn't really know or think that UbiGo was the right approach. However the mere presence of UbiGo made some stakeholders review and change parts of their business models. There also seems to be an agreement about that the goal of UbiGo to to remove the need for owning a car is a good one. A project such as UbiGo could simplify price discovery one stakeholder pointed out.

Most stakeholders agreed that a **neutral CMS broker** is possible, but have differing opinions on how it can be achieved. Some think that it can't be commercial, and that is have to be open and transparent. Others stress the issue of it having to deal with current legal frameworks. According to some, public actors such as Samtrafiken should be taking that role, but not everyone agrees that they would be neutral enough. One stakeholder stressed the issue of the importance of not commodifying the participants in the platform in order for it to remain neutral.

Regarding **data sharing and transparency** public and smaller stakeholders are willing to share their data. The more commercial and traditional the stakeholders where less open to sharing their data in the same extent. Some have contracts you need to sign in order to access their API.

After having **introduced blockchain** technology all stakeholders showed a positive attitude towards it. However it seems like not many of the stakeholders have a good understanding of the technology and are unsure on how it will affect their business. The shift to such technology also feels like a big leap in many stakeholders views. One stakeholder thought that it is good to focus on the transactions part of the CMS system and putting that on the blockchain. There are also questions that popped up like: what happens when the cars own themselves?

Different perspectives in conjunction with the interviews resulted in a point of view portrayed by the start-up companies in the region as the willingness to cooperation are relative low and development is slow. The argument is that they rather make their own solution instead of waiting for the larger corporations. The argument also resembles the picture of how normally larger organizations handle change, where the relative responsiveness differs in pace between incumbent firms and small innovative firms. A concept called *Göteborgsleran* (Gothenburg mud) was presented to us, which points to the problem that some actors prioritizing helping each other rather than take the time to finding the best solutions.

6.2 Requirements of a CMS

There are several important requirements that needs to be captured by a CMS. We have found three major categories of requirements as a result from the interviews with a diverse set of MPs:

- Identification system
- Agreement platform
- Route planning tool

The identification needs of the platform includes verification of drivers licenses of drivers and trust between drivers, which could be called identity verification. Other things that could be needed is verification of vehicle registration and service.

An agreement platform should be able to handle multiple types of transactions that vary depending on stakeholder needs. We have identified the following main types: **Shared journeys** is when you travel together with other people and share the cost equally, i.e. no profits are made. **Vehicle renting** could mean renting cars or participating in a car club. **Paid journey** is public transport or on-demand travels.

Route planning is arguably the hardest part of the CMS. It needs to take into account the starting and destination location of the user, the different service providers and travel types as well as potential preferences from users such as environmental, time and price constraints.

6.3 Role of a blockchain

There are multiple properties of a blockchain that are beneficial to use given the requirements above. The most straight forward one is identification. We take driver license as an example. Car club A needs to know that their customers have valid licenses. Right now the car club needs to have a process for verifying the license, usually involving the customer taking a photo of the license and sending it to the car club whose employees verify the information. Now imagine that the customer registers at another car club or similar service B. The process now needs to be repeated again, duplicating the work of both the customer, A and B. A blockchain provides infrastructure for proving that certain data has been verified by a specific entity at a given time. This means that B could use the fact that A already have verified that information. A could even charge a small fee from B for the service, or the service could even be outsourced by both A and B to some sort of identity verifier organization. Of course the ideal situation here is if Transpoststyrelsen would issue a digital copy of all drivers licenses on a blockchain platform. Other identification needs could use a similar model.

The smart contract system can be used to implement an agreement platform in the CMS. By putting the agreements specified above into smart contracts the process between organizations and users can be largely automated. Payments can be completely integrated into the smart contracts, resulting in a tighter integration between business logic and payments. For users this means that it becomes easier to compare different options and prices. It also removes the barrier that each MP have to have a separate payment provider, instead a customer can pay directly to a smart contract and the MP that fulfills that smart contract will automatically get the payment into its account. The smart contracts can be designed so they follow a standardized format. All contracts that follow this format and register in the system will be automatically integrated into an app of the CMS, allowing for MPs to dynamically add and remove offers for different kind of journeys.

There are many blockchain systems available at this point, but not all of them support the rich smart contract infrastructure that would be needed by a CMS as described. Systems like Bitcoin are quite primitive in that they can mostly be used as a currency with some additional features. The blockchain projects that are interesting for a CMS are Ethereum and Hyperledger. While both projects have support for rich smart contract languages and in general can do the same things, there is one major difference between the two systems. The Ethereum system is a *public* blockchain and Hyperledger is a set of tools for creating *consortium* blockchains mainly aimed for businesses. A public blockchain is not controlled by any one or set of entities, instead it uses a consensus algorithm that allows anyone to start being a part of the verification process. Consortium blockchains have a specified set of verifiers consisting of the businesses setting up the system. These verifiers have the power to censor and allow whatever transactions they see fit. By this fact alone we think that a public blockchain is more desirable if the aim is to build a neutral system. Consortium blockchains are arguably also less secure since a predefined set of verifiers are easier to target by attackers.

6.4 Technical specification for a CMS

To give the reader an understanding of how a CMS that uses blockchain technology could be built an example of a technical specification is described below. This is of course not the only, or final way to solve the problem and is a large simplification. However it could serve as inspiration for an actual implementation. The general idea of the system is that users and MPs create smart contracts which contain an agreement of a journey or subscription. Information that for some MPs is more confidential is sent directly between the MP and the user using APIs of the MP.

The system consists of one main smart contract that we call $PlatformIndex$. This contains three lists which each has a different type of contract; $Order$, $Listing$, and $Subscription$. There will be more details on each of these below. Now the interaction flow from the users perspective is described. A user starts the CMS mobile application and enters that they want to go from point A to B. the application creates an $Order$ smart contract which contains A, B, and a payment which is put into escrow in the contract. The contract is published on the blockchain and the mobile application now uses public APIs from MPs to get route planning and responses to the $Order$ contract. The MPs route planning APIs do not need to be completely open. They could for example only provide responses if there is a $Order$ contract that is relevant. Routes from different MPs are displayed and the user can pick the one they like the most. Once the response to the $Order$ has been accepted by the user the MP knows that it will get a payment if it completes the journey. The response can contain price and time information, as well as modifications to A and B as some MP might require you to go to a specific pick up location (public transport). The price could be specified in different ways, if it is a shared ride the participants might want to split the cost equally.

