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Analysis of the Integration of Carsharing Interoperability among Operators in the City of Munich

Master's Thesis

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"We are moving from a world where we're organized around ownership to one organized around access to assets." (Gansky, 2010)

"Within the automotive industry, times are changing. Data is the new horsepower and connectivity is the new chassis." (Palmer , 2014)

Abstract This study is an initial attempt to analyze the implementation of interoperability in carsharing in the city of Munich. With this purpose in mind, literature research has been done in order to set the context of this master's thesis. Through the evaluation of the Theory of Networks it has been assessed which could be the threats and opportunities of the implementation of interoperability among carsharing operators. Furthermore, the most relevant approaches to establish interoperability in Germany have been analyzed. At this point, an interoperable carsharing model is proposed for the city of Munich using the tools of the traveler information services industry. For the development of this model special attention is paid to the overall organization as well as to the processes of the carsharing service. For studying the feasibility of this model and obtaining recommendations on its implementation expert interviews have been assessed. Four experts from the carsharing industry have been interviewed (DriveNow, car2go, CiteeCar and STATTAUTO). As a consequence of these interviews, the interoperable model has been further detailed and relevant aspects of its implementation are commented. Based on the expert interviews and the literature research, it is concluded that interoperability has an important role to play for the further development of carsharing. This document gives an initial step to carry out its implementation in the city of Munich.

Keywords Interoperability · Carsharing · Munich · Traveler Information Services · Telematics ·

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Abbreviations

MVV	Münchner Verkehrs- und Tarifverbund
MVG	Münchner Verkehrsgesellschaft
DB	Deutsche Bahn
GmbH	Gesellschaft mit beschränkter Haftung (Limited Liability Company)
BCB	Bundesverband Carsharing Association
POI	Points of Interest

1. Introduction

1.1 Context and Problem Definition

Carsharing belongs to the new class of mobility services that rely on modern technology and telematics to permit the access to car-based mobility with no need for the user to own the physical asset (a car). In opposition to the traditional way of selling a car to the end user, this new mobility trend needs new organizational structures, new value propositions and new ways of interacting with the public sector (Le Vine, et al., 2014).

Nowadays, in many cities all over the world, different companies provide a wide variety of carsharing services, each of them with their own business models as well as their own registration, booking and paying systems.

Rather than mere competitors, different Carsharing companies in the same city have the potential to be complementary to each other and therefore more attractive for customers due to a larger amount of available vehicles and a wider range of models. It could also give the chance of using carsharing when travelling abroad. If implemented correctly, the implementation of an interoperable system can end up being a win-win solution: on the one hand by allowing Carsharing users to rent cars from other companies, on the second through client attraction and therefore increased revenues to the carsharing organizations.

However, many challenges arise from the idea of establishing an interoperable carsharing system. The major ones are the ones concerning the organizational aspects: How are the relations among operators to be defined? Who could be behind the organization of such an interoperable network? Nevertheless, technical and economic factors are as well to be considered: Which are the technical requirements needed to harmonize and enable an interoperable system among operators? Are fees to be set for using this interoperable service?

Carsharing seems to be appropriate to fulfill the gap between the mobility offer and demand, considering that the offer that only takes public transport into account is not adequate to satisfy some of the actual user needs. Moreover, through the enablement of interoperability among carsharing operators a common mobility offer can be developed, which takes into account public transport and shared-based transportation modes.

Telematics and wireless connectivity have transformed what used to be purely mechanical vehicles into electronically controlled transportation and mobile communications devices. Vehicle performance data is now transmitted over the air to external computers where it is analyzed. Navigation systems allow for monitoring of vehicle location and route history (Lawson, et al., 2015).

Using this technology, new carsharing business models have been developed. Moreover, thanks to telematics real time data can be sent to a central operator and analyzed to calculate intermodal trips between the different modes of transport.

Intermodality could be a key factor for developing a fully functional and sustainable transport network. In order to accomplish intermodality we need first to make the present transportation modes

fully interoperable to find synergies among them. Therefore, enabling interoperability in carsharing would help to build an attractive and sustainable mobility offer.

1.2 Objectives and Research Question

The goal of the master's thesis is to conceive a solution that enables clients of one carsharing provider to use cars from other carsharing companies. As a case study, the City of Munich and the different carsharing providers will be analyzed and the feasibility to implement such an "interoperable system" will be assessed. In Munich there are currently seven different carsharing providers, namely: DriveNow, Car2go, CiteeCar, Flinkster, STATTAUTO, Stadtteilauto and Drive-Carsharing each of them operating independently. In order to use the cars offered by the different companies, one must be client of each of them and get a device, member-card or smartphone application in order to be able to get access to a car.

For the implementation of such an interoperable model for carsharing many challenges have to be overcome. For example, the technology of the different carsharing companies used to book and unlock the vehicles has to be compatible. In this way, direct clients of a particular carsharing provider can use cars from other carsharing companies without the need of being a client of the second one. Furthermore, organizational aspects between different companies have to be defined. Another issue, especially in Germany, is privacy. Companies have to be careful when managing user data in order to protect their clients and make them comfortable to use an interoperable service.

Thus, the question of this master's thesis is: "How can a system, which enables users to rent cars from more than one carsharing company with a single registration, be implemented?"

1.3 Methodology

The first section of this master's thesis is the theoretical background that enables the comprehension of the objectives to accomplish. Firstly, the concept of carsharing is introduced (chapter 2). Hereby, a definition of carsharing is given as well as the principal characteristics of this shared form of mobility. Then the principal benefits of carsharing are shown and the principal business models of carsharing are explained.

Moreover, the German carsharing market is analyzed to understand the paramount importance that this form of mobility has in the country. With the purpose of contextualizing this master's thesis a description from Munich has been made with special attention to the public transport structure of the city. Furthermore, literature research has been done to describe the factors that determine the success in a city and have been used to justify why carsharing has been so successful in this city.

Thereafter, a brief reminder of the theory of Networks is given and it is explained why carsharing vehicles count as networks goods, while pointing out the major benefits and threats of interoperability in carsharing (chapter 3). In this way, through the analysis of network goods it has been possible to justify why interoperability would be beneficial for the carsharing world. Finally, the best practices to enable interoperability in carsharing in Germany are shown (chapter 4).

Once the literature has been reviewed, an introductory chapter explains the terminology that is required to understand the interoperable model. For developing this model the tools of the traveler information services industry has been used. Therefore, the most relevant aspects of it are explained (chapter 5).

At this point the carsharing situation in Munich is evaluated from two differentiated levels (chapter 6): the Framework Architecture and the Reference Architecture. In the Framework Architecture the overall structure of carsharing is considered, whereas in the Reference Architecture the processes of carsharing from the point of view of the customer are analyzed.

The Framework Architecture gives the tools to identify the principal elements of the carsharing operators and enables the definition of the relations among them in order to settle interoperability. Thereby, an analysis of the present situation of carsharing in the city of Munich is developed. Thereafter, the likeliest implementation scenarios for achieving interoperability among the carsharing operators in the city of Munich are proposed and analyzed. In this way, a qualitative analysis is made in order to choose the best implementation scenario.

The Reference Architecture describes the different processes that users undergo when using the carsharing services. Through this description the carsharing operators in the city of Munich can be characterized. A summary of the principal carsharing operators of Munich is shown taking these processes into account. This enables the comparison of the operators in order to find a common ground to implement interoperability among them.

Accordingly, all the processes of the interoperable carsharing model are explained (Reference Architecture) regarding the organizational elements that are involved in each one of those processes (Framework Architecture). The organizational structure of this model follows the one of the chosen scenario in the previous section (Framework Architecture).

At this point, the results from the interviews to the experts are shown (chapter 7). It is vital to understand that this interviews where the product of an iterative process. A first model was proposed and then with the feedback obtained from the first interview, substantial changes were made to the model. Thereby, an enhanced model was presented to the following interview and as a consequence the questions made to the following interviewee were altered.

With all the material gathered from the interviews with the experts and with all the information obtained from the analysis of the carsharing situation in Munich, the final results on the model are shown (chapter 8). In this section the model is further detailed and defined.

Finally, a concluding evaluation is given to remark the strengths and the weaknesses of the developed model (chapter 9). Thereby, the necessity on further research is discussed and a summary and outlook of the most relevant findings of the Thesis is presented.

2 Theory of Carsharing and Context

In this chapter the basic theory of carsharing is shown. This section is organized in four subsections. In the first one, a general definition of carsharing is given. In the second one, the main benefits of carsharing are pointed out. In the third one, the types of carsharing are explained. Lastly, a final conclusion of the chapter is made. The information of this chapter is mostly based in the following works (see (Sullivan, et al., 2005), (Le Vine, et al., 2014) and references within).

Moreover, this chapter sets the context of the present master's thesis. Once the basic concepts of carsharing have been reminded, it is interesting to situate the environment in which the analysis is implemented. First and foremost, a description of the German carsharing market is given in order to understand the magnitude of carsharing in the country. Moreover, the free-floating and stationed-based models are compared to identify the statistical differences with one another. Thereafter, quantitative data of the city of Munich is shown and a description of the public transport network is given. This information is going to set the basis to assess the implementation of carsharing in the city. Consequently, the factors that determine the success of carsharing are going to be explained and with the previous data the performance of carsharing in the city of Munich is going to be judged.

2.1 Definition of Carsharing

Carsharing is a model of car rental that allows people to use a car when needed, without the drawbacks that car ownership entails. It is a form of transport by which several people in turn make use of one or more collective cars. The car fleet that is shared among users can be either profitable or non-profitable and it can differ in structure and size. According to (Sullivan, et al., 2005) the essential features of carsharing are as follows:

- Short-term rentals: Vehicles can be rented by any period of time, but is normally worthier for short-term rentals, in opposition to traditional car rental. Usage is sometimes spontaneous and in some cases reserved in advance.
- Self-accessing: Reservation, pickup and return are self-managed. Keyless access is typically, though not all carsharing services have the in vehicle telematics that can permit it.
- Different vehicles for different uses: Most carsharing operators have a varied fleet. Members can reserve a big vehicle, a pick-up truck, or small, fuel-efficient cars.
- City-based, decentralized vehicles: Vehicle locations are distributed and able to find within the area of service. Successful carsharing implementation is normally associated with areas that have a high density of population, such as city centers or university and other campuses.
- Integrated costs: Fuel, insurance and maintenance costs are included in the costs. The cost of the carsharing service is proportional to its usage. Usage is billed in time increments of minutes or hours, and sometimes also on the basis of distance travelled. Users may be incentivized to re-fuel a carsharing vehicle through an additional increment of time to use the car.
- Admission and membership: Users are members and have been pre-approved to drive (once a payment mechanism has been established and their driving ability has been checked). There may be a single registration fee or an annual fee for using the service.

As a conclusion it can be affirmed that carsharing is therefore attractive, for users that use only the car on particular occasions or for users that would like to hire a particular car, which would fulfill a service that their own car cannot.

2.2 Benefits of Carsharing

According to (Sullivan, et al., 2005) carsharing brings a broad range of transportation, land use, environmental and social benefits for members, non-members and the wider community. The mission of carsharing leads to actions aimed at decreasing individual car ownership, reducing vehicle distance travelled, improving urban land use and development, providing affordable access to vehicle for all citizens as well as motivating the increase of modal split of the not motorized modes of transportation while reducing the emission of greenhouse gases. Some of the most notable benefits include (see (Sullivan, et al., 2005) and references within):

- Reduced vehicle Travel and Congestion: All the carsharing members that sell their car drive less. They have a car available for use whenever they need it and most important they use it only when it is the best alternative. Being the full costs of driving shown by carsharing, its members are motivated to drive less. Variable costs in carsharing are 2-10 times higher than for a personal automobile (Online TDM Encyclopedia, 2010). Most studies suggest that Carsharing typical results in a net reduction in per capita driving among participants that averages 40-60%, but this varies depending on the demographics of participants and the quality of travel options in a community (Lovejoy, et al., 2013).
- Emission Reductions: According to (Shaheen, et al., 2004) by encouraging people to drive less carsharing also helps reducing emissions of greenhouse gases and other pollutants. These benefits can be amplified when its members are able to pick the right car for the right occasion. Instead of owning a SUV for going on camping once a year, carsharing enables its members to access a range of different vehicles, a tiny car for trips around town or pick-up trucks for heavy loads. Additionally, most carsharing operators have fleets with fuel-efficient cars (including hybrid and electric cars), while the cars that their replace tend to be old and more polluting (less efficient).
- Promoting public transport: As members drive less, they use to travel by public transport or more sustainable ways of travelling like walking or by bicycle. Carsharing fosters intermodality as well, as members take public transport to a station next to their destination, and make the first of final part of their trip by carsharing.
- Reduced transportation costs: Carsharing can provide tremendous cost savings to families who need occasional access to a vehicle, and can therefore make automobile use more accessible to low-income households. It can also be an alternative to owning multiple cars for households with more than one driver. Carsharing is generally not cost-effective for commuting to a full-time job on a regular basis. Many studies have estimated a distance between 5.000 – 15.000 km as the breakeven point between finding carsharing cost-effective or not in comparison to car ownership (Spencer, 2015). This range depends basically on local context and the business model being considerate.
- Less land need for parking: Carsharing is a proven strategy to reduce the demand for parking. Independent surveys consistently show that each carsharing vehicle replaces between 9 and 13 cars (Martin, et al., 2010). Carsharing can then be a cost-effective alternative to building more parking garages, which often cost between 20.000 € – 50.000 € per parking spot (Shoup, 2014). Carsharing therefore allows us the use of the land for higher and better uses like housing and parks, helping to reshape urban areas into a more sustainable form.

2.3 Types of Carsharing

There are different types of carsharing business models and sometimes a single carsharing operator delivers more than one type of these models. It is important to understand the different types of carsharing services as they provide different experiences to its customers. According to (bcs, 2015) there are basically three main types of carsharing business models: the free-floating model, the stationed-based model and the combination of both. It is important to note that there are other types of carsharing organizational models (as peer-to-peer carsharing) that are not going to be explained because are not relevant regarding an interoperable carsharing system for the city of Munich.

2.3.1 Stationed-based Carsharing

This type of carsharing has been best established commercially. Users normally book a car in advance of when they wish to use it, generally by app or through the carsharing operator website. In some of those cases users must specify both the starting time and the duration of the trip they are planning to do. Usage is defined as “Round trip” as the customers are obliged to return the cars to the same place where they were accessed and pay for the whole time between accessing to the car and returning it at the end of the reservation. The vehicles have dedicated parking spaces to allocate them, which in some cases are on the street (which requires a permission from the manager of the street network) and in others are off the street. Regarding the situation of Munich, Flinkster, CiteeCar and STATTAUTO follow this type of business model. The advantages of this system are that its logistics are easier to manage, that it is less expensive, that it can be booked with many time in advance so a car is guaranteed and that international trips are allowed. The obvious trade-off is that its users are offered a lower level of freedom.

2.3.2 Free-floating Carsharing

The free-floating carsharing model permits one-way journeys within a specified geographic zone, in opposition to the stationed-based model. Usage is typically spontaneous and it is whether not reserved at all or only a few minutes in advance. A contractual arrangement with the on-street manager authority is generally required; this kind of agreement requires the payment of an agreed sum so the users have the right to park in almost any parking legal space in the given area. This kind of carsharing model also permits its users to make round-trip excursions. Car2go and DriveNow are the two free-floating carsharing systems in Munich and in Germany. The main advantage of this system is the great degree of freedom that offers to its customers. The drawbacks are that a large initial investment is required to have the system working. Moreover, the prices are higher and the vehicles can only be booked 15 minutes in advance. Lastly, parking places are not guaranteed and cars are not always available (the size of the fleet increases the probability of finding one).

2.3.3 Combination of free-floating and stationed based models

There are some carsharing organizations that are starting to combine the both carsharing business models. Through the combination of the two its users can benefit from the advantages of both depending on the purpose of the trip. The combination of the models is rather interesting to give an enhanced carsharing offer to its customers and meet different demands. Examples of this type of business model are Hannover Stadtmobil or Osnabruck Stadtteilauto. This type of business model shows how big an advantage would be to enable interoperability within the city of Munich.

2.4 Carsharing Market in Germany

In order to set the context of this master's thesis, the German carsharing market is summarized. The carsharing market in Germany finds itself in a developed and mature situation that gives more relevance to the study of interoperability. The data from this section has been obtained from the Bundesverband CarSharing bcs (German carsharing association) (see (bcs, 2015) and references within).

If the number of carsharing users is compared among the countries of Europe it is easy to understand the vital role that this form of mobility has adopted in the country, as it can be observed in the Figure 1 (the data on year 2015 in other countries was only found for Germany). In Germany the number of carsharing users has already surpassed one million users: 1.040.000 users as of 1st of January 2015, from the circa 150 carsharing providers in the country. It represents a growth of 37,4% compared to last year. That means that 1,5% of the population that hold a driving license are users of a carsharing organization, more than in other European countries but still with a market-share to exploit.

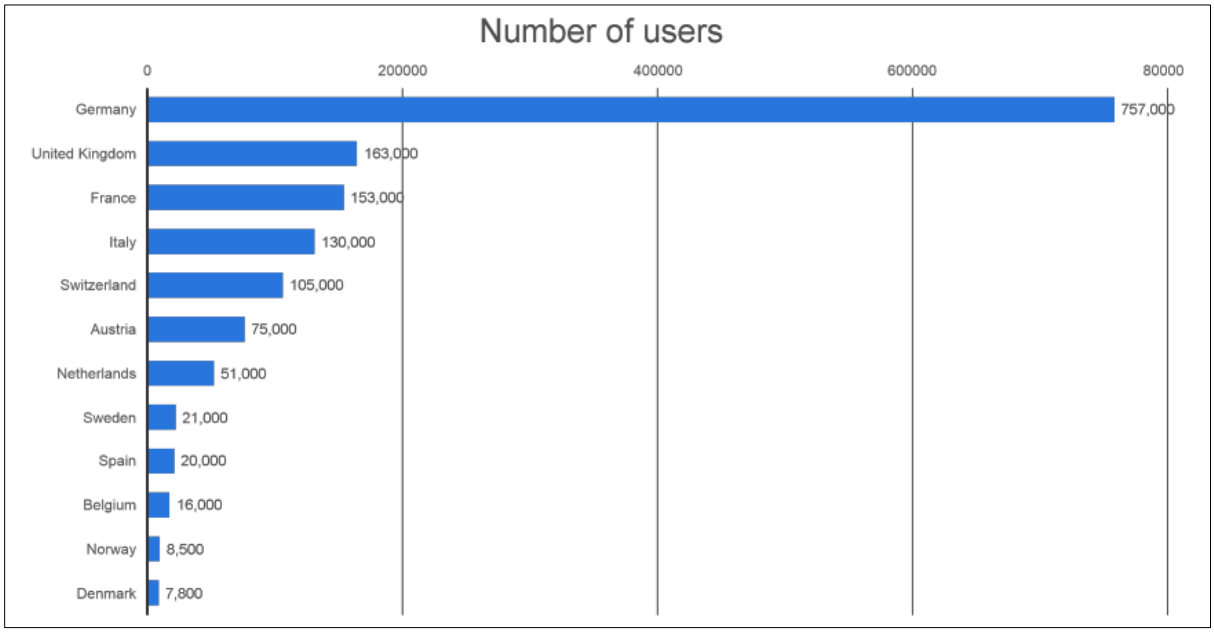

Figure 1: Number of car sharing users in Europe as of 01.01.2014, by country. Source: Frost & Sullivan.

Looking closely at the business models, the free-floating organizations have gained a higher number of customers in comparison with the stationed-based. The number of users has grown from 437.000 to 660.000. The growth is not as large as the previous year but it has still presented a 51% growth. However, the number of free-floating vehicles that are this year available is 6.400 (only 2,4% higher than last year). The growth of users has then contributed to better occupy the vehicles at hand. The number of users per car has grown from 1:70 to 1:103 in the last year.