A $Listing$ contract is created by MPs and is similar to an $Order$, but that also contains a response. Users can search these ready made listings and accept the terms of such an agreement. This will be most useful for car clubs, so information such as car type could also be included. A $subscription$ contract simply contains information of users that have paid for a subscription to some MP, along with validity, potential zone information, etc. Since the smart contracts exists in a blockchain and that the MP APIs are external the application can be implemented by multiple parties. For example one MP might want their own branded version of it that provides all of the services but can be presented differently to the user.

6.5 Simulation of potential CMS systems

What follows is the result of the simulation run on the model specified in the Method chapter. The simulation was run six times with different parameters. In all runs there where five MPs with the same areas in each run. The parameters that where changed was whether the platform was enabled and how many MPs it had, and whether the eco option was enabled or not. The simulation lasted from 1500 iterations and consisted of 2000 agents. Increasing the number of agents further doesn't seem to have a significant impact on the simulation. In figure 6.1 to 6.6 a p next to the provider means that it is included in the platform and an e next to the provider means that they are an environmental alternative and that the eco option is enabled. Also note that the 2000 agents are distributed between the five MPs. If the platform is enabled you can see how many agents that are utilizing it, but when an agent is using the platform it is also using an MP which means that the total number of agents that uses the platform can be seen without affecting the distribution of agents on the different MPs.

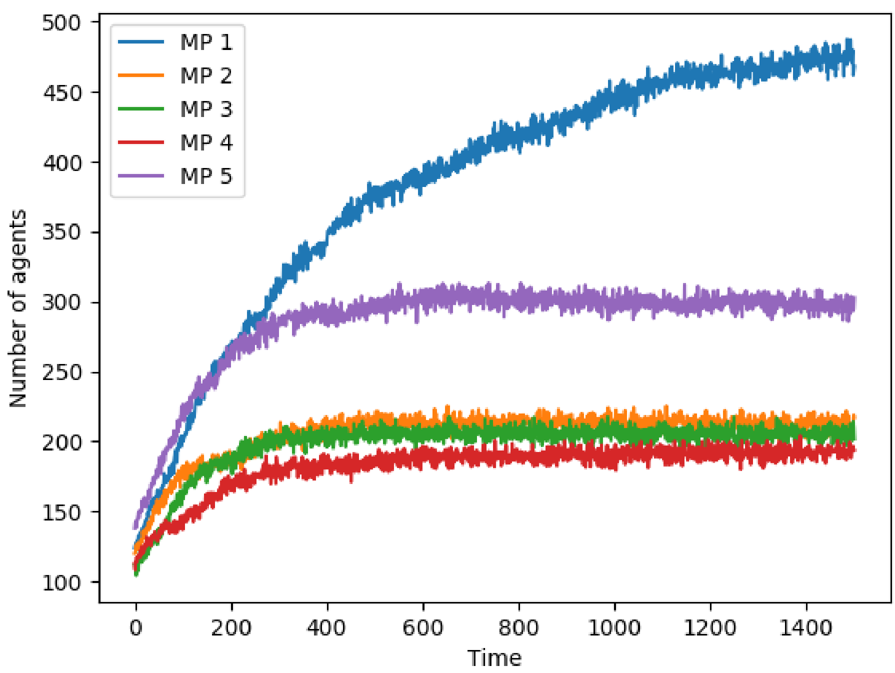


Figure 6.1: Result of simulation with no platform and eco option turned off

In figure 6.1 the base case is laid out. In the base case there is no platform, instead the MPs have to compete on equal grounds and they all separately have to gain network effects. Here it can be seen that MP 1 and 5 provides some areas that many agents wants. They are therefore used more. MP 2, 3, and 4 provide different and in some cases overlapping areas and they are competing quite equally.

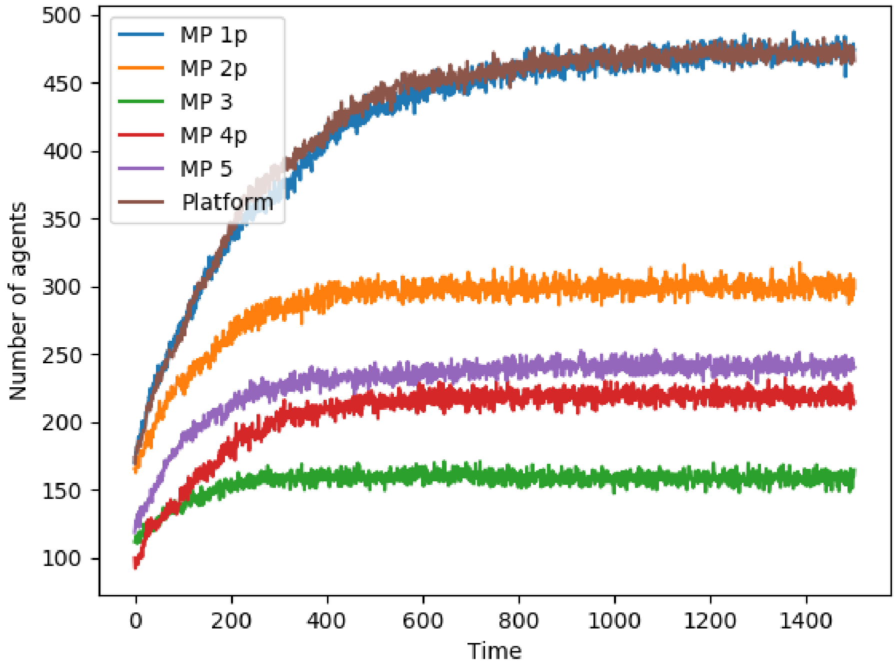


Figure 6.2: Result of simulation with a closed platform and eco option turned off

In figure 6.2 a closed platform is introduced. It allows some MPs to take part and exludes some others. By comparing figure 6.2 to 6.1 it can seen that by introducing a closed CMS the excluded MPs are worse of. MP 2 and 4 are much better of while MP 5 is a lot worse of and MP 3 is a little worse of.

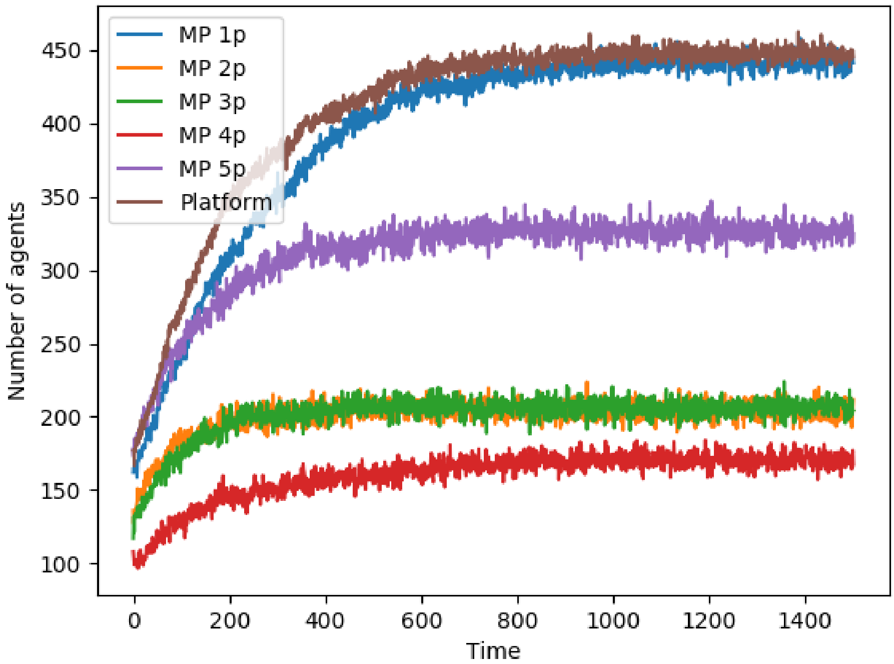


Figure 6.3: Result of simulation with an open platform and eco option turned off

Figure 6.3 depicts the use of an open platform in the simulation. Here all MPs are included in the platform. By comparing this figure to the previous results we see that the distribution of agents are quite equal to the results in figure 6.1. The main difference is that the distribution seams to converge a little quicker. What this means in the real world is that by introducing this platform there is no real impact on the MPs that choose to include their service, while users get a better experience and the cost of transactions are lowered in this more efficient system.

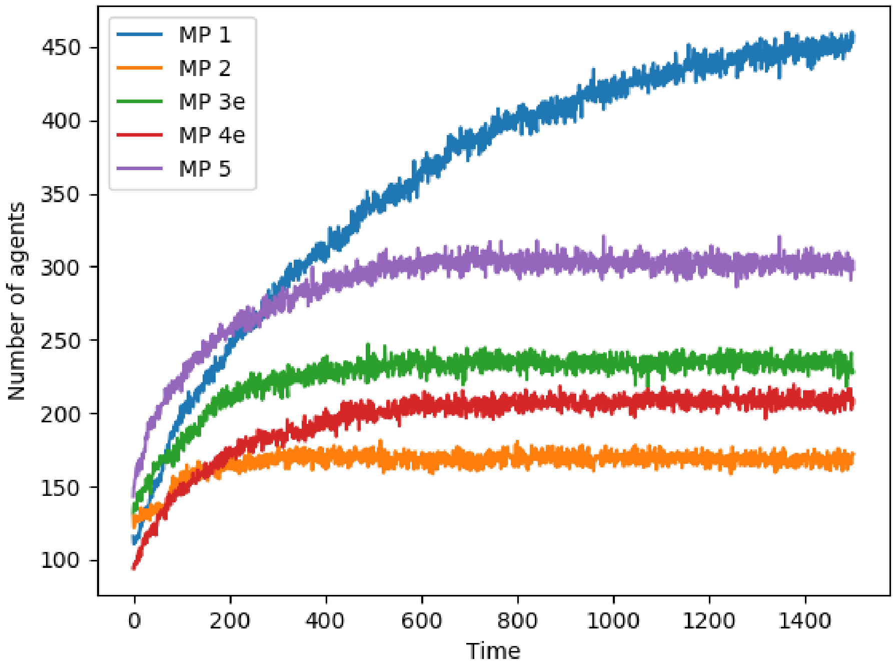


Figure 6.4: Result of simulation with no platform and eco option turned on

In figure 6.4 to 6.6 the eco option is turned on. Other than that the simulations are the same as above. The environmentally friendly MPs are 3 and 4 in all of these simulations. This enables us to see how the platform affects agents ability to choose the eco alternative. Comparing figure 6.4 to 6.1, which both have the platform disabled, we see that the eco alternatives are somewhat favored, but the option does not affect the overall result that much.