The number of carsharing users from the stationed-based providers has also experienced a significant growth, from 320.000 to 380.000 that represents a growth rate of 18,8% compared to last year. From the beginning of 2015, there are 9.000 vehicles available, 1.300 vehicles more than the previous year. The ratio of users pro vehicle has grown from 1:41,6 to 1:41,8. This fact shows that the usage patterns of both models are significantly different and that the number of available vehicles grows at the same speed than the number of users. All the data from the carsharing growth in Germany in the 2014 year has been summed up in the Table 1:

	Stationed-based car-sharing	Free-floating carshar-ing	Total
Number of users	380.000 Growth 2014: 60.000 (18,8%)	660.000 Growth 2014: 223.000 (51,0%)	1.040.000 Growth 2014: 283.000 (37,4%)
Number of vehicles	9.000 Growth 2014: 1.300 (16,9%)	6.400 Growth 2014: 150 (2,4%)	15.400 Growth 2014: 1.450 (10,4%)
Number of Stations	4.600 Growth 2014: 700 (17,9%)	-	-
Ratio Users per car (2014)	41,8 (41,6)	102,9 (69,9)	-

Table 1: Carsharing growth in Germany in year 2014. Source: bcs, as of 1st of January 2015.

It is as well worth to consider the evolution and development of both business models. If we look at the Figure 2, the patterns of usage of these two modalities can be observed. It is possible to see that carsharing in Germany began to be remarkable in Germany around 1997 but it was actually founded in the late 80's when carsharing was only conceived in its stationed-based form. This modality of carsharing has steadily increased in its number of vehicles and users ever since, maintaining its proportion constant. An increase on the slope can be observed in the last years, probably motivated by the creation of the free-floating system that has made carsharing rather popular among the population.

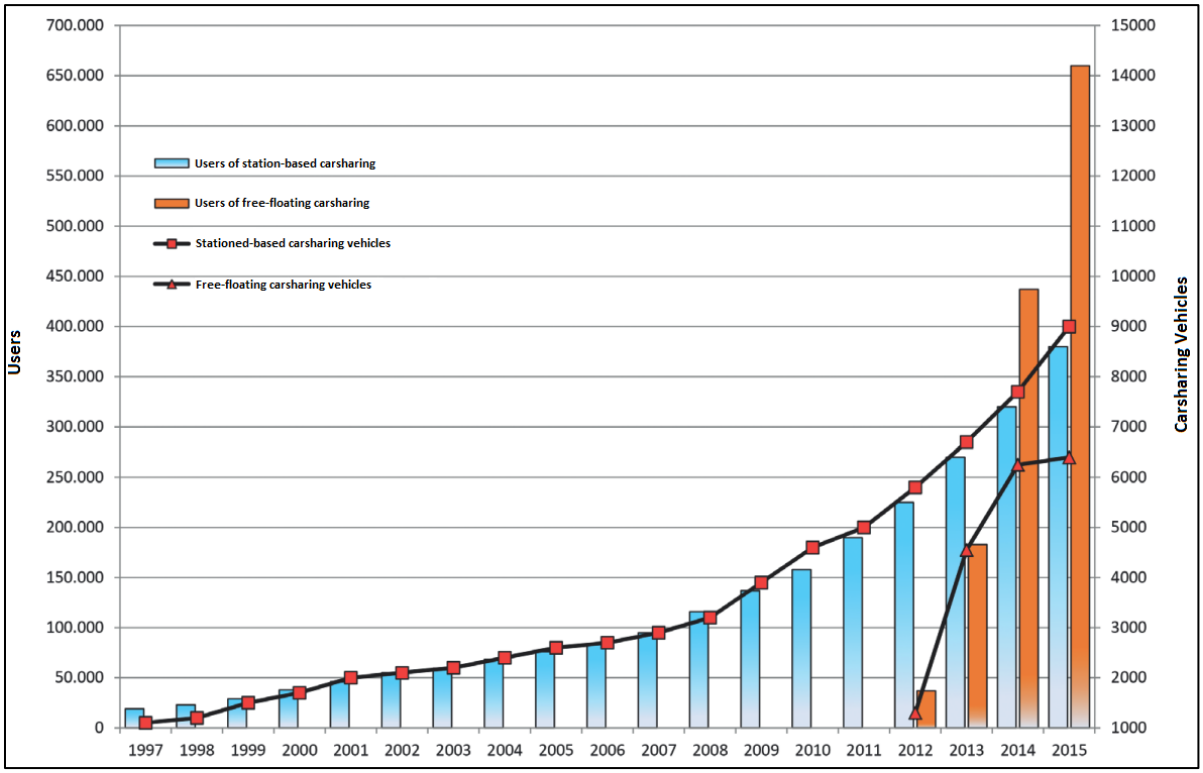

Figure 2: Evolution of the stationed-based and the free-floating models of carsharing in Germany. Source: bcs.

As it can be observed in the Figure 2, the free-floating model of carsharing was conceived in the end of the year 2011 and was introduced in Germany in the year 2012. It is worth noting, the tremendous expansion of this model of carsharing in the last years. Also notorious is the proportion of the number of vehicles and the number of users. This pattern behavior is completely different from one busi-

ness model to the other. There are two main reasons that could explain this phenomenon. Firstly, in the free-floating model the access barriers are normally lower because the registration costs are normally low or inexistent and there is neither a deposit for the insurance nor monthly fees like in the stationed-based model. Secondly, the users of the stationed-based model use the carsharing vehicles a lot more than the users of the free-floating model. Usually, the users of the stationed-based model have taken the decision of stop using their cars and relying regularly on the carsharing service whereas the free-floating users tend to use the service sporadically (Lange-Stuntebeck, 2015).

There is another difference worth commenting from this two business models: the distribution and accessibility of both among the German population. Carsharing is now present in 490 cities and communities as it can be seen in Figure 3 (in all cities where there is a free-floating carsharing system there is also a stationed-based one). Those represent 110 more than last year. Approximately 36,5 million people in Germany have access to carsharing.

The merit of it is mainly because of the stationed-based carsharing model: while free-floating carsharing is only present on the cities with more than 500.000 citizens, the stationed model can spread itself further across the country. The stationed based carsharing model has experienced a constant growth of about 20% every year for the last 10 years. The bcs estimates that this growth will be maintained in the following years.

However, when foretelling the growth rate of the free-floating model, the bcs is a little more forehanded (see (bcs, 2015) and references within). The two main car manufacturers that offer pure free-floating models (Daimler and BMW) proclaim that they have already covered the area of extent that they had planned and that they are not thinking of new offers in the German territory in the near future. The strategy is going to be then to try to acquire new customers in order to strengthen the seven metropolitan regions (where this model is served). If we look at the Figure 2 again, we can observe that the growth curve has flattened (in number of vehicles), after a steep increase in the first years.

The odds are good that this development continues in the next years. Furthermore, the estimates of the bcs are that before 2020 the number of users of carsharing will reach 2 million in Germany (for both models together). In the Figure 3 the main statistics of both carsharing models are shown.

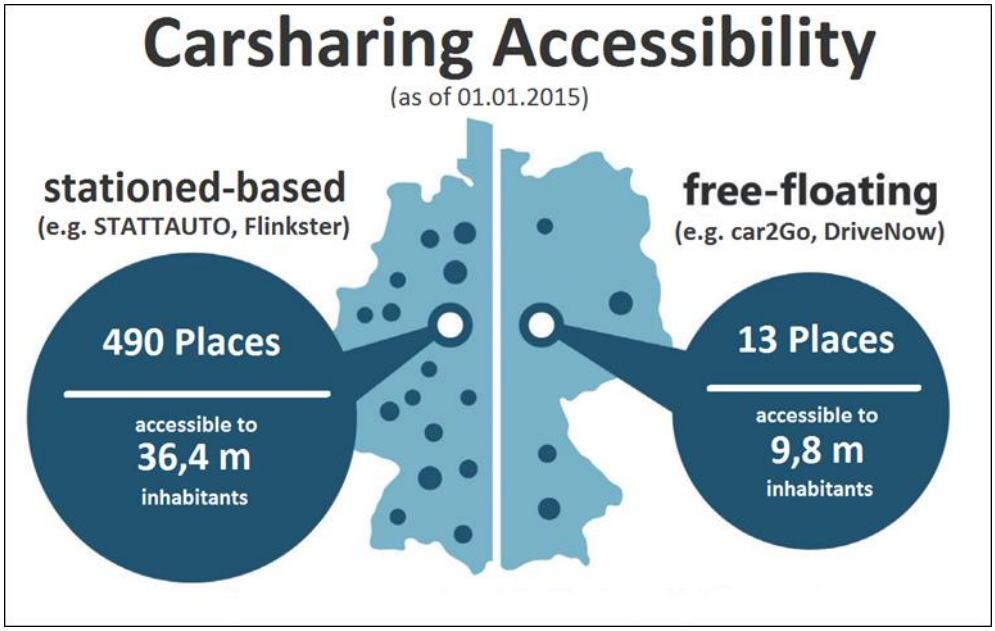

Figure 3: Accessibility of carsharing models in Germany in 2015. Source: bcs.

Last but not least, it is interesting to finish this section with a few conclusions from both carsharing models that have been deduced from the carsharing market, which complement a little the information given on the "Types of carsharing".

The free-floating carsharing model is very attractive. That is because it is very convenient (the users can access the vehicles anytime anywhere), the vehicles are more attractive (because they have a car manufacturer behind them) and it enables intermodal trips with other kinds of mobility offers such as public transport. However, owing to the high initial investment and the compelling economical demands, the service of the two free-floating carsharing providers in Germany is only established in cities with a population higher than 500.000 inhabitants among other strict requirements. This model can only survive when organized by a car manufacturer.

The stationed-based alternative is usually chosen on the basis of economic reasons and of the positive effects on traffic congestion. Only this type of carsharing model lets its users book a lot in advance, which makes that they can rely completely on having access to a car in specific moments. Moreover, this kind of carsharing model provides accessibility to a wide range of German citizens. Nevertheless, the stationed-based model is very popular among regular carsharing users and not so by sporadic users or intermodal travelers. The Table 2 summarizes the advantages and disadvantages of the both carsharing business models.

	Advantages	Disadvantages
Free-floating	+ Convenience (more freedom) + More attractive vehicles + Complements public transport + Final point must not be start point	- Tremendous initial investment - High density requirements - Usage rates are more expensive - Lower car availability - No parking place guaranteed
Stationed-based	+ More economic to implement + Booking a lot in advance possible + Greater accessibility (smaller cities) + International trips possible	- Low degree of freedom - Round-trip is a must - More difficult to do intermodal trips

Table 2: Advantages and Disadvantages of the Free-floating and Stationed-based models.

2.5 Carsharing Market of Munich

Munich is the capital and largest city of the German state of Bavaria, on the banks of River Isar and north of the Bavarian Alps. It is the third largest city in Germany with a population of around 1.5 million and the densest populated municipality with 4.890 inh. per km² (Landeshauptstadt München, 2015). The Munich Metropolitan Region is home to 5.8 million people (Metroplregion München, 2015). In the Figure 4 (following page), we can see the situation of Munich in both the German and Bavarian contexts. In the second picture the dark blue area represents the "Oberbayern" region that is one of the seven regions in which Bavaria is divided.

The data that is most relevant for the present master's thesis is the description of the public transport network. The correct implementation of carsharing is always related with a strong mobility network. In the city of Munich, the MVV (German for Munich Transport and Tariff Association) is the transit authority of the city. Its jurisdiction covers the city and its surrounding area, responsible for the Munich S-Bahn commuter trains operated by the Deutsche Bahn; and the Munich U-Bahn underground, the Munich tramway, and buses operated by the MVG (German for Munich Transport Company).

In Munich the shared forms of mobility are rather popular as well. In the city of Munich there are mainly seven carsharing operators, two of are the free-floating (DriveNow and car2go) and the other

five are stationed-based (Flinkster, CiteeCar, STATTAUTO, Stadtteilauto and Drive-CarSharing). This is an indicator, which shows that it could be rather beneficial to foster carsharing in the city.

Moreover, the bikesharing systems are as well popular in the city and the principal operators are the Deutsche Bahn and MVG, respectively: Call a bike and MVG Rad. Furthermore, the bicycle infrastructure is very extensive. Furthermore, the cycling network of Munich has more than 1,200 km in length, which represents more than half of the total length of Munich's road network (Landeshaupt München, 2015).

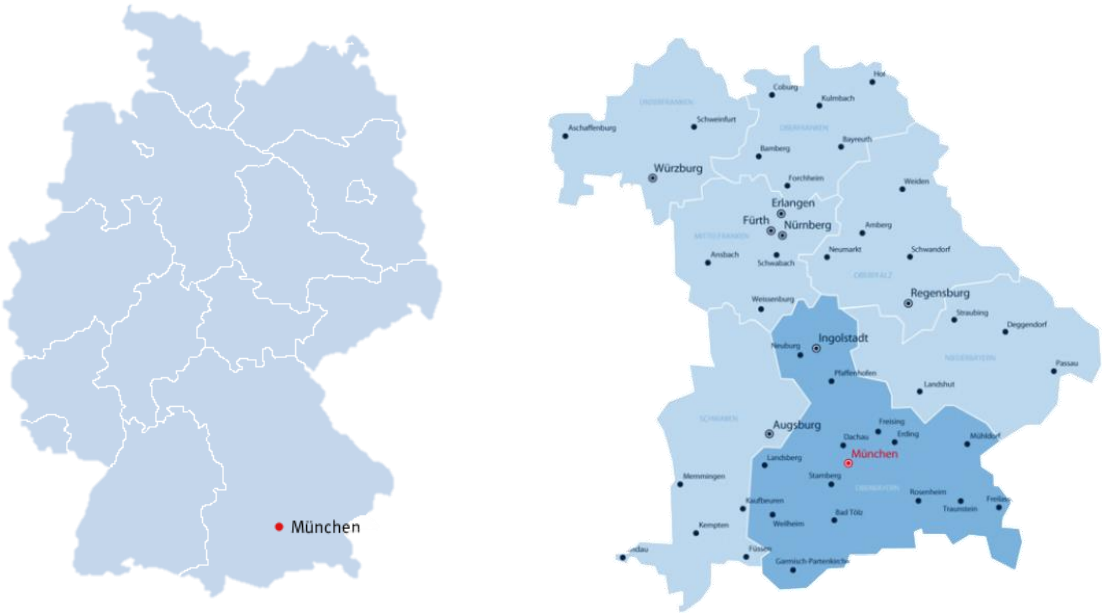

Figure 4: Situation of Munich in the Germany and Bavaria. Source: München Reiseführer/Primemaps.

Now the factors that justify the success of carsharing in an area are going to be analyzed. For the drafting of this part of the chapter literature research has been done in order to find which factors influence the success of carsharing due to its environmental context (see (Seign, et al., 2012) and references within). Thanks to the information provided from the city of Munich, it is possible to understand the success of carsharing in it.

For the adoption of carsharing the environmental context plays a crucial role. The first environmental factor to bear in mind is the population density, which is of a great importance. As it will be later analyzed, this factor varies from the free-floating system to the stationed-based one (the stationed-based system requires a lower density population to be justified in comparison to the free-floating system).

As we have seen the city of Munich has a high density of population that justifies the high presence of carsharing in the city. Another relevant factor is the main movements within an area. Thereby, carsharing is more successful in areas with a mixture of uses and is predetermined to urban areas.

The availability of multimodality is decisive for the success of carsharing. That is so because the idea of carsharing is based on not relying on private cars anymore. Therefore, reliably and cost-effectively mobility needs have to be met by using many modes of transportation. This includes the quality of public transportation, cycling infrastructure and walkability of a certain area.

The last two imply that the topography of a city plays a role as well. The topography of Munich is flat so it is very convenient both for bicycle riding and walking. We have seen in the previous subchapter that both the public transport infrastructure and the bicycle infrastructure are highly developed, which strengthen the presence of carsharing in the city.

A factor that can hinder the use of the private car, and foster the use of carsharing, is expensive or limited parking. The same is true for high traffic density regions or tourism regions where the visitors have no access to their own car. In Munich the traffic density is very high (INRIX, 2010). Moreover, its numerous architectural attractions, international sports events, exhibitions, conferences and Oktoberfest attract considerable tourism (Landeshauptstadt München, 2015). Last but not least, Munich is a traffic hub with international, national and local connections. Therefore, the number of visitors both for work and leisure justify even more the strong presence of carsharing in the city.

2.6 Summary of the Theory of Carsharing and Context

In this second chapter the concepts regarding carsharing have been explained. First of all, the main traits of carsharing have been explained as well as the main benefits of using carsharing and the most relevant types of carsharing. From the theory shown in this chapter, it can be concluded that carsharing can help enhance the mobility offer through a more sensible way of using the car.

Moreover, some carsharing organizations have demonstrated that the combination of the free-floating and stationed-based types of carsharing is interesting. Through interoperability the various business models would be combined and the users could decide which to choose depending on their necessities accomplishing the same advantages.

Furthermore, the context of this master's thesis has been set. First of all, statistical data of the German carsharing Market has shown the magnitude and importance of this form of mobility in the country. Moreover, it has been further seen the difference between the free-floating and stationed-based business models and the importance of their combination.

After that, the carsharing market in Germany has been dimensioned with statistical data from both types of carsharing business models. Furthermore, a little bit more of information has been given on both business models and their main advantages and disadvantages have been summed up.

Then, relevant information of the city of Munich has been given. In this way it has been possible to see the impact that carsharing has had in in the city. Lastly, this data has been compared with the factors that make a city appropriate for the development of carsharing. Thereby, the success of carsharing in the city of Munich has been understood.

3 Theory of Networks

In this section literature research has been carried out in order to try to justify the implementation of interoperability in carsharing. The reason for analyzing the theory of networks is because it provides a tool to evaluate the benefits and drawbacks of interoperability. First of all, some considerations in regard interoperability in carsharing are made. Then the concepts network effects and network goods are explained.

Thereafter, the main factors that influence the establishment of interoperability are analyzed. Lastly, some conclusions are made taking into account the particular conditions of this master's thesis. The most relevant literature for the redaction of this document has been (Van Hove, 1999).

The lack of interoperability hinders the use of carsharing as an important element of the modern mobility network. There is the risk that carsharing does not succeed as a transport mode within this network if interoperability among operators is not enabled. Besides, interoperability adds the ability for customers to access more carsharing providers. In this way, the size of the overall carsharing network increases because the users can access now not only a single carsharing network but the summation of all of them. Then the size of the new interoperable network is the aggregation of all the customers and vehicles of the involved carsharing operators.

There are many studies that assess actual transaction data to show that there is a positive network effect that applies to payment systems (such as ATMs) and for telecom networks (referred to as the positive effect of network externalities) (see (Van Hove, 1999), (Ackerberg, et al., 2006) and references within). However, joining an interoperable network can have negative effects as well, due to the threat of substitution and increased competition (Clark, et al., 2014).

When applied to carsharing, interoperability would lead to an increase of the use of the service (because the carsharing offer becomes more attractive for potential customers), which in turn leads to increased revenues (because more users use the service more often).

The patchwork of more than 7 carsharing operators in Munich seems untenable in the long run. Therefore, making the schemes of these operators interoperable appears as a matter of time in a mature carsharing market such as the one in Munich.

With the aim of analyzing if the implementation of interoperability in the carsharing world is beneficial or not, it is needful to consider the network externalities theory. In this section the definition of network goods will be briefly reminded, why carsharing services can be considered as network goods and which effects do network externalities have upon carsharing.

3.1 Network Goods and Network Externalities

Many goods and services are subject to network externalities. A network externality is the effect that one user of a good or service has on the value of that product to other people. When a network effect is present, the value of a product or service is dependent on the number of others using it. In other words, a network externality exists when the value that a person obtains from a certain product increases as the size of the network associated with the product increases (Saphiro, et al., 1999).

Typical network goods have little or no value in isolation; they derive their value from the connection with other goods. A salient example of this type of goods is social networks: every joining user enhances the value of the network to existing users because the number of people, to whom they can interact, increases. (Van Hove, 1999).

Carsharing is an example of this type of goods but with a notable difference with the social network example: every additional user does not directly affect the users of the carsharing network. However, there are indirect network externalities: when the number of users increases so does the number of cars and the areas that are covered with the carsharing service enhancing the service for all users. The utility that users perceive from consuming a network good depends on the size of the network and their expectations about future network sizes.

Therefore, when the size of a network increases (because of the enablement of interoperability among operators in carsharing for example) so does the perceived utility that the users have of the system.