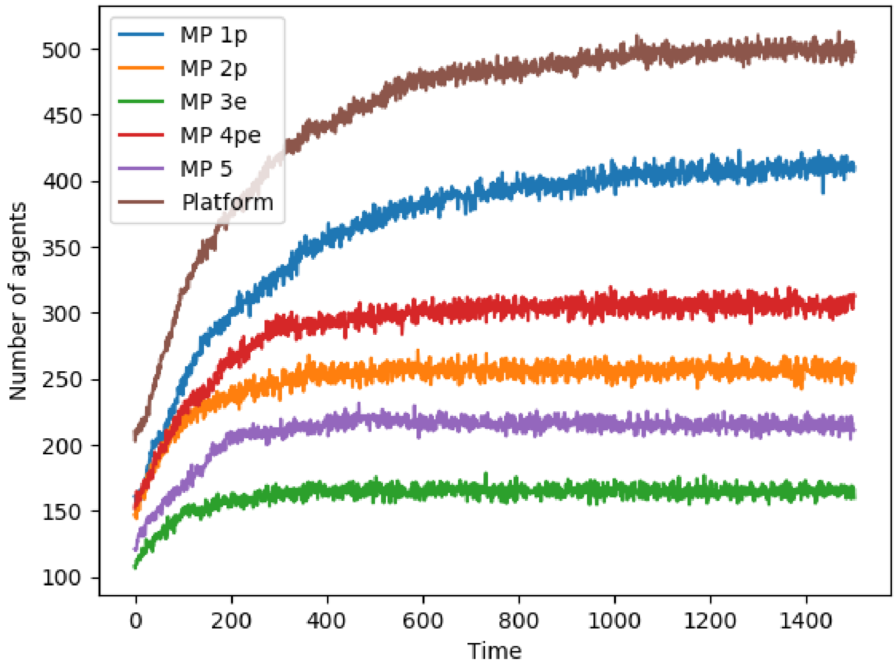


Figure 6.5: Result of simulation with a closed platform and eco option turned on

In figure 6.5 the closed platform is once again simulated as in figure 6.2 but with the eco option enabled. Figure 6.5 shows us that a platform with exclusive permissions to join impacts the ability for agents to choose eco alternatives. MP 2 is not eco but does better only on the accord of being in the platform. We also see that the platform performs better than in any previous simulations since users prioritizes it because it has an eco alternative.

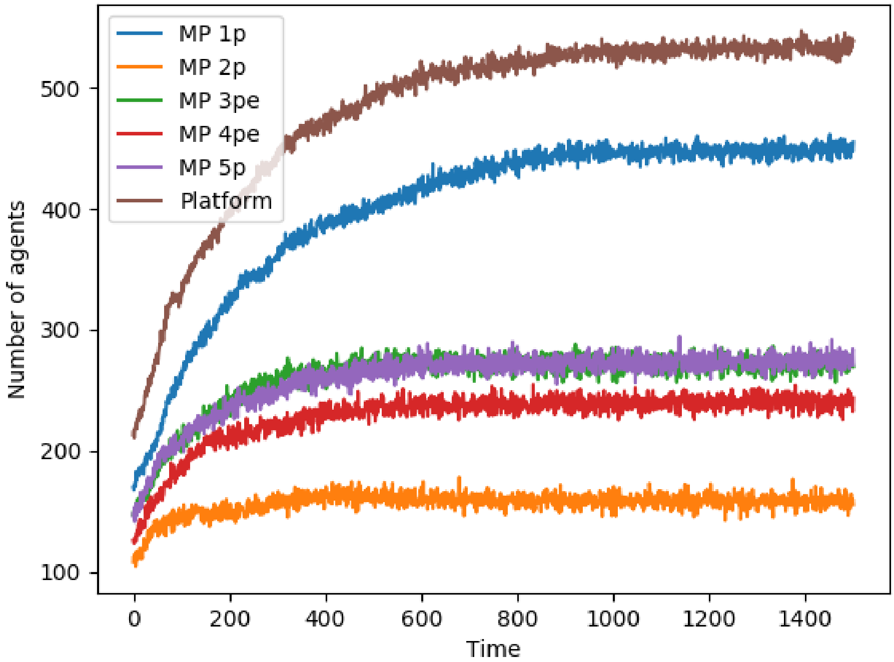


Figure 6.6: Result of simulation with an open platform and eco option turned on

A neutral platform showed in figure 6.6 shows that an open platform gives the agents better ability to use the eco alternatives. The non eco alternatives are of course affected quite a bit by this. As before we note that the platform makes the agents converge on their choices quicker.

7
Analysis

In parallel with studying the diffusion effects by the introduction of a platform in the simulation that is presented in the end of this analysis. Several theories from the literature study been used to further explore the role of blockchain technology in a CMS platform. By using information collated via the literature review and the outputs from several stakeholder interviews, emerged an analysis in understanding the concept of MaaS and how innovation takes place, formed to understand the factors of how blockchain interlink with a dynamic multi-level perspective (See figure 5.4).

7.1 Centralization vs. decentralization

The bias to our approach lies within our assumption that the current ecosystem, which is built on a foundation consisting of public traffic authorities, operating by using planned and deployed fixed spatial coverage with timetables. Is equally inefficient as the low-resource usage of privately owned cars. Where cars are defined as fragmented and closed and public traffic is the centralized monopoly solution that is used to solve the current uncertainties in the demand of mobility services (See figure 5.3). Our beliefs are grounded in the notion that this is both unsustainable and dependent on subsidies. Hence, public traffic in cities are threatened by *creative destruction*[81] by innovative companies such as Uber and collaborative services such as Skjutsgruppen, that are more decentralized solutions and enabled by connected services and communities[82]. The spatial information of where travelers are and where to go is one of the key elements, and one of the reasons why mobility platforms exist. But there is a low level of integration between these different MPs, whom are now developing their own solutions. With the advent introduction of autonomous vehicles other considerations and models are necessary to analyze the spatial pattern of the next generation of *public traffic*, which e.g. can be free-floating instead of fixed. The web 2.0[83] has enabled app-based services and platforms, providing the necessary digital infrastructure for a transition to take place. An ecosystem built on blockchain technology is the highest order of *creative destruction* on mobility services. It can with the use of smart contract enable trust among people and companies to make Business to Business (B2B), Business to Customer (B2C) and Customer to Customer (C2C) transactions with no other mediator than the distributed network itself. In addition new types of transactions are also enabled, which are Machine to Machine (M2M) and Machine to Customer (M2C). However, it is hard to predict exactly how this would work in practise. Furthermore, depending on how the blockchain platform is designed and developed, no centralized broker will be marginalizing on the profits or the costs of any participating agents. Hence, it provides a more neutral platform. This is a significant change in the way business is done on platforms today as the section 5.1.1.1 points out. Blockchain is a true disruptive technology, following Schumpeter's definition and three stages, invention, innovation and diffusion, challenging how mobility ecosystems work in the future[84]. It has the potential to challenge the current regime if the adoption rate increases and the cause is diminished transaction costs.

7.2 Sharing economy platforms

New ways of collaborating together are enabled by IT, which connects people[82][85]. The result is that the trust between people increases and this is affecting mobility services. This evolution is an extension to how the internet started, in the figure 5.3 referred to as the *Internet model*[73]. The boundaries of what is a merit good and what is private has started to consolidate and is now becoming a trend in our society, supported by the positive externalities of MaaS (See section 5.1.1). From this, the term *sharing economy* can be explained as a collective effort to solve wicked problems with new types of solutions. Where people start to think in new patterns and thus subverting the prevailing power structures of the current regime by co-creating a decentralized system. Hence the discourse about how the role of blockchain can enable a new type of ecosystem in a combined mobility platform. Accessibility over ownership together with the increased awareness of sustainability and resource efficiency is driving factors behind this transition. Hence, the importance of involving the civil society in the design of the future MaaS platform at an early stage as lead users. As the innovation systems theory in section 5.2.2 and figure 5.1 suggests.

The barriers between public transport and other mobility services has started to fade. The notion of the definition of public transport in the future is challenged and as Samtrafiken suggests in their report, *Traveling with shared resources* can be a new paradigm in mobility services (See section 3.3.3).

Implication of sharing economy is under investigation[32], and one of those investigation has been carried out by The Swedish Tax Agency. They studied tax-related effects of the sharing economy and the risks. The conclusion was that they should not tax p2p services at a lower level than traditional services. One notable thing the report point out is a risk that complex regulations increase the risk for mistakes, especially as control of peer-to-peer transactions is low[33]. However with the use of blockchain technology it is possible to track even the p2p transactions since they are publicly available in the ledger. One could also imagine a system where taxes are automatically collected from each transaction.

7.2.1 Shared mobility, or not?

The mobility market has already started a transition towards digitization, ICT is deployed throughout the transport system and infrastructure, vehicles, end-users are all started to be connected in a higher pace. The integration of broadband connectivity and GPS tracking acts as enablers to guide the decisions to both vehicles and end-users. Multi-modal trip planning is made possible by sharing of data on a platform. These technological developments are referred to as “Non-transportation technologies”, and are transforming as well as disrupting transportation [82].

To understand the development of how digitization impact and changes our lives, examples like Facebook for social connections, Uber for transport, and AirBnB to find a place to stay etc. are commonly used when talking about platforms and peer-to-peer solutions. The common denominator is that they all take advantage of the network effects(See section 5.1.1) and the strategies (See section 5.1.1.1) to become the dominant design. But what these companies is trying to do is not often presented(See section5.3). They try to build their own verticals by creating in fact, closed platforms. Furthermore, they do not permit users to switch between platforms and e.g. take their data with them. Hence, they have full access and control over the data, users cannot take their usage data from Uber and use it as input in other mobility services. The platform owners often profit on both sides and in the case of Uber they also can change the contract of what the drivers earn at anytime, reducing the income of the driver and increase their profit. On the other hand customers are charged more with something they call *price surge* in high demand situations. The example above depicts the current situation on a *fragmented market* (See the framework 5.3). Furthemore, this can cause antitrust to the platform and if customer feel omitted to what they deserve in terms of rewards, the possible outcome is that they will leave the platform. This has a great impact on how they currently create digital solutions. However, these services are operating in closed environment (5.1.1) and in the case of Facebook, e.g. users can create their own account for free and access the content on the platforms for free, on the supply-side companies are paying Facebook to show their ads to the users. In the case of mobility, an example is the bike sharing system *Styr & Ställ*, where the operating company JCDecaux has a monopoly on outdoor advertising in the city of Gothenburg[32].

7.2.2 Dimensions of open and closed

Uber is now known all over the globe for its strategy and disrupting effects. The competitive advantage of connecting drivers and customers on a platform, has proven to be a success[86]. Despite this, Uber is having problems with provisions in several locations and has been pushed back by different reasons and even forced to leave countries like Italy completely and Sweden partly with their service Uber POP due to legislation and regulatory circumstances[32]. Uber is almost a *de facto* standard by now and is operating in a closed environment. Furthermore, where they control and permit both drivers and customer to access the platform. They set the price in a centralized way. By means having a monopoly situation with its dominating design (in some areas, they are under fierce price competition), where they can dictate the terms for both drivers and customers.

The competition in the *GSM model* (see figure 5.3) is often based on a oligopoly and because of this, the different MPs that are separated from each other can divide the market between themselves, i.e. collude. Which is a cause for antitrust laws. One argument points out the problem with this model, that the centralization builds high barriers to entry and therefore the service never takes off[87]. On the other hand ensures the centralization that the MPs can use some sort of standard to communicate, e.g. the *GSM* system where they use same frequencies for interoperability, harmonization etc. This enables lower switching costs to users.

In an open environment the rules of business changes dramatically. One way of doing this is to adopt the *internet model* as depicted in figure 5.3. This can develop *de facto* standards of how to operate and do transactions in a network. The current use cases for blockchain i.e. bitcoin is a *de facto* standard now. A mobility platform built on blockchain can be subject to also become a *de jure*, which means if the smart contract enforces actors in a formal legal institution. Something that is possible and brings higher trust, because of the transparency in a publicly available blockchain ledger. This enables diversity and a wider service scale due to a built in controlled level of fairness. However, the quality of the service cannot be guaranteed for new actors and to achieve a standard level of high trust, that is necessary i.e blockchain technology is one way to solve this. E.g. in the case of public transportation, there will possibly be a question of deregulation, otherwise the option is to adopt the *GSM model* with regulations controlling the platform. Furthermore, an open and neutral combined mobility platform, particularly in the city, then possibly becomes similar to an innovation system platform that is built on diversity and collaboration(See section 5.2.2). That eventually could be the solution that makes travel cheaper, cleaner, and more accessible by including everyone and excluding no one[82][32].