3.2 Interoperability of Network Goods

When the network externalities are large (meaning that an increase on the number of users that join a network increases significantly the value of the network) the strategic decision of establishing interoperability among network products is of a high relevance (Katz, et al., 1985).

When taking this decision into account an enterprise has to weigh up two opposing effects on its profitability (Economides, 1991). The positive effect is that once the networks are unified the perceived utility will be that of the complete network and not of every individual network. Therefore, it will increase the customers' willingness to pay. This is the so-called *network effect*. However, there is a negative effect associated that is caused by increased competition because product differentiation is reduced and because consumers are less likely to be locked into a firm's service. This is called *substitution effect*.

The network effect (size of the benefit) from moving to interoperability depends on the strength of the network externalities. If these are large, the users' willingness to pay will increase (for example more eagerness to access/use the system). The network externalities of carsharing are intuitively large: if new users join the system, more cars will be available.

Thereby, user convenience will be enhanced because the distance to nearest car will be reduced, and the whole service will be more attractive. In this way the benefit of making the system interoperable is supposedly high. According to (Barth, et al., 2004) interoperability in carsharing would likely result in higher customer satisfaction and lead to greater market penetration of this and other modes of transport.

As it has already been introduced, joining an interoperable network can have negative effects due to the threat of substitution, as the differentiation of the service would be harder for network operators, as well as increasing costs for implementing and operating compatible systems, because competence becomes tougher. It has to be considered that operators would become better overall substitutes that would lead in turn in to intense price competition between operators.

This trade-off between substitution and network effect is normally analyzed in two-by-two scenarios (Farrell, et al., 1985). In this situation there are two cases that have to be considered. The first case is when the two firms are equal in strength (symmetric case) and the second is when one firm is more powerful than the other (asymmetric case). Interoperability is only to bear in mind when network externalities are strong (in both cases).

Given that externalities are strong enough, in the symmetric case both enterprises will benefit from interoperability. In the asymmetric case, there will be a conflict of interests: the strongest enterprise will oppose to interoperability and the weakest will try to embrace it.

When there are more than two enterprises on the market (carsharing situation of Munich) the analysis of interoperability is a bit more complex because of coalitions. To study this situation it is helpful

to compare it with the ATM networks. In the network externalities literature, there is a relevant model that analyses three banks with ATM networks of equal size that are competitors in the deposit market (Matutes, et al., 1994). A remarkable result from this study, it is that the three banks will never agree on full interoperability: in equilibrium, either partial interoperability or total incompatibility will prevail.

That is because if all banks agree on sharing their networks none of them obtains a network advantage and the only effect from interoperability is to make competition tougher among banks and these are not capable of internalizing the positive network externality, which is completely perceived by consumers. The outcome of partial interoperability or no interoperability depends again on the strength of network externalities (if the effect that the incoming users have on the joined network are high, that means that the externalities of the network are high and then the enablement of interoperability is to be expected).

3.3 Summary of the Theory of Networks

The theory of the network externalities shows that when deciding to make carsharing services interoperable, carsharing operators have to weigh the network effect against the substitution one. On the one hand, consumers' willingness to pay increases because the unification of the carsharing network increases the expected utility of the customers; on the other hand, the carsharing operators face more intense price competition because the carsharing operators become better substitutes. However, according to (Hayashi, et al., 2003) there is evidence that, if network externalities are strong, the positive effect is more valuable than the negative impact.

According to (Le Vine, et al., 2014) there is evidence that carsharing networks are increasing, as well as users and shared vehicles. That means that network externalities of carsharing and the benefits of an interoperable carsharing network are increasing as well. It is intuitive to think that the network effect would outcome the substitution one in the city of Munich. However, further studies have to be done to reinforce this conclusion and to determine under which conditions this would be achieved.

It can be concluded that without the presence of other external factors, interoperability among carsharing operators makes only sense when the operators have a similar fleet size (to resemble the symmetric case). If there were only two operators involved that would lead to interoperability (because network externalities in Munich are strong). When more operators are involved is more difficult to predict.

4 Best Practices of Interoperability in Carsharing

In this section the most significant approaches of enabling interoperability of mobility solutions in Germany are going to be explained. First of all, the present and recent relation of Car2go and Flinkster is going to be explained (Flinkster, 2015). Secondly, the approaches of the MVG (German for Munich Transport Company) to try to ground a joint mobility solution (MVG Multimobil) that combines public transport with sharing modes of transport is going to be evaluated.

Thereafter, the polygo card offer, where mobility and other services are united in a single device, is going to be assessed. Lastly, the joint network of Stadtmobil is going to be examined. These implementations show the vital role that interoperability can play to enhance mobility. Furthermore, it indicates that enterprises are interested in interoperability because it is not only crucial for the future of public transport but also because it will bring revenues for the mobility sector and the companies themselves.

4.1 Car2go and Flinkster

Recently, the carsharing operators Flinkster (from the Deutsche Bahn, German railway company) and Car2go (a subsidiary of Daimler AG) have joined forces in order to allow their customers to use both fleets (Flinkster, 2015). They have also partnered with the mobility enterprise moovel GmbH, which is a provider of mobility services from Daimler, in order to manage the organization of both services. Although it is not exactly what is attempted in this master's thesis (just two carsharing providers are being considered in this case), it is a good example to understand what is being done in the field of carsharing interoperability.

With this union they have settled the largest network of carsharing in Germany. With the association of both companies the users have a shared offer of 7000 cars at their disposition (3300 from Flinkster and 3500 from car2go), from which 750 are electric cars according to (Carsharing News, 2015). The strategy that these companies have followed corresponds with the findings from the literature research that has been made on the economics of networks (see third section of chapter 3 regarding the symmetric case example). If just these two players are taken into account they can be compared with the symmetric case.

They have a similar fleet size and a similar number of customers (car2go has 160.000 customers and Flinkster has 300.000, in Germany). On the one hand, for car2go customers can be very helpful from time to time use another type of car for other purposes (they are only offered Smart Fortwo cars in car2go) and profit from more economical prices thanks to the stationed-based business model of Flinkster.

Moreover, for car2go is very attractive to partner with the Deutsche Bahn because of their customer base. On the other hand, for the Flinkster customers the offer is rather attractive thanks to the freedom that the car2go free-floating business model enables. Last but not least, this union in terms of number of clients is as well interesting in order to fight against the enormous competence with DriveNow that has the most number of vehicles and customers in Germany (3800 cars and 500.000 customers).

Moovel is a mobility platform with many affiliated partners basically public transport, taxi, carsharing and bikesharing companies. Through the data of these affiliated partners this app enables the users to calculate many alternatives for travelling from A to B. Users can decide if they want to choose the cheapest, fastest or the most convenient way (lower transfer, fewer walking, proximity to POI (Point of Interest), etc.). The carsharing partners affiliated to the platform are Flinkster and car2go. This cooperation can be seen in the Figure 5 (screenshot of the moovel app and the Flinkster app):

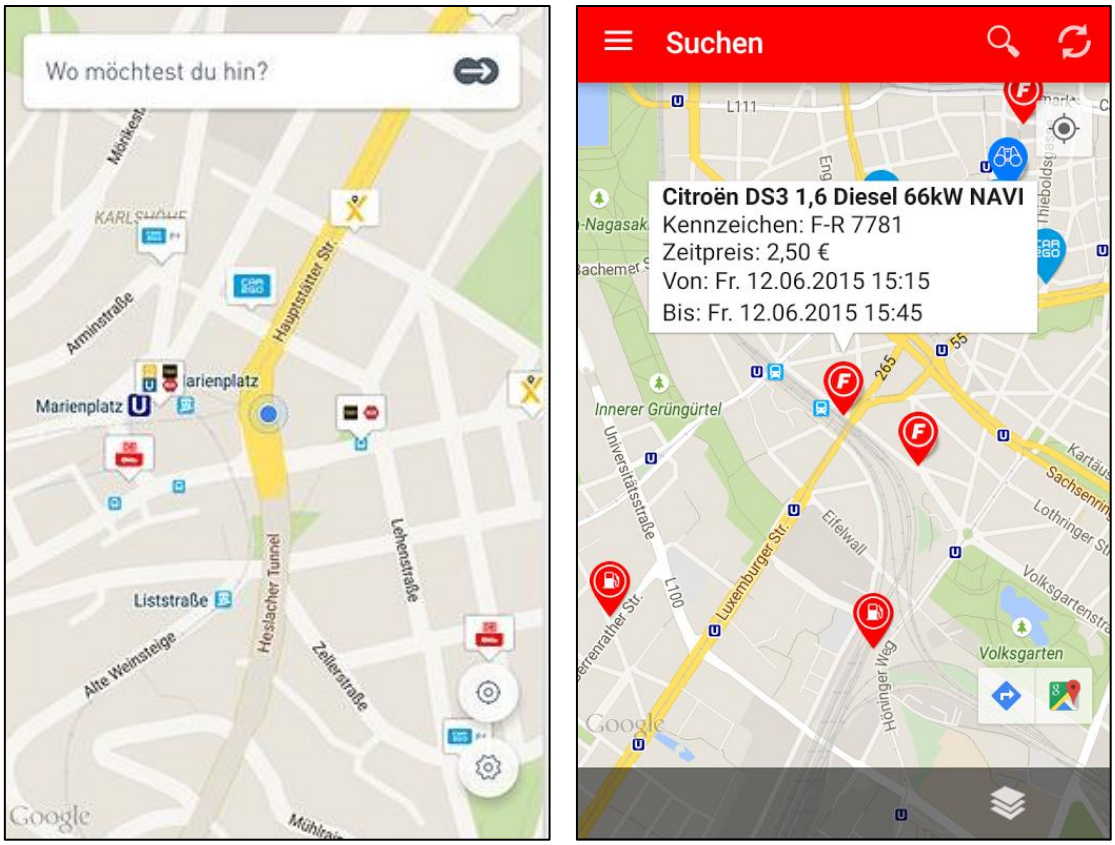

Figure 5: Screenshots of the Moovel app and the Flinkster App. Source: Moovel.

The users of moovel (car2go) can book and use the vehicles from Flinkster, including all the partners that are affiliated to the Flinkster network (through the moovel app). The users of Flinkster can, in turn, book and use the vehicles of the car2go fleet (through the Flinkster app). That means that both users have in Germany 1.000 stations at their disposition (among them all the large ICE stations) across 200 cities with about 3300 Flinkster (which includes those from the affiliated partners, like Drive-CarSharing) vehicles available. They have as well 3.550 car2go vehicles in six conurbations that present a free-floating business model. For the city of Munich that represents about 500 Car2go vehicles (car2go, 2015) and 121 Flinkster vehicles (MVG, 2015).

For the users to access this carsharing network an extra physical registration is not required. The users are able to make an online registration upgrade to the moovel app and through this app book the vehicles of both companies. The users are also able to open the cars through the moovel mobile app. Thus, the complete rental process is done through the smartphone.

4.2 MVG Multimobil

The Münchner Verkehrsgesellschaft (German for Munich Transport Company) or MVG is a municipally owned company responsible for operating public transport in Munich, Germany. It operates buses, the Munich tramway and the Munich U-Bahn (subway). The company is a subsidiary of Stadtwerke München (Munich City Utilities), and a member of the Münchner Verkehrs- und Tarifverbund (German for Munich Transport and Tariff Association, MVV).

Since the beginning of 2014 MVG offers the internet service MVG Multimobil that connects public transport with carsharing (My Muenchen, 2014). On the one hand, all the stations of Bus, Tram and U-Bahn are shown with data about arrivals in real time. On the other hand, the vehicles of the carsharing organizations DriveNow, Car2go, CiteeCar and STATTAUTO are as well displayed. Since the beginning of October of 2015, the app shows as well the position of the new MVG Rad bicycles, which is a new free-floating bike-sharing system of the city of Munich, with 1200 bicycles available

(SWM, 2015). A capture of the website service is shown in the Figure 6, where the MVG public transport as well as the bike and the carsharing alternatives are displayed:

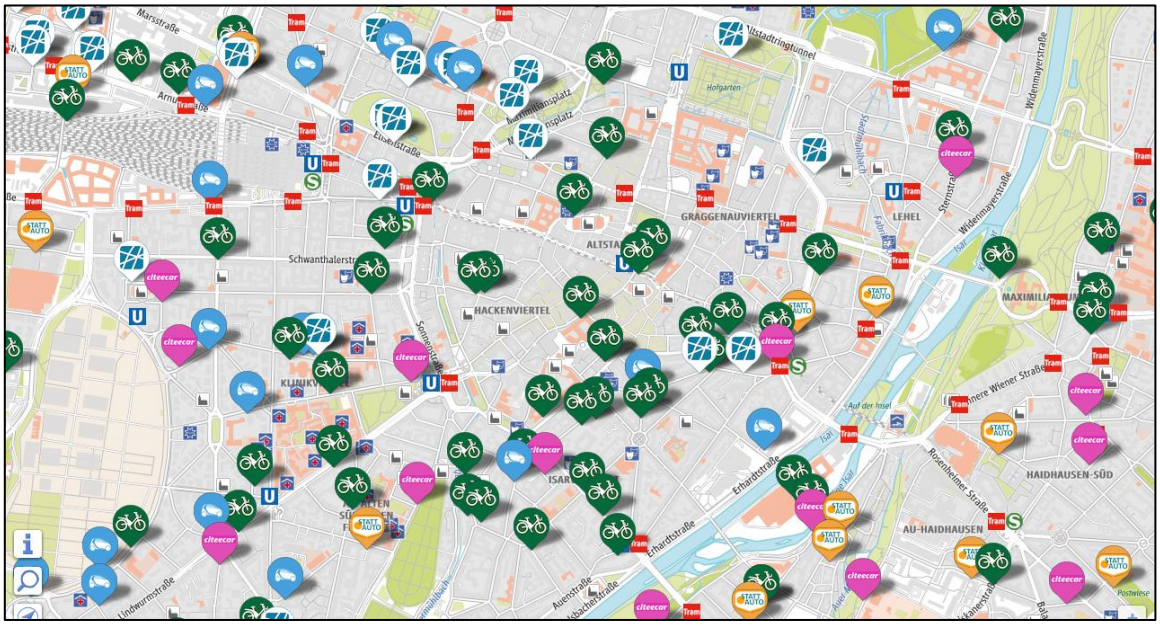

Figure 6: Display of the website service MVG Multimobil in the city center of Munich.

All the carsharing vehicles from the companies that cooperate with the MVG are shown with symbols that show the real-time position of them. The information shown on the website from these vehicles depends on every carsharing operator, but it normally displays: the plate number of the vehicles, the fuel level (or battery level), the address where the car is parked and the level of cleanness. With this information the users have a quick overview of the carsharing vehicles that are available in their surroundings independently of the carsharing operator.

The website shows as well the real-time position of the MVG bicycles and the identification number of them. The bikesharing system is rather convenient for riding through the center of Munich where any carsharing vehicles can be parked. The webpage enables the users to register to the carsharing organizations through a link to their respective homepage. Moreover, the cooperation of the MVG with these carsharing organizations has achieved that the registration costs for the subscribers of the "IsarCardAbo" (which is a year-long subscription to the public transport Network from Munich) are for free.

The strategy of the MVG is to offer a mobility package for its users that is completely interconnected. Not only are they offering an efficient solution for the travelers of the city of Munich but also a sustainable one. The city of Munich is in many lists described as one of the cities with the best public transport cities in the world (BBC Travel, 2013) (Jalopnik, 2014).

4.3 Polygocard

The polygocard is the result from the research project Stuttgart Services from the Stuttgart Region. This research project tries to foster sustainability, through bringing together many mobility partners and other services. This project was requested by the Federal Ministry of Economy and Energy. There are 23 partners that are involved in this project from many different sectors, mainly: Public Transport, Software, Mobility, Industry, Urban Services, and Science Consulting. The leader of this consortium lies on the Sttutgarter Straßenbahnen AG (SSB), which is the principal public transport operating company in the German city of Stuttgart (SSB, 2015).

The polygocard is a device that enables the access to different forms of mobility and other types of services. Through the associated carsharing partners, it enables as well a primary form of interoperability (in carsharing and intermodality among services). However, the users must register and accept the terms and conditions of every carsharing organization and pay all the registration costs.

First of all, it is important to remark that are other services in Germany that are trying to achieve similar objectives to the ones of the polygocard, like for example the "switchh" platform in Hamburg (Switchh, 2015) or the CarJump platform in Berlin (CarJump, 2015). In this document the polygocard has been selected, because the MRK Management Consultants GmbH, where this master's thesis has been written has been an active partner of the Stuttgart Services (Stuttgart Services, 2015) and the polygocard (POLYGO, 2015). In means of simplicity, only this service is explained because the background idea is the same.

The objective of the card is to be the access device to many services within the city of Stuttgart. These services are summed up in the following categories. Every user can choose to which services wants to register and then has to sign in to every single service online (and for some of them show documentation in the corresponding offices).

- Public transport: the users can use the card for validating the year subscription for the VVS (regional transport cooperative of Stuttgart) as well as a token for the public transport network.
- Carsharing offers: the users are able to unlock and use the cars (in Stuttgart) of the associated partners. The partners that are associated are Car2go, Flinkster and Stadtmobil.
- Bikesharing offers: the users are able to access the bicycles from the partners that are associated in the offer. The bikesharing companies that are associated are: Call a bike (stationed based bikesharing system of Deutsche Bahn, with some electric bikes) and Nextbike (stationed based).
- Charging Stations: through the partner EnBW (energy supplier company in Stuttgart) the users can charge their electric cars with their polygocard.
- Payment function: the users can upload credit to the polygocard thanks to the BW Bank (Baden-Württembergische Bank) and use the card as a payment method (up to 100€ per month).
- Parking: thanks to PBW (parking association of Baden Württemberg) the users can park in the associated garages.
- City Services: the city of Stuttgart offers also many services such as book rentals in public libraries and paying in municipal offices for example.

Figure 7: polygo device to access the services associated with the polygocard. Source: polygo.

4.4 Stadtmobil Network

The carsharing network stadtmobil offers a stationed-based carsharing system. An association of many carsharing providers forms the network. First of all, it is composed by the different stadtmobil organizations. They are completely independent firms that have a cooperation agreement and share a central operator, which is organized by the software enterprise cantamen GmbH (cantamen, 2015). The stadtmobil enterprises are named after the city they operate in, specifically: stadtmobil Berlin, stadtmobil Hannover, stadtmobil Karlsruhe, stadtmobil Rhein-Main, stadtmobil Rhein-Main, stadtmobil Rhein-Neckar, stadtmobil Rhein Ruhr and stadtmobil Stuttgart.

Thereafter, the stadtmobil association has also other carsharing partners that are associated to their network. With regard to their association, there are two types of partners: the ones that are operated by the software enterprise cantamen and the ones that use their own operator. In the first group we have the following carsharing enterprises: teilAuto Biberach/Riß, StattAuto, Stadtteilauto, ConfiShare, stadt-teil-auto Göttingen, stadteilauto Osnabrück, teilAuto Tübingen (stadtmobil, 2015). The carsharing organization that uses its own operator is cambio CarSharing. All of this carsharing partners offer the stationed-based carsharing business model and some of them the combined model (stationed-based with free-floating).

Through all this associations and partnerships the stadtmobil network has around 3400 vehicles and more than 120.000 customers in more than 100 cities (Scherler, 2015). The partners of the network have assigned cities for operation, where the other partner cannot operate to avoid competence. There are then other cities such as Berlin or Hamburg, which are free to operate. In the Figure 8, we can see the booking system of Stadtteilauto Osnabrück and all the possible carsharing providers to choose from. It is as well possible to see that this is a combined carsharing business model because users can choose the flow-k option (free-floating model) or the different options for the stationed-based model.