The section 5.1.1.1 deals with strategies in network based markets. If the way forward is with a closed model such as UbiGo suggest, the question is how a MaaS platform will be design related to openness or rather openness within a certain community. As the figure 5.3 depicts, a *license to operate* GSM model could emerge. Because the exclusive UbiGo model is bound to produce fierce competition, with possible better solutions in the future at the expense of welfare factors. One way to please the actors with an open platform provided with as few limitations as possible (openness for everybody) there is natural reasons and a need for regulation. The smart contracts can resolve many of the issues related to negative externalities automatically, and a way to adopt the open blockchain solution instead of enforcing a *license to operate* solution.

7.3 Diffusion, transition and barriers in MaaS

The UbiGo case is a good example of a socio-technical system transition, but because it was a limited trial it is hard to draw any conclusions regarding the adoption. In the normal case and as described in the section 5.3.2, adopters tell several of their friends about the product, who in turn tell several of their friends. The heart of the diffusion process consists of the interpersonal network exchanges and social modeling by those individuals who have already adopted an innovation and those individuals who are influenced to follow their lead. Diffusion is fundamentally a social process (See section 5.3.2 and 5.2.2).

The three technologies that enabled MaaS is the convergence between: IT, ICT and ITS. These three technologies has brought us real-time data and new possibilities to understand how people are travelling. As cities now becomes smarter and have connected devices and vehicles, the opportunity for a new transformation is advent.

During our interviews, we encountered a barrier referred to as *Göteborgsleran* (In English "Gothenburg mud"), this depicts how small *niche* MPs are excluded to any benefits of the current regime today and how larger MPs and their consortium is resistant to change and presents character of slow adoption. The result is due to this gap that the different actors try to develop their own solutions. The perception of this problem is related to the figure 5.4 and how technological niches evolve over time. This is what the theory predicts, later these different solution can converge into one solution in the end if collaboration takes place. Additionally, due to the *winner takes it all* principle of network effects, what needs to be done to stimulate innovative niche solutions can be seen in the figure 5.2.

The Go:Smart R&D project in Gothenburg, that produced the UbiGo trial claimed to be a quadruple helix project[42]. But the users involved in the field operational test was only used to capture value as portrayed in the section 5.2.1 instead of creating new value. Hence, the outcome of the project as a top-down initiative is that it never resulted in a real attraction to the Public Transport Authority (PTA) because it was exclusive to the participating MPs and UbiGo that had to much bargaining power in negotiations. However, it concluded how important ICT is as a mediator to MaaS[43]. This raises the question if one can trust the systems mediator, and points towards the need to have a neutral broker instead of a company like UbiGo. Other forms of trust issues in a platform is in the case of a driver, does the person have a valid driving license, is the vehicle insured etc. In case of a self-driving car, who is responsible? This is a question that has been raised before in an earlier report[32].

One question we sought to find out more about was: Does the complementary MPs in a real situation join the platform? During the interviews we observed that there is a need for a *neutral* Combined Mobility Service platform. Most stakeholders showed little interest in integrating towards a new third party organization. However, some of them thought that integrating with a public organization like Västtrafik could potentially work out. The decisions that needs to be taken when building a platform, that is neutral, meaning that any MP could join and leave at any point and can offer their service in the way they want, is a difficult problem. This process needs to be performed according to the principals in section 5.2.2. There could also be potential legal issues with a open platform that needs to be considered, and policymakers should be included as well. Although we think that most of the issues could quite easily be avoided because the blockchain technology bonds together the actors in ways that policy discussions ties them, but on a technological level instead. Another thing that needs to be tackled if the platform is to be neutral is who should build the platform, and what incentives do they have to do so? One potential solution to this is to develop the platform completely open source and then charge consulting fees for companies that need help integrating their services in it, much like the Linux Foundation and Red Hat does as a comparison. Another maybe more realistic way is that multiple MPs come together to propose a standard set of smart contracts that are released open source and which can act as the basis for a CMS.

Some are arguing that the subscription model *one-size fits all* is not sufficient and with an increase of alternatives and numerous apps connecting travelers it is important to consider the diversity and accessibility of a platform[88]. These apps have been adopted by changing how people communicate and commute. Alternative non-profit solutions subsist to be explored by the civil society. One thing that these all have in common is that they try to create their own natural monopolies and achieve high market power, in high competition of a closed environment. Just as the public transport system has subsidies, these new app-based services tries to create their own platforms often with two-sided market effects.

As a consequence of subsidies, the current mobility market is skewed towards public transport, this leads to a strong distribution of bargaining power to Västtrafik. This is something that can be observed in Internet of Things ecosystem services and two-sided marketplaces, where usually one side is subsidized and the other pays a higher cost (See section 5.1.1.1). What the consequences are of disruptive companies such as Uber is still under investigation due to the fact that Uber never shown a profit yet. Arguably the trend is moving from chain of command towards decentralized communities. Arguably an important part of this movement will be from the blockchain *niche* technology, which has been under rapid development the last couple of years. It is considered as an enabler for trust and transparency, using consensus algorithms and automatically enforced contracts. However the use of blockchain technology has for now mostly been explored in the financial industry and has yet to be tested in the mobility sector.

Samtrafiken state in their report that no player can reach the desired position on his own, and need to interact with each other[44]. Furthermore, they conclude that issues related to legislation, infrastructure, supply of transport services, etc. are crucial to enable the development of combined mobility services but may be managed in another forum.

Despite the information we got from the interview there are numerous efforts that has already been released, Samtrafiken together with their partners has released an open data platform called *Trafiklab*[89]. And a company named PreciFishbone has helped the actors create a service called *Trafiken.nu*[90].

The problem is that the services in the platform is not yet integrated if compared to the table in the figure 3.2b

7.4 Blockchain Ecosystems

A platform that is built on a open and distributed blockchain is an exponential technology and what the paradigm in the section 5.2.2 Open Innovation 2.0 talks about. The concept of rapid adoption with this innovation stems from the inherent network effects due to the monetary incentives involved.

What blockchain technology actually can do is to provide an equal and fair p2p matching without any company or organization getting involved as an intermediary. Hence, disrupting the current way of how platforms operate. The figure 5.3 show the concept of decentralization and the *internet model* in section 5.3. Our analysis by exploring the role of blockchain is that it can actually go further than the current theoretical framework in 5.3 suggest. This is because the current negative externalities in the theory of network effects (See section 5.1.1), can be controlled by smart contracts. The increase in returns can also be adjusted for. Thus, preventing a market failure. One concept that derive from the research in open innovation and network-based markets is *(F)RAND*, (Fair), Reasonable and Non Discriminatory terms. In a MaaS platform with smart contracts this concept can be programmed into the core logic of the contract. Hence, a very good argument in favour of using blockchain technology is that it can be seen as a public good that not excludes anyone from the start as the *GSM model* in figure 5.3 does. Furthermore, the concept of transparency will be redefined, as the information is handled in a cryptographically secure manner and incentivized by oracles as section 5.4 suggests.

Information can also be kept in the network to prevent the principal-agent problem[91], that a platform sponsor such as UbiGo could exploit.

The background to the problem is who will be the *Integrator* (MaaS operator) in the future? And who will decide how the platform will look like as *sponsor*? The value chain of MaaS operators is subject to a momentary change and the threat of being disrupted. The possible outcome of using blockchain technology can result in a displacement in the future if the current model of MaaS is implemented, the risk is that the integrator will be replaced with a smart contracts solution if the trust to the central authority is low. This is not the only reason, as the quote in section 5.1.1.1 state, the cost of producing a platform need to be considered. Today it seems like companies such as UbiGo are just *rent-seeking* and try to maximize their profits[92]. These profits can on a blockchain platform go where they are supposed to, namely from travelers to the ones performing the service. Users with real-world experience, who are in need of a solution is in the best position to provide data. This theory presented by Von Hippel described in section 5.2.1 can be applied in the context of blockchain technology because there is a dissatisfaction against centralization and closed systems. The design of the platform and the specification in the smart contract, built on blockchain technology, can enable this technology to become truly a disruptive innovation. Together with complementary technologies such as autonomous and electric vehicles combined with the sharing economy[82].

The envelopment threat in two-sided network markets 5.1.1 is very tricky[58] but smart contracts will have a significant impact on this. The MPs can bundle their services in advance and thus the requirement specification becomes important. They need to consider if it is reduced cost, environmental aspect, time or comfort / quality aspects that are of relevance to the customer and offer special solutions etc. The way blockchain impacts this is that no more antitrust behaviour such as price fixing, such as artificial high prices on taxi rides occur. The price will truly be set under of the principle of demand and supply. One remaning question is how MaaS will supply the mobility need in suburban and rural areas where demand is low. One can argue that it is unnecessary to have planned routes of buses going around in these areas, one of the main reason why public traffic is subsidized today is to cover this cost. With smart contracts in combination with spatial data, the MPs can solve this more efficiently by coordinating the routes. A prerequisite is thou that a diverse supply of MPs are affiliated to the network, such as non-profit actors like Skjutsgruppen that can serve flexible demand by scaling up supply when necessary.

One possible outcome if the need of subsidies vanishes, is that resources can be re-allocated to allow special public transports to be totally subsidized between public institutions such as schools, hospitals etc. and let other MPs solve the rest of the demand.

An interesting case is the Real networks with their music player that tried to reinvigorate their business model to offer services as a systems integrator, helping enterprises knit together diverse systems and technologies[58]. Samtrafiken is doing the same thing as Real Networks when they try to be the integrator (See the figure in 7.1). Notable in this context if that they also following the manual, to the letter in standard wars.

The increasing returns issue is not a problem with smart contracts as a fairness judging code can be implemented, user will also have much higher degree of participation in how they choose to use the platform.

On a neutral platform based on smart contracts the mutual benefits of a two-sided market can still be kept positive, and to further develop the concept of MaaS an insight is that if a customer is using the platform to get from A to D, one MP can take him from A to B, another from B to C and a third from C to D without any transaction costs and involvement from a company like UbiGo[93]. In our analysis we can conclude that UbiGo operated under the old paradigm of trying to become the *dominant design* and marginalized on the profits by acting as a travel agency (See section 5.1.1.1). The smart contract can further be designed to manage *subsidies*, where the first trip A to B can be willingly or automatically performed with a taxi ride that is more expensive but that cost will be merged with the much cheaper bus ride that takes place between B to C because the smart contract can in theory adapt to the current market situation and provide the benefit of giving both modes of transport a customer and match the pricing in real time. The higher level of integration also fills up the bus with passengers at the right place, at the right time, minimizing the total cost of the trip and thus, enable assets to reduce the cost of the first trip. The same goes for the third leg where the trip can be performed via bike or taxi, depending on current need and willingness to pay of the customer.

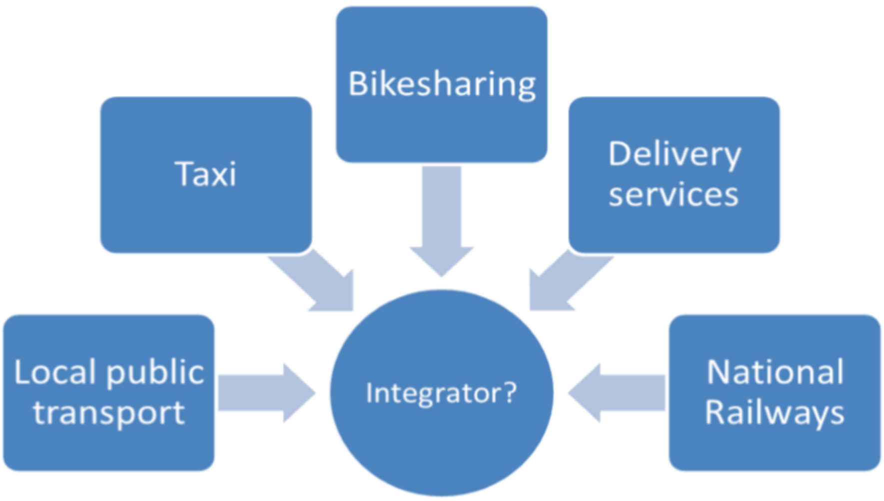


Figure 7.1: *Potential MaaS integration models* adopted from Figure 8 in Eckhardt & Aapaoja[42, p.22]