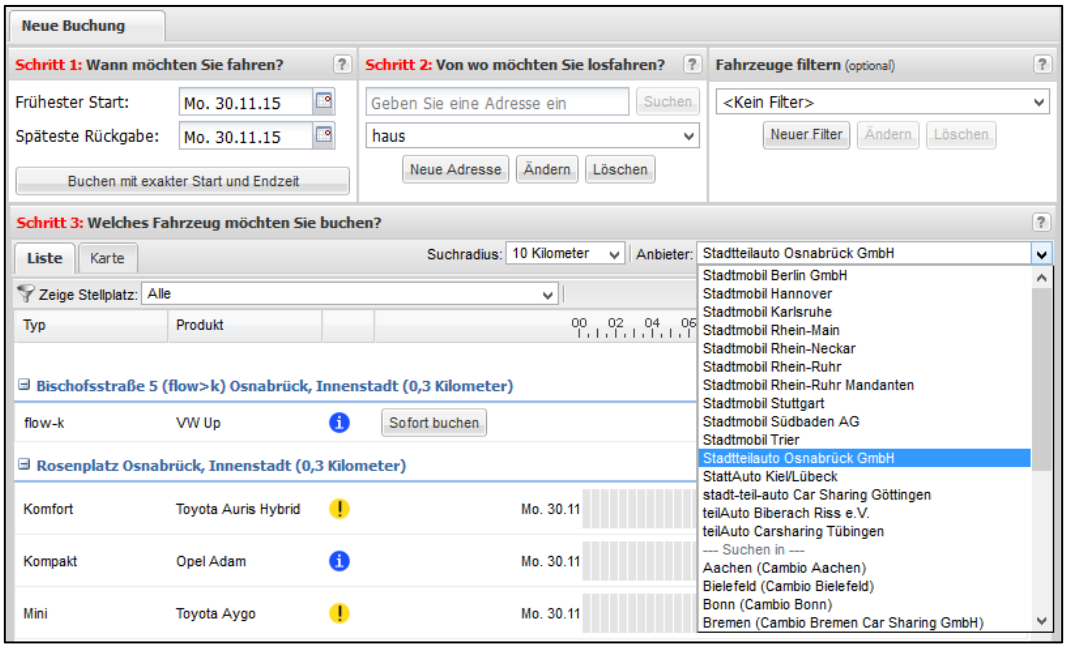

Figure 8: Software system of the Stadtteilauto Osnabrück GmbH. Source: Stadteilauto Osnabrück.

4.5 Summary of the Best Practices of Interoperability in Carsharing

With the union of car2go and Flinkster an important objective has been achieved: the creation of a large carsharing network that combines the free-floating model with the station-based model and that it is connected to the public transport facilities thanks to the Deutsche Bahn. That enables the carsharing users to have a great flexibility when travelling that is exactly what they are looking for. The problem of this solution is that it is high improbable that all the carsharing companies of Munich accept to partner with Moovel due to the high competition among operators. That is why it is not a sufficient solution for the fulfillment of the objectives of the present master's thesis.

MVG is making steps towards a joint mobility offer that enables the user to do intermodal trips with real time information. However, in the carsharing aspect, and because of the high agreement costs they are far from reaching interoperability (especially with Flinkster which is a direct competitor). Nowadays, the users that download the MVG Multimobil app are not able to use other carsharing operators without registering. Therefore, in this document some proposals are made in order to determine how total interoperability among carsharing operators could be implemented.

The idea of the polygocard is rather interesting. First of all, it is offering an initial form of interoperability of carsharing (among others). Secondly, the goal of this master's thesis is to define an interoperable model of the carsharing operators in the city of Munich. Once this objective is reached, the next logical step to follow is to provide a common mobility offer for the city of Munich. The combination of sharing modes of mobility with public transport is rather compelling because they help interconnect the public transport network in a flexible and sustainable way. However, this option is not enough because users still have to register to all carsharing operators and pay the registration fees. Moreover, all the carsharing organizations are not taken into account.

The presence of a network like the Stadtmobil one in the carsharing world is vital to understand that it is possible to establish interoperability among different operators and that it already exists. The problem is to overcome the high agreement costs among carsharing organizations that operate in the same city. This example shows that such an interoperable network is technically possible and that brings already many benefits to its customers.

5 Travel Information Services

This chapter is going to define the Travel Information Services Industry that will provide the tools to describe the proposed interoperable model. This chapter is divided in 2 subchapters: In the first one, the terminology used to carry out the analysis of the implementation of interoperability is presented. In the second one, the two architectural levels, which are going to define the interoperable model, are explained.

Once the literature research has been done it is now possible to start the analysis of the integration of carsharing interoperability among operators in the city of Munich.

As it has been shown in the Carsharing Market of Munich chapter, in the city of Munich there are mainly 7 carsharing operators: DriveNow (490 vehicles), Car2go (500 vehicles), CiteeCar (150 vehicles), Flinkster (120 vehicles), STATTAUTO (430 vehicles), Stadtteilauto (30 vehicles) and Drive Carsharing (40 vehicles).

In the Theory of Networks chapter it has been concluded that interoperability makes only sense when the different operators have the same fleet size (to resemble the symmetric case that has been presented in the same chapter). If we consider their fleet size the first five operators are comparable. Therefore, these are the ones that are going to be considered in this document.

5.1 Terminology

The objective of the present master's thesis is to analyze the establishment of interoperability in the city of Munich. For the development of this analysis the Role Model from the Project EasyWay is going to be used (EasyWay ITS, 2012). This model describes the value chain of the traveler information services. In the Figure 9, this value chain is represented:

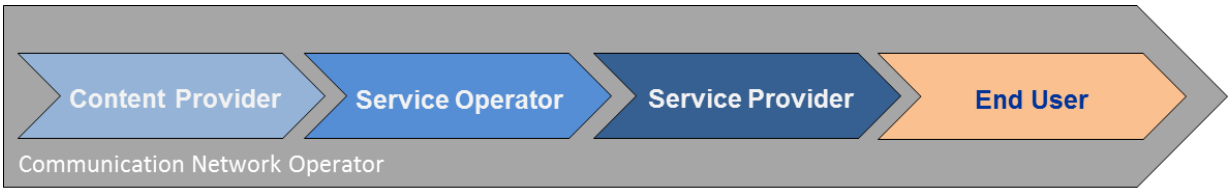

Figure 9: Value chain for traveler information services. Source: EasyWay.

In the value chain there are several key actors in providing dynamic traffic information services. These actors have the following central roles:

- Content Provider: it is the source of all information services and owns the content (e.g. traffic data) and/or provides the content for a service application.
- Service Operator: uses the content from the content provider to generate information with added value. The information then forms part of a service and covers not only the adaptation of the original data but also the visualization of the information (e.g. the creation of a thematic map).
- Communication Network Operator: publishes the service (to a service provider) and supplies the communication network for the service (like a mobile network or an internet provider).
- Service Provider: it is the interface to the customer. They publish the service and are responsible for all marketing and contractual issues with the end user.
- End user: is the consumer of the information service.

In this document, these terms are used for referring to the carsharing structure (the vehicles that provide the data of the service), the carsharing operator (the central system that manages all the information from the vehicles and transfers it to the carsharing interface), and the carsharing interface (the platform that is used to offer the service to the customers).

5.2 Classification of the Architectures for the Development of the Model

With the aim of analyzing the implementation of interoperability in the city of Munich, two different levels of the carsharing organizational structure are considered. The first one is the overall framework architecture on which the carsharing is built upon and the second is the reference architecture that considers the different carsharing processes from the user point of view.

It is important to remark that there could be many reference architectures, but we are only going to analyze the one referring to the carsharing processes. In the Figure 10, the different architectural levels are represented.

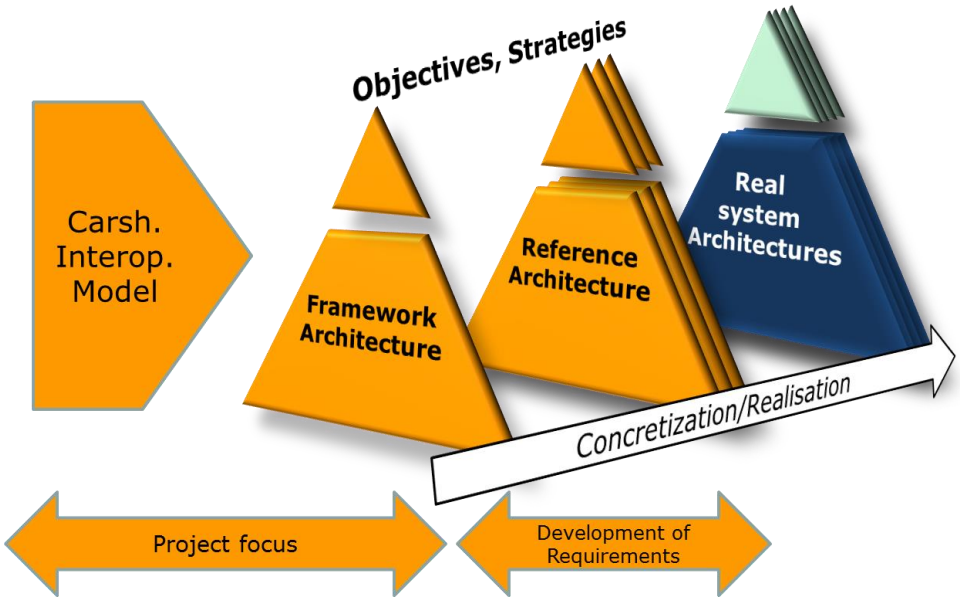

Figure 10: Classification of the master's thesis in relation to the Architectural levels. Source: MRK GmbH.

The reason for analyzing the former is to describe how the relations among the carsharing operators should be in order to enable their interoperability. With this purpose in mind, the most relevant scenarios are analyzed taking into account the relations of the different stakeholders at three levels of action: the Content Provider level, the Service Operator level and the Service Provider level.

The reason for analyzing the latter is the intent of comparing the different carsharing operators, in order to set a common ground that will enable, in a forthcoming stage, the proposal of an integrated model that could be implemented in the city of Munich. Therefore, the key processes from the consumer point of view are analyzed, namely: registration, reservation, access, metering and accounting, vehicle return and bill.

6 Analysis of the Implementation of the Interoperable Model

This section analyses the implementation of carsharing interoperability in the city of Munich. For the development of this analysis the two architectural levels introduced in the previous section are considered.

6.1 Framework Architecture

In this document the term Framework Architecture refers to the global organizational structure of the carsharing providers. In order to establish interoperability new relationships among the carsharing providers have to be settled. For presenting these relationships the tools of the traveler information services industry have been used because there are many organizational similarities with the carsharing structure. The terms Content Provider, Service Operator and Service Provider have been introduced in chapter 5.

This section introduces the hypothesis on the likeliest implementation options that should be considered for achieving the interoperability among the different carsharing operators in the city of Munich. For each approach identified, a summary is provided with its strengths and weaknesses from the point of view of the carsharing organizations. At the beginning an explanation of the actual situation is provided and it will be justified why is not considered as an alternative.

The framework scenarios described in this section are:

- Scenario 0: Status Quo.
- Scenario 1: Bilateral agreements between carsharing operators.
- Scenario 2: Common service provider for all carsharers.
- Scenario 3: Common service operator for all carsharers.

The above scenarios are described using overview diagrams to illustrate connectivity between participants. In the diagrams blue symbols indicate private or individual agents and red symbols indicate common agent for all the participants. Once all scenarios are defined, an analysis of the different alternatives is going to be carried out in order to choose the best implementation scenario.

6.1.1 Scenario 0: Status Quo

In the present framework situation the carsharing operators act as content providers, service operators and service providers themselves. Every single Carsharing operator is the owner of the carsharing data (situation of the cars, description of the cars, condition of the vehicle, tariffs, and availability). At the same time, they process this data through their service operators and show it to the end customer through their own service providers' platforms (App, Web, and Hotline).

With the actual situation the only way that users have to access all of the carsharing providers is to register to every single one of them. However, and as it has been shown in chapter 4, from June 2015 the Carsharing Operators Car2go and Flinkster announced their cooperation (Flinkster, 2015). Now every user from either of them can use the fleet from the other. The users continue to use their orig-

inal service provider platforms in order to use the service (the users of Car2go book the cars of the Flinkster fleet over the Car2go platform and vice versa). A schema of the present situation is shown in Figure 11, where this relation between Flinkster and Car2go is pointed out:

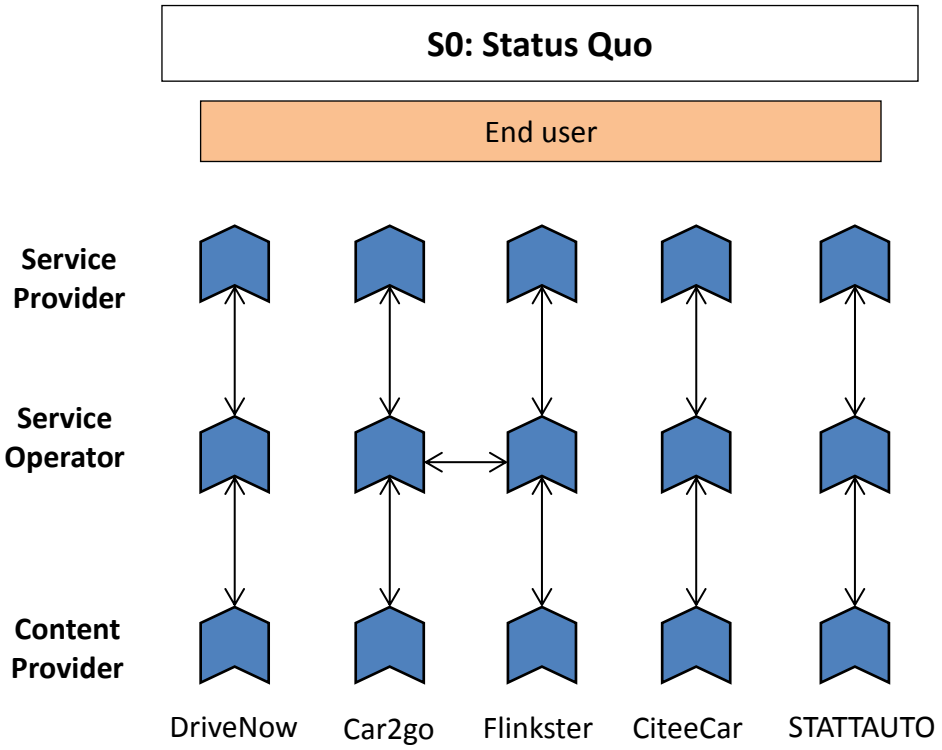

Figure 11: Present framework architecture of carsharing operators.

From this Scenario 0 some strengths and weaknesses can be pointed out:

Advantages	Disadvantages
+ There is no business risk associated. + There is no complexity of implementation. + There are no investment costs associated. + There is no need for agreement. + Time to market is immediate. + The brand concept is respected.	- User experience is limited. - Local market focus instead of a reunite one. - Lower customer attraction.

Table 3: Advantages and disadvantages of the present carsharing situation.

When looking at the Table 3 it may seem that the advantages outgo the disadvantages. However, if we look closer at the previous statements we understand that they are all a consequence of the fact that nothing is implemented. The only strong argument of this alternative is that the brand concept is respected (the different carsharing service providers are respected).

Furthermore, the goal of this thesis is to propose a way of implementing interoperability in the city of Munich. Several reasons have been shown in the previous chapters to depict that interoperability would bring many benefits to both the carsharing companies and the carsharing users.

Therefore, the maintenance of the present situation as a possible scenario for the business model of carsharing companies is no longer going to be considered.

6.1.2 Scenario 1: Bilateral Agreements

This scenario is the simplest approach in terms of understanding. It consists on the interchange of information between all the carsharing service operators. For doing so previous agreements between the carsharing operators have to be reached two by two (every single operators must be connected with all the other ones). Furthermore, an interoperable scheme should be introduced. Carsharing operators would have to join this scheme and agree to be bound by the rules set by it. In this scenario everything would work as it works now, but every user would be able to see the information of the other carsharing operators in their original service provider platform (comparable to the present relation between Flinkster and Car2go). This first scenario is represented in the Figure 12:

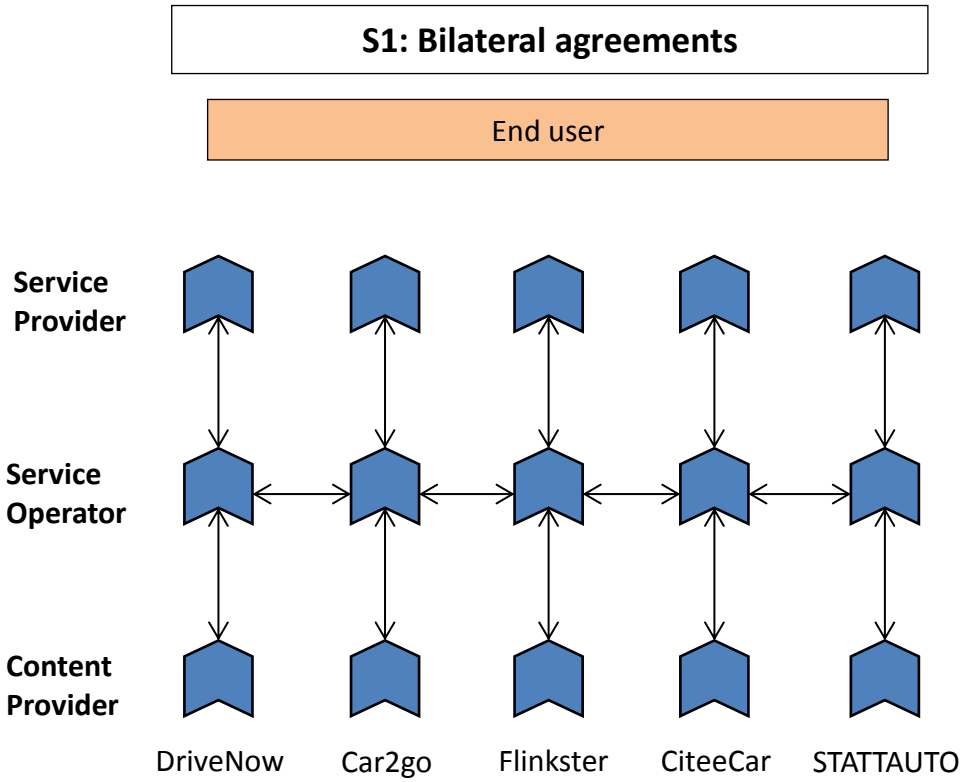

Figure 12: Scenario 1, bilateral agreements between the carsharing operators.

The most relevant positive and negative aspects of the scenario are shown in the Table 4:

Advantages	Disadvantages
+ Organizationally easy to deploy. + The brand concept is respected. + Time to market is relatively fast. + Low risk associated because the operators settle the business agreements they want. + The received data can be operated. + Harmonization of information can be done. + Other services can be implemented.	- There agreement costs are expected to be high. - The feasibility of this model is low due to a lack of a moderator. - Duplicates efforts (two by two connections). - Complexity increases with number of parties and efficiency decreases.

Table 4: Advantages and disadvantages of the framework scenario 1.

This scenario is organizationally easy to deploy because no common operator has to be defined or established. The brand concept would be maintained because every single carsharing operator would be able to make their own marketing and users would continue to use their original service provid-

ers. Moreover, time to market is relatively fast once the scheme is defined and agreed among all operators. The business risk associated is low due to the fact that the carsharing operators decide under which terms they want to partner (to avoid client loss) and which information do they want to share. Furthermore, the received data could be operated and therefore, it would be possible to implement harmonization of information or the integration of other services in the future.

On the other hand, the high agreement costs among the carsharing operators would make this scenario difficult to implement, due to the fact that the operators work in the same city. Without the presence of a central moderator that coordinates and structures all the relations among operators it seems improbable that this scenario would come to realization. Moreover, due to the fact that the efforts are doubled (relations between operators are settled to by two), the scalability of the model would be relatively high. Moreover, and due the high number of channels of information, the overall efficiency of the system would be very low.

6.1.3 Scenario 2: Common Service Provider for all Carsharers

In this scenario, a common carsharing service provider would replace all the carsharing service providers. This service provider would act as an intermediary between the different service operators and the end user. The different carsharing companies would not purely interoperate, but some effects of interoperability would be achieved.

In this case, all the carsharing operators would send their data to this common service provider, not interoperating between them but enabling the interoperability of the service. In order to use the vehicles of other companies the users would only have to use the common service provider platform.

The scenario 2 is represented in the Figure 13, where blue symbols indicate private or individual agents and red symbols indicate common agent for all the participants:

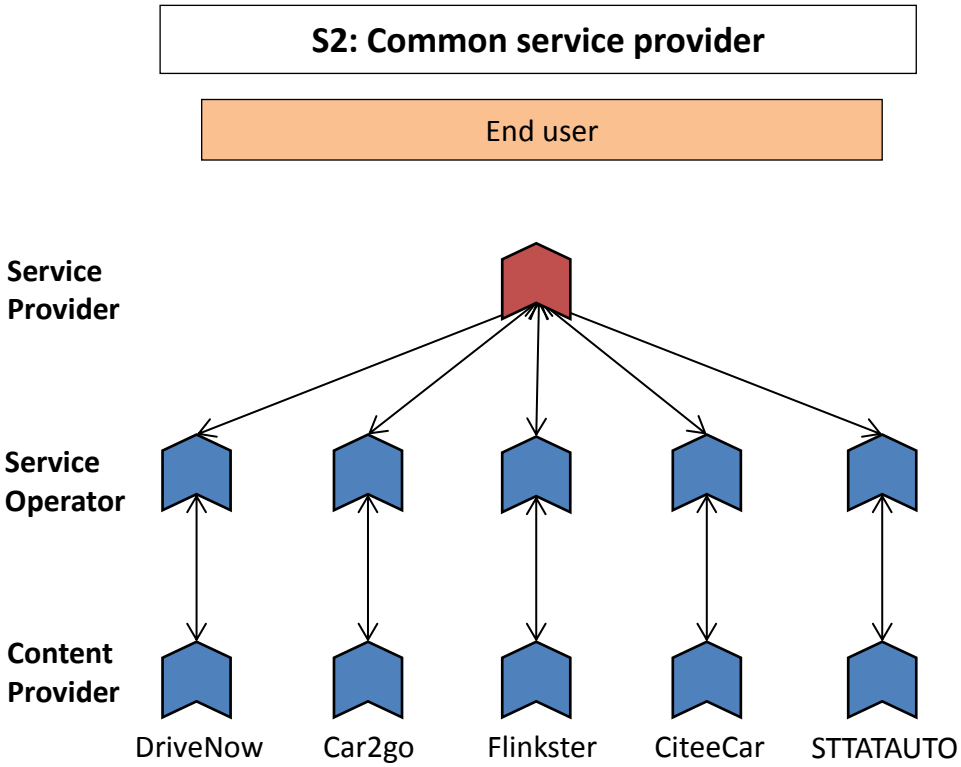

Figure 13: Scenario 2, common service provider for all carsharers.

A simple evaluation of its advantages and disadvantages is provided on the Table 5:

Advantages	Disadvantages
+ Simplicity for the user. + High degree of efficiency. + Low structural changes (define service operator and establish interfaces with it).	- The agreement costs are expected to be high. - Brand concept is weakened. - The received data cannot be operated. - There is no harmonization of information. - Other services cannot be implemented. - High substitution effect.

Table 5: Advantages and disadvantages of the framework scenario 2.

This scenario would be uncomplicated for the user to understand, because there would be a single service provider platform to use all the carsharing services of the city of Munich (it would look like the MVG Multimobil app shown in chapter 4). Moreover, it would present an efficient system with relative low changes on the structure. These changes would be the definition of a common service provider and the establishment of connections among the carsharing operators with the common service provider.

Nevertheless, there are some major drawbacks that make this scenario difficult to implement. First of all, it would be difficult to make all carsharing operators to come to an agreement because of the loss of the brand concept (business organizations do not want to lose the capacity of branding their customers through their service provider platform).

Furthermore, in the long term it does not present such an attractive solution for the customer, because the received data cannot be operated and therefore, the information would not be harmonized and other mobility services (e.g. joint mobility offer with other sharing systems or public transport) could not be implemented (as we have seen in chapter 5 this information is edited by the service operator and here the connection is at the service provider level).

This is because every single operator would choose which information would he want the common service provider to receive, and therefore, it does not have to be equal among operators (current case of MVG Multimobil).

Besides, there is a lack of a central service operator who could decide to make agreements with other service providers in order to integrate other services (if other services are implemented a full mobility intermodal service could be developed). In this model the high degree of interoperability would make it difficult to avoid the shift from clients from one service to another, and therefore the risk associated is higher.

6.1.4 Scenario 3: Common Service Operator for all Carsharers

In this scenario, there would be a common service provider as well as a common service operator. This business model would represent a complete level of interoperability. It would mean that the different carsharing providers would be using the same network.

In this situation, the different carsharing operators would send the raw data from their fleet to the common service operator, which would transfer it to the common service provider.

The perceived interoperability for the end user would be pretty much the same as in the scenario 2. However, customer satisfaction would be enhanced by the offer of a more complete service (because the relationship is made at the service provider level and the data can be edited).

The customers would then use the common service provider platform for using the carsharing service, as well as in scenario 2. A schema of the scenario 3 is shown in Figure 14, where blue symbols indicate private or individual agents and red symbols indicate common agent for all the participants:

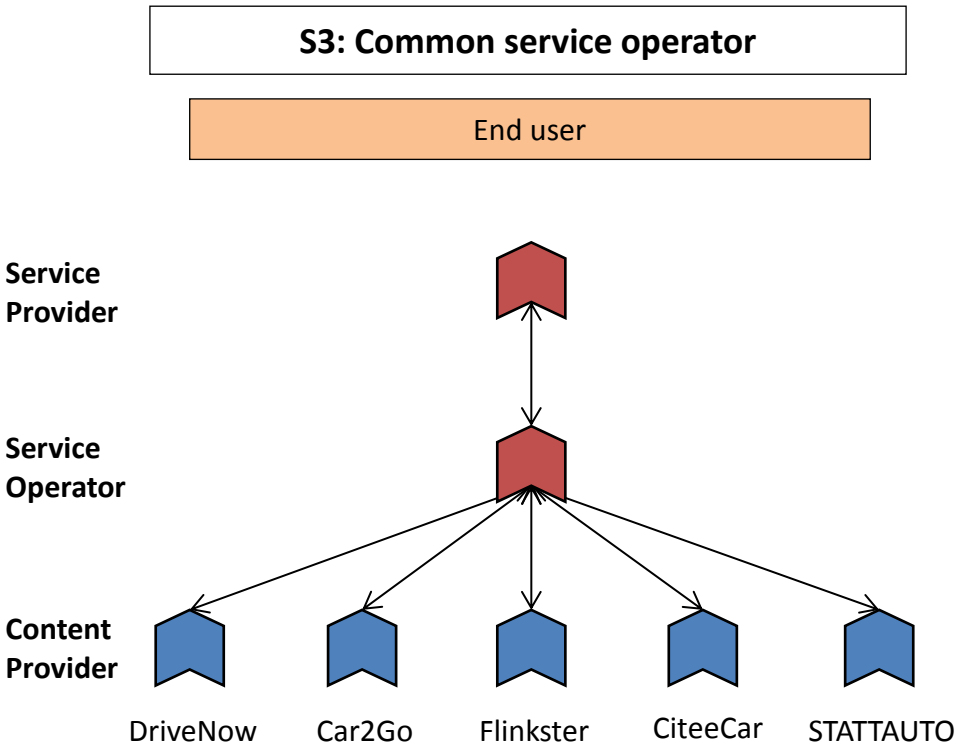

Figure 14: Scenario 3, common service operator for all carsharers.

The major benefits and downsides of this scenario are given in the Table 6:

Advantages	Disadvantages
+ Simplicity for the user. + Highest degree of efficiency (lowest number of information channels). + The received data is raw. + Harmonization of information can be done. + Other services can be implemented.	- There agreement costs are expected to be the highest. - Brand concept is weakened. - The infrastructural costs are high as a new service operator is needed. - Time to market is high. - High substitution effect.

Table 6: Advantages and disadvantages of the framework scenario 3.

This scenario is really simple for the user to use, as there would only be a common service provider. The efficiency level would be very high because the carsharing vehicles would stand as data providers and the central operator would collect all this data within a harmonized system. Fewer connections, and the fact that these are set on the service operator level, mean lower possibility of mistakes.

By stating that the received data is raw it is meant that the common service operator has the possibility to decide which kind of data he wants to receive and how does he wants to receive this data.

Thus, when the received data is raw data, it is possible to harmonize the received data and other services can be implemented, if the common service operator has access to other data sources. This system would enable the highest degree of customer satisfaction because of the high degree of efficiency, simplicity, and the fact that other services could be offered.

This scenario presents some challenges that are difficult to overcome. Firstly, the agreement costs appear to be very high because nowadays the content providers do not have the necessity to send their core information to a central service operator.

Moreover, if they do not operate their data they have no control over the service and some key processes from it such as billing. Hence, the loss of the brand concept would make the agreement costs even more difficult to overcome. The infrastructural costs are high because a new central operator is needed. Time to market would therefore be very high. Customer shift among operators would be difficult to prevent.

This scenario presents the final stage of a carsharing interoperable model. It would present a fully interoperable service that could be complemented with other types of services (through data edition from the common service operator). This would be interesting for the users because they could benefit from a complete mobility offer, where intermodal trips could be calculated and synergies between different transport modes could be enabled.

This scenario is the final step of interoperability. However, the market is still not mature enough to reach this situation. It looks improbable that from the present situation this scenario could be enabled. It sounds more feasible to think of scenarios that are in between the present situation and this ideal situation.

Conclusion on the Loss of the Brand Concept

The implementation of the last scenario 2 and scenario 3 introduces a major problem, which is the loss of the brand concept. In order to amend this situation, two alternative scenarios are introduced:

- Scenario 2A: Alternative to Scenario 2 to prevent the loss of brand concept.
- Scenario 3A: Alternative to Scenario 3 to prevent the loss of brand concept.

6.1.5 Scenario 2A: Alternative to Scenario 2

This scenario presents an alternative for the Scenario 2 to avoid losing the brand concept. In this hypothetical situation interoperability would be enabled through a common service provider, just like in Scenario 2. However, the brand concept would be maintained because the carsharing operators would be able to continue with the provision and operation of their services.

To better understand this situation, the combined scenario 2A is presented in the Figure 15, where blue symbols indicate private or individual agents and red symbols indicate common agent for all the participants.

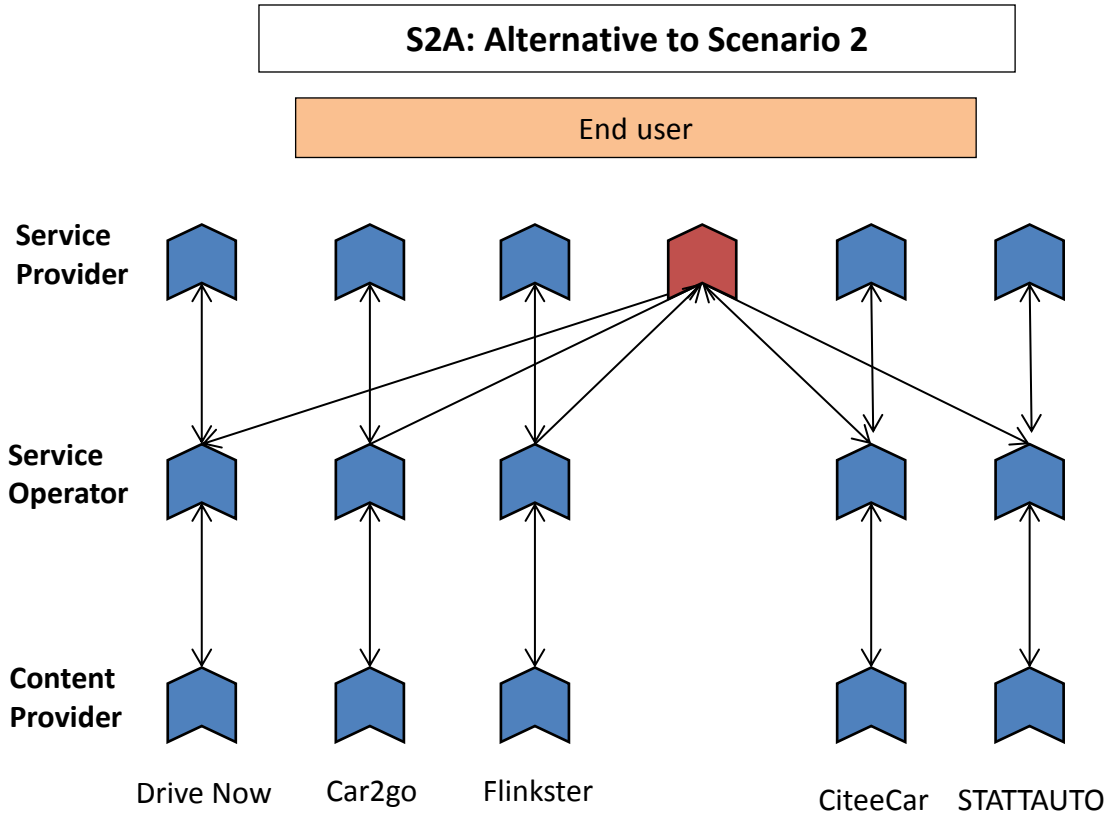

Figure 15: Scenario 2A, alternative to scenario 2 to preserve brand concept.

The strengths and weaknesses of the framework scenario 2A are pointed out in the Table 7:

Advantages	Disadvantages
+ Low agreement costs. + Brand concept is respected. + Low structural changes (define service operator and establish interfaces with it). + Time to market is fast. + The risk of customer shift is not so high because of original service providers	- Efficiency loss (two channels of information). - The received data cannot be operated. - There is no harmonization of information. - Other services cannot be implemented.

Table 7: Advantages and disadvantages of the framework scenario 2A.

This scenario presents a realistic solution to the enablement of an interoperable system while being a middle step between the present situation and the scenario 2. With the maintenance of the original carsharing service providers the brand concept would be preserved.

Thereby, the agreement costs would be easier to overcome. The infrastructural costs would be exactly the same as in scenario 2, which are the definition of the common service provider and the establishment of interfaces between all the service operators with the common service provider. Thus, we can consider the time to market fast, in comparison with other scenarios.

Last but not least, the risk of customer shift from one operator to another would not be so high because of the fact that the original service providers would be maintained (this consideration, which will be further discussed, depends on how the common service provider is implemented).

On the other hand, the maintenance of the brand concept would come at the cost of a loss of efficiency, because the information channels would be doubled. Moreover, the data that the service

provider would receive could not be operated. This would not permit the harmonization of information or the implementation of other services (the addition of mobility services would be of a great interest and the calculation of intermodal trips for example).

This scenario presents a feasible solution that even not offering the best technical characteristics would be a notorious first step towards achieving interoperability in the future.

6.1.6 Scenario 3A: Alternative to Scenario 3

This scenario presents an alternative for the Scenario 3 to avoid losing the brand concept. The principal purpose of this scenario is to obtain the advantages of the scenario 3 while maintaining the brand concept. In this hypothetical situation, interoperability would be enabled through a common service operator, but the brand concept of the actual carsharing operators would be maintained through the actual system.

Users would be able to use their original service provider platforms' or use the common service provider platform when using other carsharing vehicles. This scenario pretends to be a middle step between the present situation and scenario 3. Horizontal relations between operators have been designed because the fact of the carsharing operators sharing raw data is rather unrealistic (send vehicle data directly to the central operator).

The scenario 3A is presented in the Figure 16:

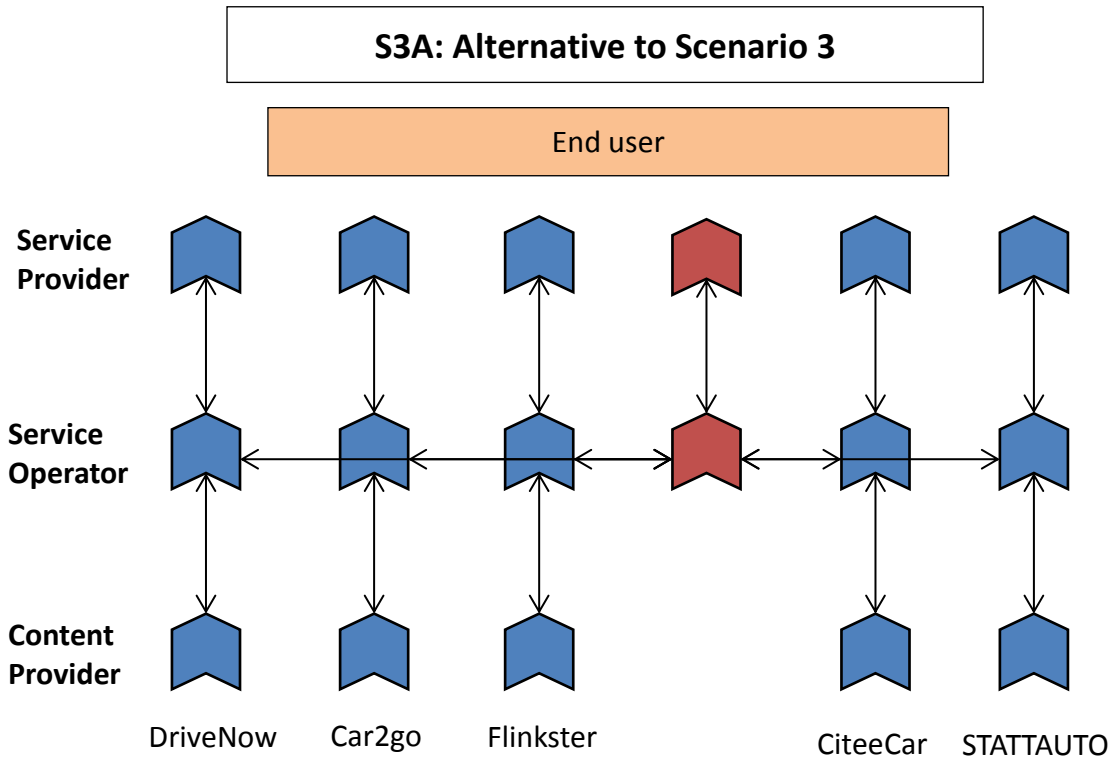

Figure 16: Scenario 3A, alternative to scenario 3 to preserve brand concept.

The advantages and disadvantages of the scenario 3A are outlined in the Table 8:

Advantages	Disadvantages
+ Brand concept is respected. + The received data can be operated. + Harmonization of information can be done. + Other services can be implemented. + The risk of customer shift is not so high. + Reasonable agreement costs.	- The infrastructural costs are the highest as a new service operator is needed. - There is a loss of efficiency. - Time to market would be higher.

Table 8: Advantages and disadvantages of the scenario 3A.

This is another interesting possibility to take into account. The brand concept is respected due to the maintenance of the original service operators and providers. Furthermore, the received data could be operated because of the figure of the central service operator, so harmonization of information and the implementation of other services can be done (intermodality).

Thereby, the common service provider could offer to the users a complete mobility offer. They could for example calculate a route where carsharing, bikesharing and Public transport were combined.

Moreover, the risk of customer shift is again not so high because of the maintenance of the brand concept (this consideration, that will be further discussed, depends on how the common service provider is implemented). The agreement costs would be reasonable because the carsharing operators could decide which data they would like to share.

On the other hand, time to market is high as in Scenario 3, because a common carsharing operator and service provider have to be defined and implemented. The infrastructural costs are also high for the same reason. Lastly, it is interesting to remark that this alternative scenario would be a little less efficient than Scenario 3 because of the fact that the information channels are doubled.

This scenario enhances customer satisfaction and efficiency in comparison to S2A but the costs of implementation and the time to market would be higher due to the development of a central operator.

6.1.7 Alternative Analysis

In order to decide which scenario is the most appropriate for implementing interoperability in the carsharing business an analysis considering the relevant characteristics of all the alternatives may be undertaken. By doing so, a scenario can be objectively chosen given the specific conditions of the carsharing market. In means of simplicity, each scenario is going to be given a qualitative rating.

This analysis is going to consider the following assessment criteria:

- Customer Satisfaction
- Overall efficiency
- Agreement costs
- Implementation complexity

We are no longer going to consider the scenarios 2 and 3 because their alternative scenarios offer respectively a better solution for implementing interoperability. It has been considered that the loss of the brand concept is under no circumstances going to be accepted by the carsharing providers.

Moreover, the risk of customer shift is greater because of the loss of the brand concept. Thereby the time to market would be more than bearable.