7.5 Synthesizing agent based model with diffusion of innovation theory

As can be observed in the result of the simulation (6.5) a CMS can have a significant impact on the mobility ecosystem. A CMS that is controlled by one of a limited group of MPs impact the overall system badly and could even have a negative impact on the environment because users will have a harder time choosing more environmentally friendly options. New innovative MPs can also have a very hard time to get into the market in this system. However a neutral CMS that lets all MPs join on more equal terms does not seem to have these problems. It can even help the environment since users are given more options to choose from and have a better opportunity to pick the environmentally friendly option. In addition some of the MPs that provide the less environmental options can become worse of, but them leaving the platform would porbably only increase this effect. This fact could actually cause an increased competition to create more environmentally friendly services, if the conditions are right.

The simulation in 6.5 shows similarities with the s-curve in relation to innovation in section 5.3.2. When an open platform is introduced the network effects accelerate the process and the MPs converge faster. What is expected is that the other MPs are worse off when the platform is introduced. The number of agents that are using a MP are of significance to how the MP develop over time. Most of the results can be expected from the theory of how network based markets behave but what draws attention is what happens when the circumstances change with barriers to entry and incentives to use environmental friendly option, as can be seen in figure 6.5. The diffusion in figure 6.6 shows that an open platform bring an equal portion of agents to each of the MPs and supports diversity in the long term. Once the effects of the platform is diffused, the quick convergence provides incentives to innovate. The other results from the simulation regarding the permitted platforms can be related to the report in section 5.3. Regarding the situation where the market fails to reach the potential due to vendor lock-in effects, these barriers to entry are related to switching costs (See section5.1.1).

8
Conclusion

This thesis has shown that the use of blockchain technology in the MaaS ecosystem is not only possible but it could also help solve some of the fundamental problems with creating a CMS. This is achieved by using smart contracts to serve the function of a MaaS operator, in addition they could also reduce the cost of transactions significantly. Smart contracts could also help in removing barriers with payment systems and reduce the cost of doing user identification. Moreover, the research shows that if a CMS is to have a positive impact on the mobility ecosystem it needs to be *neutral* and built upon the principles of an open and transparent process. This makes the case of using a **public** blockchain rather than a private / consortium blockchain, since the latter is controlled by one or more parties that could in theory exert unwanted restrictions on selected MPs. As shown, such restrictions could have negative impacts on both competitiveness and environmental issues. With this knowledge, the simplified technical specification that was created can be used as a inspiration source for the development of a CMS utilizing blockchain technology. Concluding that the current MPs need to change how they operate by adopt the terms of sustainability.

8.1 Suggestions for further research

There are multiple topics that we discovered which needs further research. Among them are the following:

- How can a blockchain enabled mobility service connect to other infrastructure services once they become smarter such as road tolls, parking, insurance systems, etc?
- How will taxation work in a blockchain based mobility service? How can having more information about how we move make subsidizes more efficient?

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A

Smart contract example

Below is an example of a simple crowdfunding contract which allows one to collect funds from investors without the need of a central actor like kickstarter or rely on external payment providers. The contract is written in a special language called Solidity that is specifically designed for the ethereum platform and is copied from *https://ethereum.org/crowdsale*.

```
pragma solidity ^0.4.2;
contract token {
    function transfer(address receiver, uint amount){  }
}

contract Crowdsale {
    address public beneficiary;
    uint public fundingGoal; uint public amountRaised;
    uint public deadline; uint public price;
    token public tokenReward;
    mapping(address => uint256) public balanceOf;
    bool fundingGoalReached = false;
    event GoalReached(address beneficiary, uint amountRaised);
    event FundTransfer(address backer, uint amount, bool isContribution
    bool crowdsaleClosed = false;

    /* data structure to hold information about campaign contributors *

    /* at initialization, setup the owner */
    function Crowdsale(
        address ifSuccessfulSendTo,
        uint fundingGoalInEthers,
        uint durationInMinutes,
        uint etherCostOfEachToken,
        token addressOfTokenUsedAsReward
    ) {
        beneficiary = ifSuccessfulSendTo;
        fundingGoal = fundingGoalInEthers * 1 ether;
        deadline = now + durationInMinutes * 1 minutes;
        price = etherCostOfEachToken * 1 ether;
        tokenReward = token(addressOfTokenUsedAsReward);
    }
```

```
/* The function without name is the default function that is
called whenever anyone sends funds to a contract */
function () payable {
    if (crowdsaleClosed) throw;
    uint amount = msg.value;
    balanceOf[msg.sender] = amount;
    amountRaised += amount;
    tokenReward.transfer(msg.sender, amount / price);
    FundTransfer(msg.sender, amount, true);
}

modifier afterDeadline() { if (now >= deadline) _; }

/* checks if the goal or time limit has been reached and ends
the campaign */
function checkGoalReached() afterDeadline {
    if (amountRaised >= fundingGoal){
        fundingGoalReached = true;
        GoalReached(beneficiary, amountRaised);
    }
    crowdsaleClosed = true;
}


function safeWithdrawal() afterDeadline {
    if (!fundingGoalReached) {
        uint amount = balanceOf[msg.sender];
        balanceOf[msg.sender] = 0;
        if (amount > 0) {
            if (msg.sender.send(amount)) {
                FundTransfer(msg.sender, amount, false);
            } else {
                balanceOf[msg.sender] = amount;
            }
        }
    }

    if (fundingGoalReached && beneficiary == msg.sender) {
        if (beneficiary.send(amountRaised)) {
            FundTransfer(beneficiary, amountRaised, false);
        } else {
            // If we fail to send the funds to beneficiary,
            // unlock funders balance
            fundingGoalReached = false;
        }
```

```
        }
    }
}
```