Customer Satisfaction

In this section the user experience when using the service provided by every scenario is going to be evaluated. Here the scenarios that enable a higher degree of interoperability and make it easier for the user to use the service are going to punctuate higher.

- **S1:** In this scenario the information from the other carsharing operators could be enabled in the original service provider platforms as an extra function for example. However, every single carsharing operator would choose which information they were willing to share and there would be no regulatory organism to control the problems in between the operators. Harmonization of information would have to be done by every single operator and each single operator would have to decide if to implement other services.

- **S2A:** Through the presence of a central service provider the relationships between carsharers could be organized. Nevertheless, the lack of a central service operator would not enable harmonization of information or the implementation of complementary services (intermodality). Users would be able benefit from interoperability through the common service provider or use their original carsharing provider as usual.

- **S3A:** Full interoperability would be enabled thanks to this scenario, because the implementation of new services and the harmonization of information could be implemented, thanks to the common service operator. Users willing to benefit from interoperability could use the common service provider for doing so and the other ones, could still use the original service providers.

Overall Efficiency

In this category the simplicity of the model is going to be evaluated. More travel of information means a higher probability of mistakes and longer time processes. The scalability of the system is as well being considered (the flexibility of the system if more carsharing providers were to join it).

- **S1:** This scenario scores poorly both in terms of simplicity and scalability. It is the scenario with more channels of information and therefore, the mistake probability and the length of the processes is going to be higher. Moreover, if more stakeholders are to join the system, it is going to be increasingly complicated. For understanding the negative effects of scalability in this model, the Figure 17 is represented (the different colors are only for differentiating the connections):

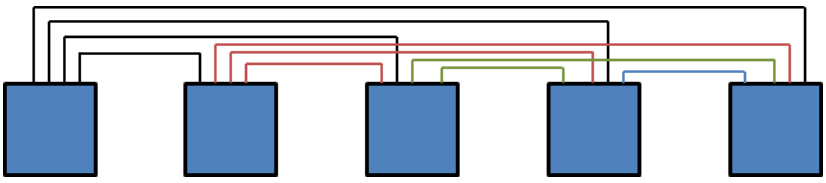

Figure 17: Establishment of communication between the carsharing service operators in S1.

In order to establish interoperability among operators, all the carsharing service operators have to be connected two by two. Therefore, it is easy to determine that the number of information channels that there would be in the whole system follows the next rule:

$$N = (n-1) \cdot n/2 = 1/2\,(n^2 - n)$$

Where “N” means the number of information channels there would be and “n” the number of operators that participate in the system. We can observe that this formula escalates nearly as fast as a quadratic formula.

- **S2A:** The overall efficiency of this scenario is acceptable because all the service operators would send their information to a single service provider. The problem would come at the time of receiving the information that would not be harmonized. The Figure 18 shows the scalability of scenario 2A:

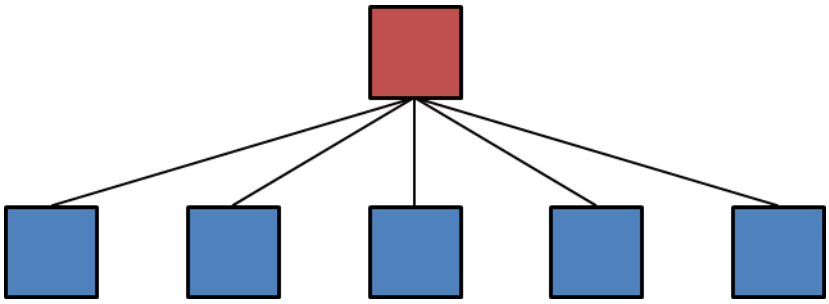

Figure 18: Communication between a common service provider and the different carsharing service operators in S2.

We can easily estimate that the scalability of this scenario is determined by the following rule:

$$N = n$$

Where "N" means the number of information channels there would be and "n" the number of operators that participate in the system. It is possible to observe that the scalability speed of this scenario is only linear.

- **S3A:** This scenario is the most efficient of the three because it has an optimal number of information channels, but at a lower level that permits the harmonization of information. In terms of scalability this scenario follows the next formula:

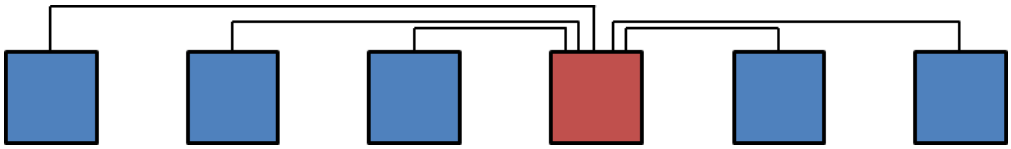

Figure 19: Communication between a common service operator and the different carsharing service operators in S3A.

$$N = (n + 1)$$

Where "N" means the number of information channels there would be and "n" the number of operators that participate in the system. As we can see the scalability speed is a bit faster than scenario 2, and that is because at the beginning an extra information channel has to be implemented between the common service operator and the common service provider. Once this connection is installed, the scalability is exactly the same as the previous scenario.

Agreement Costs

Here the probability of agreement between the carsharing organizations is going to be assessed. This category is paramount to the enablement of interoperability and it's one of the main reasons why the Scenarios 2 and 3 are not going to be considered in this analysis.

- **S1:** The agreement costs for the scenario 1 would be remarkably high. The problems would come mainly from the lack of a central impartial figure, which could act as a moderator in between the carsharers. Another problem is that with the current market situation the different carsharers do not have the necessity to cooperate and without the appearance of a central figure that shows the benefits of interoperability and organizes the different parties this scenario would be difficult to implement.

- **S2A:** Scenario S2A presents reasonable agreement costs. The fact that this scenario respects the brand concept and that the carsharing providers share the information at the service provider level are obvious advantages for reaching an agreement.

- **S3A:** Scenario S3A presents similar agreement costs to S2A but with different characteristics. The fact of sending the information directly to a common operator would mean that they would decentralize their service a little bit more as in scenario S2A. However, the interoperability benefits perceived by its customers would be greater than in the previous scenario, and a better argument to convince the carsharing operators.

Implementation Complexity

In this field the technical difficulties of implementation are going to be judged. In this category the investment costs are also taken into account. Both are directly related with the amount of elements that have to be implemented in every scenario and the number of connections between the elements that have to be applied.

- **S1:** In this scenario the financial investment would relatively low, because only software interfaces have to be applied. However, if we look at the Figure 17 we can see the great number of connections that would be required. For the present situation that would mean a total of 10 connections.

- **S2A:** Scenario S2A presents the lowest complexity of implementation. That is because it is the scenario with a lower level of connections simplifying both the complexity of implementation and the initial investment. If we look at Figure 18 we can observe that 5 connections would be needed.

- **S3A:** Scenario S3A presents a complexity similar to S2A but a bit higher. That is again because of the implementation of a common service operator that would require hardware interfaces in addition to the software interfaces that are required in the scenario S2A. If we look at Figure 19 we can see that 6 connections for the implementation of Scenario 3A would be required.

6.1.8 Selected Scenario

The different categories are going to be assessed with a simple traffic light system to score the impact of each option. Color red means represents a negative impact (worse), yellow indicates that the impact is acceptable (OK) and green represents a positive impact (best). It is than possible to give a score to every category in order to select one winning scenario: 1 point to green, 0 points for yellow and -1 point to red.

This score comes from the reasons given in the previous section for every singles scenario. It has been considered that all the criteria are equally important, because of the lack of information to consider otherwise.

	Alternatives		
Assessment criteria	**S1**	**S2A**	**S3A**
Customer Satisfaction			
Overall efficiency			
Agreement costs			
Implementation complexity			
Total	**-2**	**2**	**3**

Table 9: Results Matrix for the most relevant scenarios.

From this matrix we can conclude that **the scenario that would be most appropriate for implementing interoperability in the city of Munich is Scenario 3A**. This does not mean that it is the scenario with the most benefits but it is the one that the market would be more prompt to accept. Now we are able to consider this scenario in more detail to fully understand its requirements and implications.

6.2 Reference Architecture (Carsharing Processes)

With the aim of setting a common ground for interoperability, the main carsharing providers of the city of Munich are analyzed. Thereby, literature research has been done in order to identify the key activities of the process of using carsharing (Hayashi, et al., 2014) (Gómez, 2015) (Hildebrandt, et al., 2015) (Pieper, et al., 2013) (Barth, et al., 2003). These are shown in the next figure:

Figure 20: Key activities of the process of using carsharing.

First of all, a summarizing table is shown to make a comparison between the carsharing service providers of the city of Munich taking these key activities into account. With this table is it is possible to see the main differences that have to be overcome technically in order to enable interoperability. Once this comparison is done, a model will be defined according to scenario S3A.

6.2.1 Carsharing Providers Comparison

In the Table 10, the main carsharing providers of the city of Munich are compared. Every category of the left column represents the possible barriers that could be encountered in every process of the carsharing usage.

	DriveNow	car2go	CiteeCar	Flinkster	STATTAUTO
Fleet Size	490 vehicles	500 vehicles	150 vehicles	120 vehicles	430 vehicles
Registration Fees	One-time fee: 29,00 €	One-time fee: 19,00 €	One-time fee: 9,00 €	One-time fee: 50,00 € (with the BahnCard free of charge)	One-time fee: 50,00 € Monthly fee: 7,00 € Deposit: 500 €
Booking Platform	App/Internet/ Hotline	App/Internet/ Hotline	App/Internet/ Hotline	App/Internet/ Hotline	Internet/ Hotline
Access Technology	Member Card/ RFID label	Mobile Phone/Member Card	Member Card	Mobile Phone/Member Card	Member Card (Key box)
Accounting System	Electronic	Electronic	Electronic	Electronic	Manual (Book note)
Business Model	Free Floating Carsharing	Free Floating Carsharing	Station-based carsharing (original neighborhood/parking spot)	Station-based carsharing (original neighborhood/parking spot)	Station-based carsharing (original parking spot)
Payment Methods	SEPA automatic debit/Credit Card	SEPA automatic debit/Credit Card	SEPA automatic debit/Credit Card	SEPA automatic debit/Credit Card/Transfer	SEPA automatic debit/Credit Card/Transfer

Table 10: Comparison of the most relevant carsharing providers in Munich. Source: MVG multimobil (MVG, 2015).

6.2.2 Registration

When we consider the registration process of the interoperable system we have to make an initial distinction. There are mainly two situations to consider: the users that are already members of a carsharing company, and new users. These two types of users have a particularity in common and it is that both want to access the carsharing interoperable system. The different procedures that old users and new users have to follow are:

- Old Customers: The carsharing companies maintain the data of its old users as usual. The ones that want to benefit from the interoperable service agree to share their data with the common service operator and sign a new contract to accept its terms and conditions. Furthermore, they have to accept the terms and conditions of every carsharing organizations they want to join.
- New customers: First of all, they have to choose the carsharing operators, whose services they want to access. They would then register online and validate their documentation in any of the validation points of the carsharing operators. That carsharing operator would send the data to the common service operator, who would further the information to the other carsharing organizations.

It is important to remark that the members that would have access to the customer data in the interoperable model would be both the common service operator and the carsharing organizations involved in the system.

The users could choose then if they want to access the interoperable system or not. This would consist in an interoperable package with slightly higher registration costs. The users that accepted to join this offer would have to accept the terms and conditions of all the involved enterprises. In exchange they would be able to access the vehicles of all of these organizations.

6.2.3 Search Function and Booking

The main goal of this function is to achieve that the users are capable through the common service provider platform (app, computer or tablet) to see all the information of the main carsharing operators in the city of Munich. Furthermore, the users would be able to choose which carsharing operators they want to see in their interface.

As it has been shown in the MVG Multimobil section (Figure 6), the MVG Multimobil interface is a good example for understanding how the desired search and reservation function would look like. The limits of this MVG tool, as it has already been commented in chapter 4, are that it does not let users to book or access the car. For doing so, users have to be registered to every single carsharing provider.

This tool connects the users with the service provider of one carsharing company, and there they are able to book the vehicle of their choice. On the other hand, the system that is proposed in this document would show all the carsharing providers that have been considered in this master's thesis (the same that are shown in the MVG multimobil but taking Flinkster into consideration as well).

Through this hypothetical service provider the users would be able to search and book the cars, following the characteristics of every carsharing operator and having registered to the interoperable service according to the proposed registration process.

For understanding how this function would work organizationally, the Figure 21 shows the diagram of steps to follow to enable the users to book the car. The authorization processes from Automatic Teller machines (ATM) (Hayashi, et al., 2003) have inspired this authorization process. The model follows the structure from the winning scenario S3A selected in the Framework Architecture.

The steps of the booking process are as follows:

1. The user selects the desired vehicle and inserts a PIN or signs in to the common service provider platform in order to prove authentication. This request is sent to the common service Operator that already has the data of the customer.
2. The common service operator decides whether to authorize the transaction by verifying the customer's account. If the customer data is all right the common service operator sends a request to the service operator of the selected carsharing company.
3. Once the carsharing service operator has received the request from the common service operator, verifies if the car is available and forwards the request to the particular vehicle.
4. The vehicle sends back a confirmation message to the service operator of the carsharing company and this is able to block the car for the user to access it.
5. The carsharing service operator sends and authorization message to the central operator, in order for the central operator to know that the car is on hold (and prevent double-bookings).
6. The common service operator sends an authorization message to the customer indicating that the reservation of the desired car is done and the vehicle is ready for use.

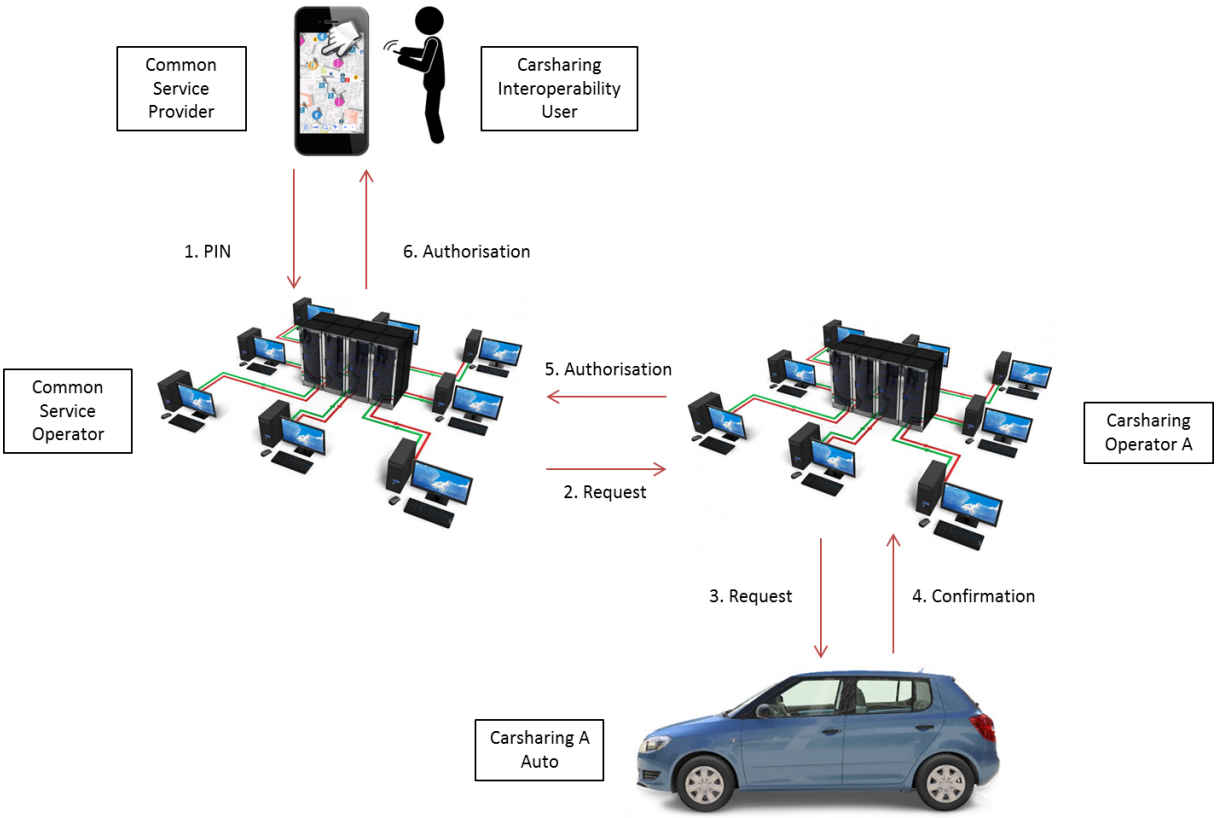

Figure 21: System model for the booking process.

6.2.4 Access

The next function to contemplate is the access function. This can come either after the users reserve a vehicle or by accessing the vehicles spontaneously (following the reservation processes of the car-sharing business models see Table 10).

The presented model for accessing the car is shown in the Figure 23 and the Figure 22. These two figures represent the two possibilities of accessing the car: one taking into account that the device contacts firstly with the car (Bluetooth or smart-card technology) and the second taking into account that the device contacts first with the operator (Wi-Fi).

These schemes represent the situation in which a user wants to access the vehicle from a carsharing organization through the interoperable service provider. The steps for accessing the car taking into account the Wi-Fi communication are:

1. Users log in through the common service provider and select the access the car function after having chosen the desired vehicle. This request is then sent to the common service operator.
2. The common service operator verifies the data of the customer and if everything is OK forwards the request to the carsharing operator of the selected vehicle's company.
3. The specific carsharing operator (that already has the data of the customer) verifies that the car is ready for use and sends the order to the vehicle to open the car.
4. The car opens thanks to its telematics technology and sends a confirmation back to the particular carsharing operator.
5. The particular carsharing operator forwards the message to the common service operator.
6. Finally the common service operator sends a message to the user.

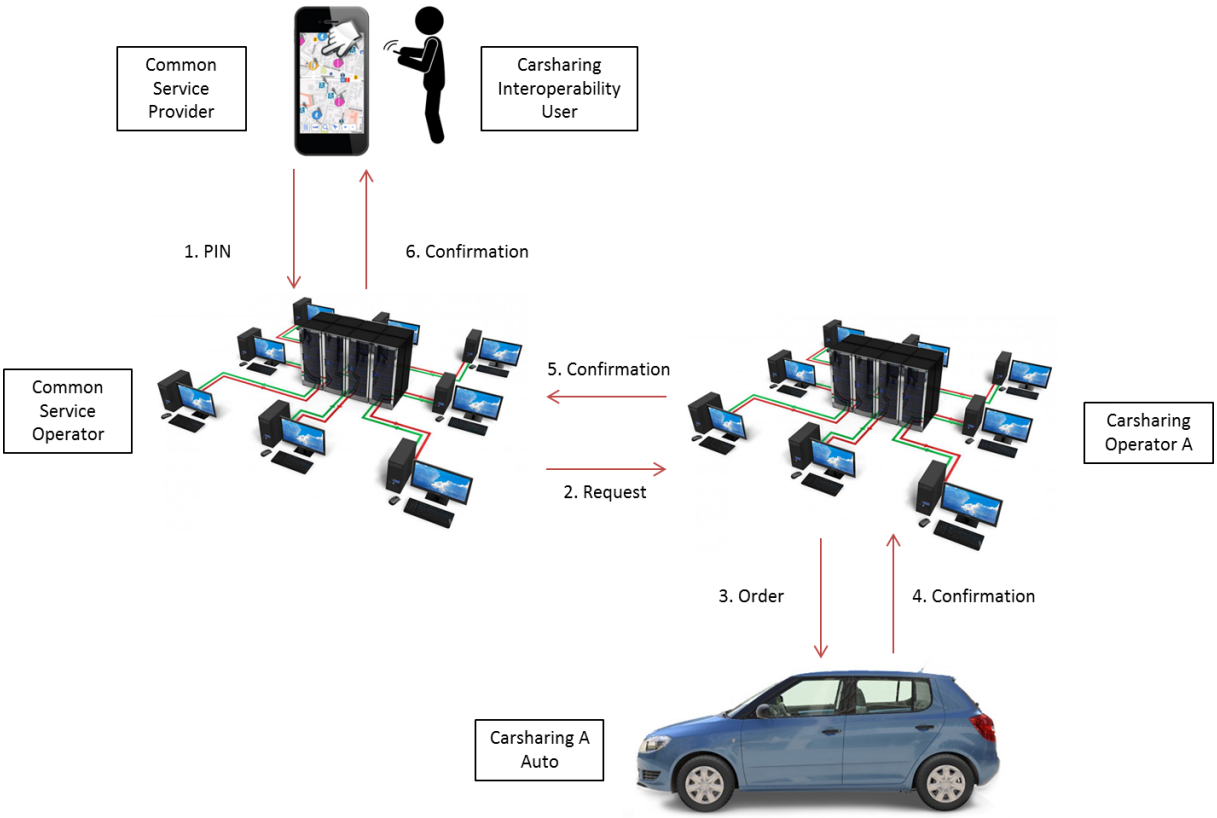

Figure 22: System model for the access system with Wi-Fi technology.

The steps for accessing the car with the Bluetooth technology are:

1. The users log in in the common service provider application and select the option to open the car. This request is then send to the selected vehicle.
2. This vehicle forwards the request to the particular carsharing service operator.
3. The specific carsharing operator (that already has the data of the customer) verifies that the car is available and if everything is OK forwards the request further to the common service operator.
4. The common service operator verifies the data of the user and forwards the authorization to the selected specific carsharing operator (giving the input on the whole interoperable system that the car is already booked).
5. The carsharing operator sends the order to the car to open.
6. The car opens and sends a final confirmation to the user.

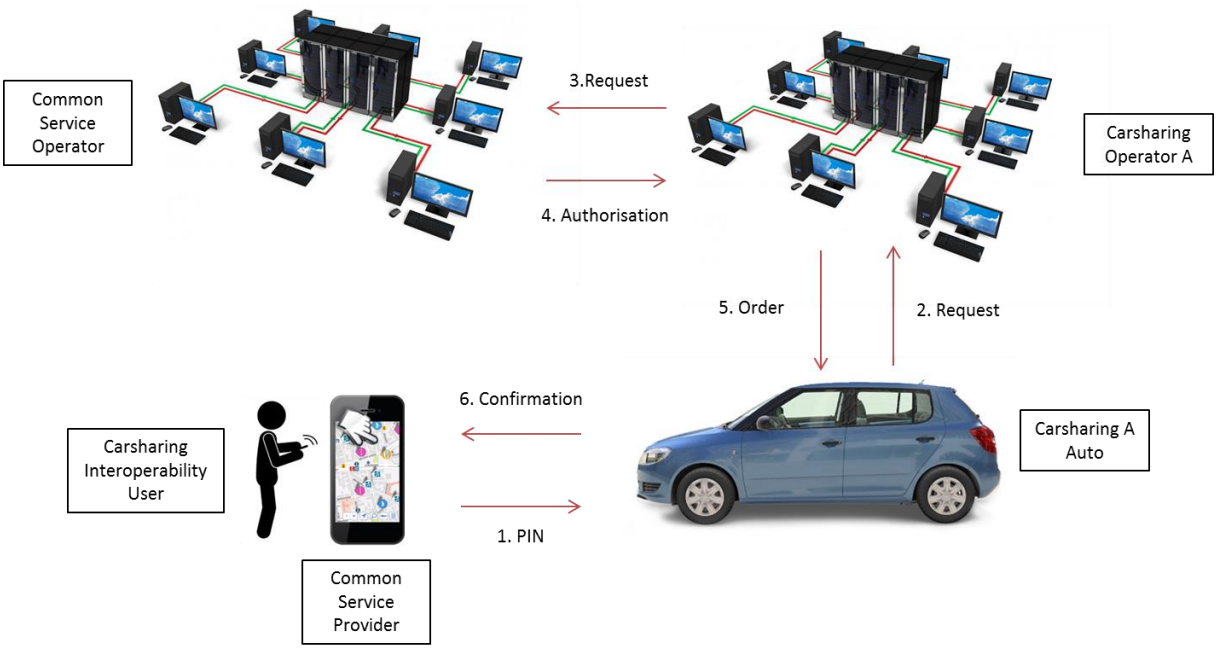

Figure 23: System model for the access system with Bluetooth technology.

6.2.5 Metering & Accounting

The Metering and Accounting process takes into account the measuring of the usage data. It is a vital function because it is going to be directly related with the final bill. Moreover, if an external investor is interested in such an interoperable system is because of the information gathered through this process.

It is paramount to say that given the actual technology and taking into account the fleet sizes of the carsharing organizations that are being analyzed in this document it is perfectly justified to obtain and forward the data through a telematics system. That is the case of all the carsharing systems except for STATTAUTO as it has been shown in the Table 10.

Without this telematics infrastructure it would be impossible for a carsharing organization to join the interoperable system proposed in this document because of the risk associated, the impossibility of communication with the central operator, and the fact that the investor would not be interested in an organization unable to provide data.

6.2.6 Vehicle Return

The following process to analyze is the one that involves the return of the vehicle. This process is remarkable because it enables to obtain the total usage time/mileage with which the final bill is going to be calculated. The user is going to return the vehicle according to the type of business model of the particular carsharing company, which has already been shown in the Table 10 for every carsharing operator.

Technically, the process is similar to the one from the access process but going backwards. This process is related with the metering and accounting and the billing processes because the three together enable the development of the final bill.

The travel of information in which this process is also involved is going to be discussed in the billing process. The process for returning the vehicle for the Bluetooth technology follows the next schema:

1. Once the user has properly parked sends a logout command to the vehicle through the common service provider mobile-phone app.
2. The vehicle forwards this request to the particular carsharing operator (so it can show through their service provider that the car is available for further users).
3. The particular carsharing operator sends a request to the common service operator (to avoid organizational problems).
4. The common service operator stores the usage information of the user and sends an authorization message to the particular carsharing operator.
5. The particular operator sends than the order to block the car and leave it ready for next user.
6. Finally the vehicle sends a confirmation message to the user providing that everything is OK.

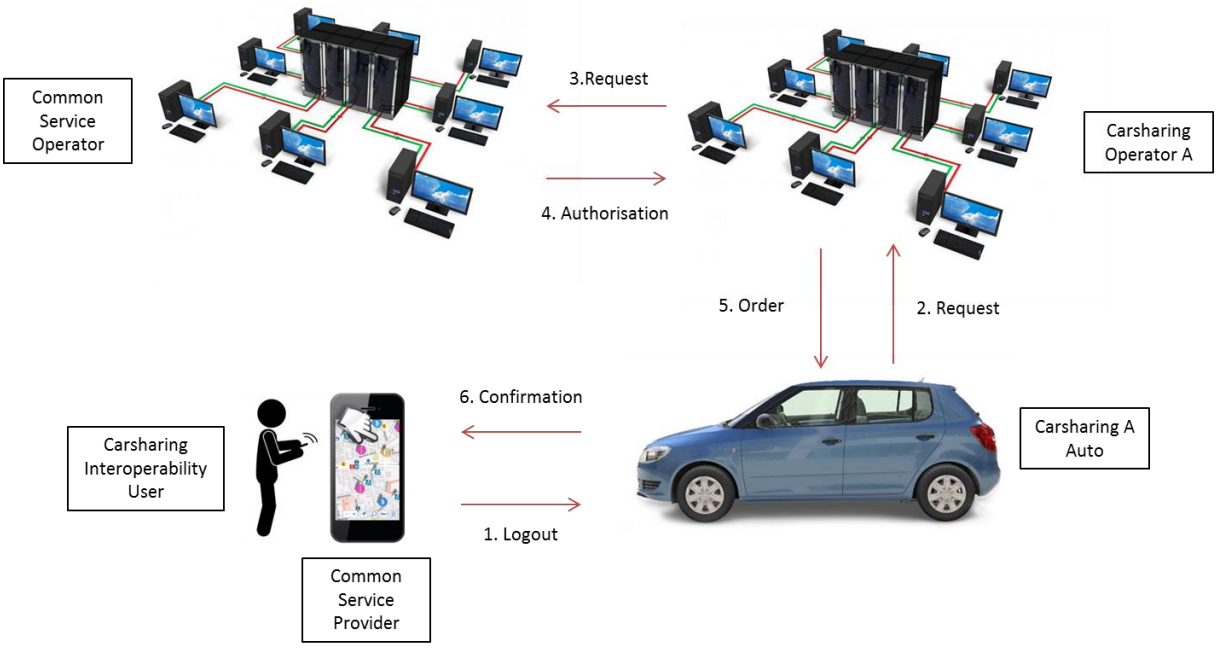

Figure 24: System Model for the vehicle return process with Bluetooth technology.

The process for returning the vehicle for the WI-FI technology follows the next schema:

1. When the user has properly parked the car, sends a logout request to the common service operator.
2. The common service operator verifies the data of the customer and if everything is all right forwards the request to the particular service operator.
3. The particular carsharing operator sends then an order to the vehicle to log out.
4. Once the vehicle is logged out it sends a confirmation to the particular carsharing operator.
5. The particular operator sends a confirmation to the common service operator.
6. The common operator relates stores the information of the user (for the final bill) and sends a confirmation to the end user.

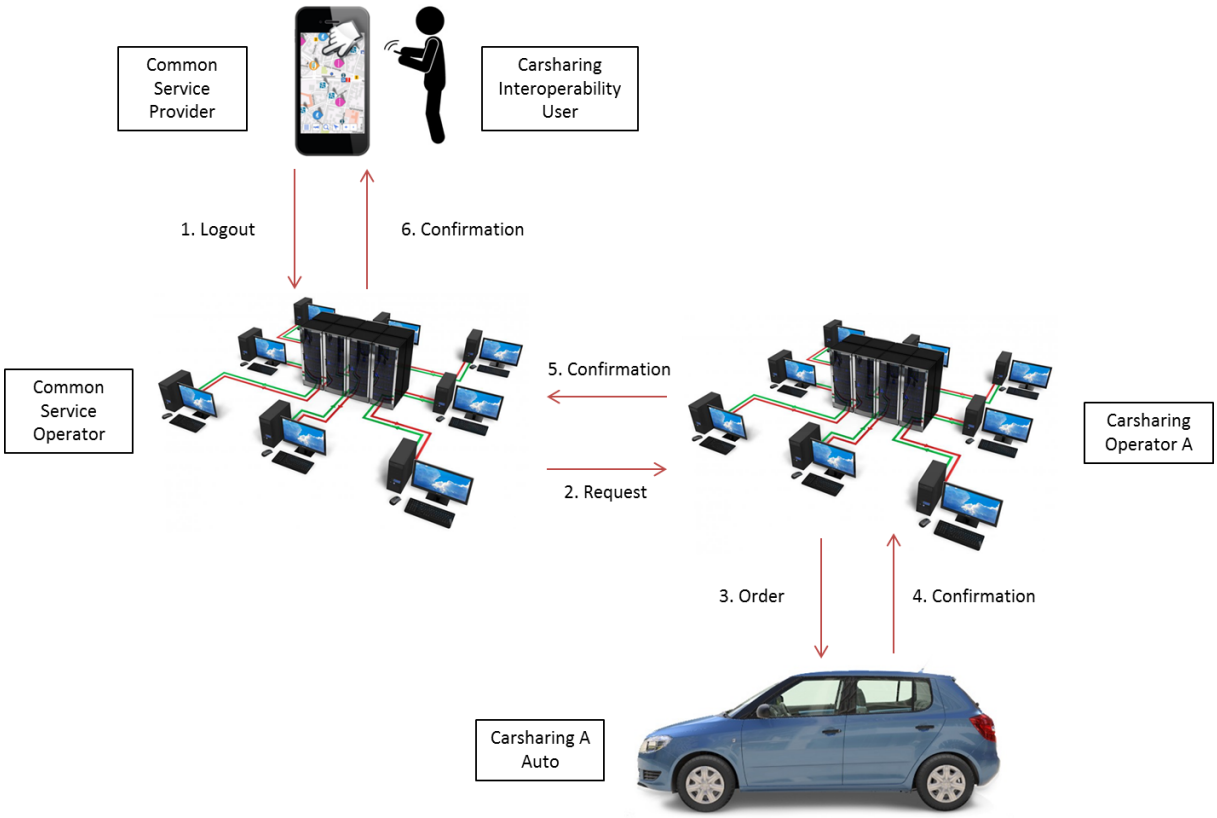

Figure 25: System Model for the vehicle return process with Wi-Fi technology.

6.2.7 Billing

This is the most delicate process because implies the travelling of customer data and money. It is only going to be considered the travel of information and money that happens when using the interoperable network.

The Figure 26 shows the different relations concerning this process. This process begins exactly when the user returns the vehicle and logs out with the common service provider platform.

1. Once the vehicle is properly parked and the user has logged out the car forwards the data corresponding to the usage of the service (time/mileage) to the particular carsharing operator.
2. The carsharing operator that owns the car calculates the bill taking into account the usage fees. Then sends it to the common service operator.
3. The common service operator receives the bill of the service. Then he charges the user for the particular service done.
4. The user is then charged with the actual amount to the account number that has provided to the common service operator.
5. The common operator receives the total amount of money. Then forwards the amount corresponding to the usage to the carsharing company that owns the vehicle. He is going to calculate a final bill for the user that is going to show the cost of all the carsharing services he has used at the end of the month and forwards to the user once a month.

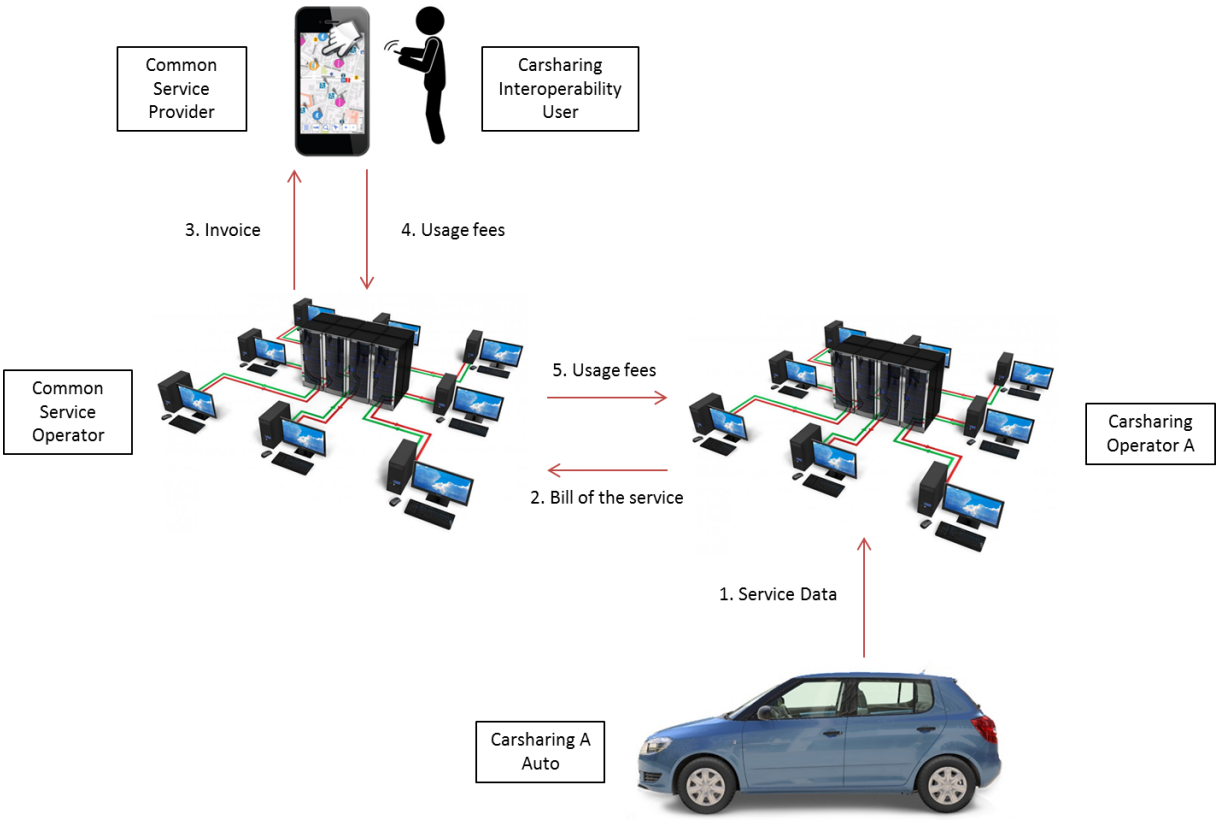

Figure 26: Travel of money and Information within the Billing process.

6.3 Summary of the Analysis of the Implementation of the Interoperable Model

In this chapter an interoperable model for the city of Munich has been proposed. For doing so, two architectural levels have been analyzed.

In the first architectural level, the Framework Architecture, different organizational scenarios have been proposed. These scenarios are to study how interoperability could be best established among the 5 largest carsharing companies of the city of Munich.

For deciding which organizational structure is most suitable, three structural levels are considered: the Content Provider Level, the Service Operator level and the Service Provider Level. From the possible relations among the operators at the three structural levels 5 alternative scenarios are presented with the most relevant advantages and disadvantages. The taking these into account 3 of the scenarios are preselected.

With these 3 scenarios an alternative analysis has been made taking into account the customer satisfaction, the overall efficiency, the agreement costs and the implementation complexity. From this analysis the scenario S3A has been selected as the most appropriate for the implementation of interoperability in the city of Munich.

Thereafter, the Reference architecture regarding the key activities of the carsharing service has been analyzed. The main purpose of this analysis is in the first place making a comparison of the involved carsharing operators to see the similarities and differences among them.

Once the main processes of carsharing have been identified, they have been redefined for the enablement of interoperability. A schema of every process has been described that takes follows the structure of the winning scenario of the Framework Architecture.

At this point, interviews with experts working on the considered carsharing organizations were developed to confirm the validity of the model and draw further conclusions on the establishment of interoperability in the city of Munich.

7 Expert Interviews

In this section it is shown a summary of the interviews with the experts. At the end of this master's thesis, in the Annex 1, there are the corresponding reports of the interviews, where more information can be found. Furthermore, attached with this master's thesis there are the audio files from the interviews to be found as well as the summary of the interviews that could not be recorded and the PowerPoint presentation used for introducing the model to the interviewees.

7.1 Methodology

The intention of these interviews is to get an opinion from the proposed carsharing interoperable model from the experts as well as recommendations on some of the topics of the model. To choose the experts for the interviews some criteria has been set.

First of all, the focus of the interviews has been on the carsharing branch so only staff-members of carsharing operators, which operate in the city of Munich, have been looked for. Moreover, it has been intended to realize an equal number of experts in both business models (free-floating and stationed-based).

Taking into account that there are only two free-floating operators in the city of Munich (DriveNow and car2go) the two experts from this business model are already set. It has also been considered that an expert from STATTAUTO had to be interviewed because it is the operator that most differences present with the other carsharing organizations.

Finally, CiteeCar (that is an example of a stationed-based carsharing organization) has been the operator that has completed the required number of experts to interview.

Moreover, a consultant of MRK had previously worked 4 years in Stadtteilauto Osnabruck, a carsharing system that combines the free-floating with the stationed-based model, gave also his expert opinion on the model (Lange-Stuntebeck, 2015).

In the same way, the manager of the MRK transportation division, with more than 15 years' experience in telematics and information services, gave as well his thoughts on the model as an expert on the topic (Kieslich, 2015). Although, their opinion was taken to reinforce the results of the model, those interviews are not shown, as they did not speak on behalf of the considered carsharing organizations.

It is crucial to understand that these interviews were the result of an iterative process: as new feedback information from the model was obtained, the questions for the following interview were slightly different and so was the proposed interoperable model. As a result, it has been possible to calibrate the model to a sufficient level of accuracy and realism.

For the development of such interviews a presentation in power point was shown to the interviewees, which shows the main points of the Analysis of the implementation of interoperability (chapter 6). This presentation was actualized when new information was received.
In the Table 11 the details of the interviews with the experts are summarized:

Company	Car2go	CiteeCar	DriveNow		STATTAUTO
Interviewee	Andreas Reiter	Birger Holm	Christian Bäres	Katrin Lippoldt	Olaf Rau
Position	Sales Director	Business Development	Business Development	Business Development	Former Managing Director
Date	06.11.2015	10.11.2015	20.11.2015		26.11.2015
Type of interview	In person	Telephone conference	In person		Email
Business model	Free-floating	Stationed-based	Free-floating		Stationed-based

Table 11: Details of the interviews with the experts.

7.2 Summary of the interviews

In this section the most important conclusions obtained from the interviews have been summarized. The information summed up here is going to provide the material for developing the final conclusions of the model.

7.2.1 Interoperability

Do you believe interoperability is worth it for the carsharing world? Which threats and opportunities do you see? Do you think it can be achieved in the city of Munich?

- Car2go: “I think if an interoperable system works, is because all the carsharing organizations are involved. The objective is to make such an attractive carsharing offer that the citizens of the city of Munich decide to get rid of their cars. However, the bigger benefit is going to be perceived by the smaller players. Something really great has to be offered to Drive Now (80.000 clients) and Car2go (25.000 clients) in order to join this interoperable system while joining their clients."
- CiteeCar: “From a technical perspective it is absolutely possible to have a joint network. The biggest problem is about psychology and trust. The problem in Germany was that there was a lot of mistrust because of the Deutsche Bahn AG.”
- DriveNow: “Interoperability makes a lot of sense in the actual carsharing situation. It is actually sort of happening. We are aware that lots of our users are registered to more than one carsharing service operator and very often they combine the stationed-based model with the free-floating model. Enabling interoperability would be a logical reaction to the present situation.”
- STATTAUTO: “For the users of carsharing it would be interesting for sure because their mobility would then be more flexibly shaped. However, I believe that right now cooperation between all the operators of the city of Munich is a bit unrealistic because the interests among them are too dissimilar. STATTAUTO could imagine participating in such an interoperable system when it was demonstrated that the use of the free-floating carsharing model (DriveNow and Car2go) per se is sustainable.”

7.2.2 Framework Architecture

Which scenario is the most appropriate to establish interoperability?

- Car2go: “Scenario 3SA is the best scenario to implement interoperability, because of the fact that there is a central organizer that would be able to organize and edit data and would lower the agreement costs if properly implemented.”

- CiteeCar: "The scenario 3SA is the most appropriate to enable interoperability. The central operator must have access to the information of the particular carsharing operators from the city of Munich to avoid situations where cars are booked twice. It is vital to know who is going to pay for the infrastructure that enables interoperability."

7.2.3 Figure of the Central Operator

Who would be a good candidate for being the central operator of an interoperable system within the city of Munich? Would you consider the MVG a good candidate to do so?

- Car2go: "It could be great to have MVG as a central operator and develop a combined offer of carsharing and other public transport services like the MVG Rad for example. The plan is to get closer together with MVG, who would be very attractive to join because its great number of clients they have."
- CiteeCar: "MVG is appealing to the carsharing operators because of its customer base and the possible implementation with public transport. Although MVG is a good idea for the city of Munich we must think on a national level. In that case, MVG is not appropriate."
- DriveNow: "A good idea for the figure of the central operator would be someone complete out of the game, someone who would take the risk of the financial aspects (insurance and payments) and would do that because of being interested in the customer base and use the information as a research project. MVG is not a good candidate because it would take too long to come to an agreement, and because made no sense at a national level."
- STATTAUTO: "I could easily imagine the MVG, in its role of municipal society, as a central operator because they already have collaborations with the carsharing operators and they have the required competences as well."

7.2.4 Access Device

Which are the benefits and drawbacks of choosing smart card technology or mobile phone technology to access the vehicles?

- Car2go: "It is fundamental to equalize the access system in order to enable interoperability. The smart-phone technology is more appropriate because the searching function already requires a mobile phone, so there is no need to introduce and extra accessing device."
- DriveNow: "DriveNow vehicles can be both accessed with smart card and mobile phone. The mobile phone technology is very convenient but the smart technology serves as back up device in case of having problems with the battery of the mobile phone."
- STATTAUTO: "I do not see any drawbacks for the user when the access to the vehicles is done by card instead of mobile phone app. However, in cooperation with all the operators there could be difficulties when different access systems were used that are not compatible."

7.2.5 Additional Usage Fees for the Use of the Interoperable System

Do you think fees are to be established for using an interoperable system in Munich?

- Car2go: "It is necessary to establish different fees for the different carsharing operators. Lower fees should be established for the users of Car2go and DriveNow because they have a more interesting customer base."
- CiteeCar: "The users should pay interoperable fees for using the service. They should pay on a per-used trip basis because users would then only pay for interoperability when they perceived an added value."
- DriveNow: "It is not a good idea to implement extra usage fees because users are really price sensitive and could endanger the whole carsharing business model. Such a business model could lead to misuse of the service (I would download the interoperable app, look which car is the most convenient for me and then book it through the service provider of the particular operator, paying it registration fees)."
- STATTAUTO: "To operate an interoperable system like that costs money, which at least partly would have to be financed through higher tariffs or fixed costs."

7.2.6 Access Barriers to Enable Interoperability

Have you thought of eliminating registration costs, as they are a barrier to enable interoperability?

- DriveNow: "We maintain registration costs as an access barrier so the customers do not have instant access to the service and make a misuse of it. However, we could accept to turn down the registration fees because we are aware it can hinder the implementation of interoperability."
- STATTAUTO: "We have thought of the abolition of our deposit and we have already implemented an offer called "Young mobility" for apprentices and students (there is no deposit, no monthly fees, but with 10% higher usage fees in exchange). 33% of our Fleet is already automatized."

7.2.7 Legal Aspects

Do you have any concerns on legal aspects on such an interoperable model?

- Car2go: "Users have to accept the terms and conditions of the carsharing operators that they want to use and they would be treated as normal user in case of accident."
- CiteeCar: "It is vital that the users accept the terms and conditions of every single carsharing organization they are whiling to use. There are 2 major issues from a legal point of view. Firstly, it has to be defined who should be responsible for communicating with the customers (owner of customer information). Secondly, how should operators organize their systems together (in legal terms). It is crucial that the central operator, in this case MVG does not offer himself a carsharing service."
- DriveNow: "The problem with registration is that because of the German law the driving documentation cannot be 100% online."
- STATTAUTO: "Nowadays the insurance of the carsharing roaming networks is organized in such a way that the user has to abide the conditions of the carsharing organization whose service is being used. Nevertheless, in an interoperable system it would certainly be meaningful to settle a unified insurance."

8 Evaluation of the Interoperable Model

This discussion comes from the interviews with the experts were the principal conclusions that describe the interoperable model are summarized (chapter 7). These conclusions are classified in three fields: organizational, technical and economic aspects.

8.1 Organizational Aspects

In the chapter 6 (Analysis of the Implementation of the Interoperable Model) the scenario S3A has been selected as the most suitable scenario for enabling a carsharing interoperable model in Munich. Thereafter, this scenario has been confirmed in the interviews with the experts as the most appropriate scenario for establishing interoperability (chapter 7).

In the scenario S3A there are a common service provider and a common service operator that have to be implemented and someone has to take the role of developing those functions. In terms of ownership this operator can have two main natures (World Bank, 2004):

- State owned enterprise: The benefits of this kind of organization are that no competition interests would be involved. Therefore the different carsharing organizations would be more confident to participate in such a project.

- Private enterprise: Because of acting in behalf of economic reasons, the organization can become more efficient. The problems are that an enterprise of this nature is probably not going to be neutral with the involved stakeholders. Therefore, it could be that not all the carsharing organizations are involved in such a project.

The first candidate that has been considered is moovel from the private sector (chapter 4), but it has been rapidly discarded because of the high level of competition with some of the carsharing organizations involved in the mode (as we have seen moovel is a subsidiary of Daimler like car2go).

Thereafter, MVG from the public sector was considered an optimal candidate for fulfilling this function. The main reason for believing so is that MVG has already have a contractual relation with almost every carsharing organization in Munich (except from Flinkster) and has already developed a common service provider where the complete carsharing offer of Munich is shown (explained in chapter 4).

Furthermore, its large customer base could be a reasonable argument to convince the carsharing organizations to join an interoperable model. For those reasons the experts of STATTAUTO and car2go (see chapter 7) considered that it was a good candidate for developing this function.

However, after the interviews with the DriveNow experts (see chapter 7) it was suggested that MVG was not an interesting idea because the negotiations with state-owned enterprises are too slow to ever come to realization.

Moreover, in two of those interviews (DriveNow and CiteeCar) it was pointed out that it did not made sense at a national level. Thereby, it is foreseeable that if every local transport association

makes its own interoperable system, the following problem will be to implement interoperability at a national level.

It had been taken for granted that the candidate enterprises that wanted to take the role of the common service operator had to come from the mobility sector, independently of being public or private.

After the interview with DriveNow, it was suggested that actually the best option would be someone that was complete out of the game (see chapter 7). Their suggestion was that it should be someone that could take the risks of the financial investment. Siemens and Bosch were proposed as two optimal candidates for fulfilling this function.

On the one hand, these firms are large enough to accept the financial risks of enabling interoperability at a national level and because they had already shown their interest on collaborating on such a project. Their greatest appeal for involving themselves in such a project would be because of gathering marketing information of the customers.

Moreover, PayPal was as well listed as a great candidate because of financial reasons and because of the interest they could have on customer information. Following the guidelines given by the interviewees it is believed that a suitable candidate would be Google (was confirmed in the interview with DriveNow).

That is because the firm has a great budget for research projects and they could offer the service as an extension of Google Maps (the people would the access the service through the google maps app). Given the strong and aggressive market expansion of Google in the mobility sector in the last decade (Route One Publishing Ltd, 2012), it is possible that the company will seek new business opportunities in sales of mobility products and services, including public transport tickets.

Furthermore, after literature research Google is presented as a relevant director of the mobility of the future (Cornet, et al., 2012).

A suitable candidate for assuming the responsibility of the common service operator would be a player that is in the position to assume the financial risks of the investment in exchange of marketing information.

8.2 Economic Aspects

8.2.1 Access Barriers to Enable Interoperability

When a fully interoperable model has to be developed, registration costs are only access barriers that hinder interoperability. A customer that wants to use an interoperable carsharing system is not whiling to pay all the registration costs of every single carsharing operator.

The interviewees agreed on this (STATTAUTO DriveNow) and expressed that they would not have a problem with turning down registration costs. They said that they only had established registration costs in order to avoid people registering without any interest on using the service. A common interoperable registration fee could be implemented. This could serve as a regulatory measure to avoid people doing a misuse of the system and to help financing the whole interoperable model.

Another access barrier could be the deposit from the carsharing organization STATTAUTO. Nevertheless, as this has directly to do with the insurance it is further discussed in the Insurance section.

A common registration cost is to be set in order for the users to access the interoperable system where all carsharing operators are involved.

8.2.2 Additional Usage Fees for the Use of the Interoperable System

One logical argument is to believe that interoperable fees among operators should be set. From the theory of networks (chapter 3) it has been argued that carsharing operators will only accept to interoperate when they perceive a benefit from interoperability.

Therefore, through the establishment of additional fees (like in the ATM network or the roaming service for mobile phones work), the carsharing organization (as well as the common service operator) could perceive this benefit from the interoperable system. Moreover, fees could serve as a regulatory measure to clearly differentiate new users from one service to another.

However, in the interview with DriveNow (chapter 7) it was argued that the customer was extreme price sensitive. Therefore, the establishment of fees could hinder the business model of carsharing. Thereby, if no interoperable fees are settled, it could be asked from where the operators are going to benefit from.

As it has already been explained in this chapter, and from the interview with DriveNow, they could benefit from the fact that some player outside the mobility sector accepts the financial risks of such an interoperable system. The motivation for such an enterprise would be to obtain customer information for marketing purposes.

Interoperability fees do not have to be charged on the customers. The investment on the interoperable network has to be financed by the common central operator.

8.2.3 Owner of the Interoperable Network

If no differentiating measures are set (such as interopera2bility fees or registration costs) it is at first glance hard to tell who has to be the owner of the customers. It could be asked why someone should choose an operator upon another when there are no fees or difference between registration costs.

However, if an interoperable package is to be developed where users can access all the vehicles of the involved organizations, they should agree on sharing their data with all the operators that are involved in the interoperable model and with the central operator as well (and accept their terms and conditions).

In order to develop this interoperable carsharing model two IT networks have been identified. If we take a look at the framework scenario S3A again we can better differentiate both infrastructures:

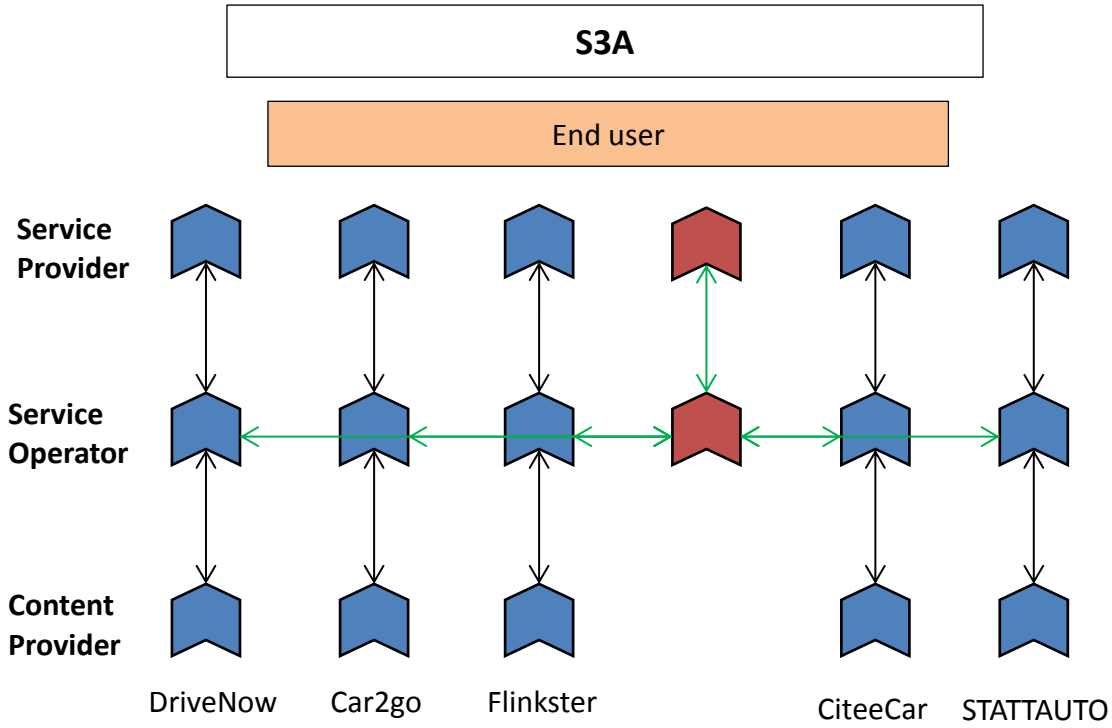

Figure 27: IT Infrastructure of the proposed framework Scenario.

In the Figure 27 the present infrastructure is left in black and the interoperable is represented in green (for the elements red color indicates common agent and blue individual or private agent, as a reminder from chapter 6).

Therefore, we can observe in the framework scenario 3SA that there are two differentiated IT-infrastructures. One is the already existing infrastructure, in which the customers are handled by every carsharing organization individually (in black color). The other is a new infrastructure that has to be created in order to enable interoperability through a common service operator (in green color).

The investment for this new infrastructure has to be made by the organization that assumes the role of the common service operator, as well the software and the Interfaces that have to be made with the operators. In exchange, the access to all the information regarding the interoperable carsharing system is gained (carsharing organizations would only have the possibility to access the data of their company).

An important consideration has to be made about the interoperable carsharing system. All the operations have to go through the common service operator too (as well the information of the users that are only registered to a single organization) in order to avoid double-bookings of the same car.

The IT-Technology of the new infrastructure belongs to the common service operator (investor) and the access to the data of the interoperable system. The carsharing organizations can access the data of the customers who have joined the interoperable system and to the data of their vehicles.

8.2.4 Insurance

The proposal of this document for the insurance is when the users signs the new contract for using the interoperable service they agree to follow the rules of the insurance conditions from the carsharing companies whose services they want to use, as it has been confirmed in the interview with STATTAUTO (see chapter 7).

The insurances of the vehicles are calculated taking into account the particular conditions of every carsharing company. Therefore, the users should agree to meet their terms and conditions.

It is as well interesting to remark that there are new insurance models based on the behavior of the driver (regarding sustainability or security). With a telematics infrastructure it would be possible to introduce reward or penalization according to the user's driving behavior (Husnjak, et al., 2014).

However it has to be considered that STATTAUTO is not ready to turn its deposit down (although having made relevant efforts, as seen in chapter 7). That represents a very important access barrier.

Therefore, it makes sense that the common operator helps assuming the insurance costs of the carsharing organization. Nevertheless, in an interoperable system it would certainly be meaningful to implement a unified insurance (as seen in the interviews, see chapter 7).

The users of the interoperable system would have to abide the conditions of the carsharing organization whose service is being used. Nevertheless, in a later stage it would certainly be meaningful to settle a unified insurance that profits from the telematics system of the vehicles.

8.3 Technical Aspects

8.3.1 Access Function

The main problem with this function is the harmonization of technology used for opening the cars. The technology associated to the automated car and the carsharing world is being constantly enhanced by the use of telematics (FIPA, 2015). Thus, it is difficult to define a particular technology but it makes no sense to have different access devices.

There are two main trends in the access technologies for the carsharing technology. These are the smart card (RFID) and the smart phone technology (Wi-Fi and Bluetooth) (INVERS, 2015). It has been shown in the Table 10 that those are the access technologies, which are used by the vast majority of operators considered in this document. As it has been confirmed in the interviews with the experts (chapter 7), it is vital to implement a fully integrated system in order for this to be attractive. It only makes sense then to choose one accessing technology.

Having analyzed the literature research on this topic (INVERS, 2015) and taking into account the opinions of the experts the conclusion of this document is that the best access technology is the smart phone and the recommended technology for an interoperable carsharing network in the city of Munich.

That is mainly because users already have to use the smartphone for finding the cars so it is not coherent to introduce an extra device. Moreover, when being abroad users do not necessarily need an Internet connection because the vehicles can as well be opened with Bluetooth technology.

One advantage for using smartcard is the fact that there is no risk of running out of battery. It is for that purpose that some carsharing organizations (such as DriveNow) enable to access the cars with both mobile phone and smartcard technology.

Lastly, the conclusion on the access process is that the entire involved carsharing organizations should enable access at least with mobile phone technology.

8.3.2 Technical Description of the Processes of the Model

An interoperable carsharing service for the city of Munich has been proposed through the description of the key activities of the carsharing business model. This proposal has principally defined the main organizational relationships among the carsharing agents that were introduced in the previous chapter.

For the establishment of these relationships, interfaces among the carsharing service operators and the common service operator have to be set. With this purpose in mind, the information has to undergo a standardization process that enables the connection of all the carsharers with the central operator. These and other requirements are hard to overcome because of technical complexity and high agreement costs, but are not impossible as the actual relation between Car2go and Flinkster shows (chapter 3).

The purpose of this section is to sum up all the characteristics and considerations that have been made during the description of the carsharing processes and further explain how this system would function but from a more global perspective. For doing so, the following process diagrams have been designed. In these process diagrams the actions that users have to carry out are represented and which agent is involved when doing so (at which structural level).

Thereby, all of the carsharing processes introduced in chapter 4 and further explained in the previous sections of this chapter are represented. The registration process is represented in the first diagram. The processes of booking, access and logout that represent the actual use of the service are represented in the second diagram.

The billing process is represented in the last of the three diagrams. Last but not least, the metering and accounting process is represented in the third diagram as well when referring to the process of sending the data (which is the conclusion of the metering and accounting process).

The different elements of these diagrams are: the end user, which carries outs the actions through the commons carsharing service provider; the service provider, which is the common platform that enables the carsharing interoperable service; the carsharing content provider, which is the infrastructure (the vehicles) that give the information of the service; and the common carsharing service operator and the common carsharing service operator that are the background organizers of the whole service. It is important to remark that communication between the particular and the common service operators is vital to avoid malfunctions of the service.

The first diagram, represented in Figure 28, shows the various steps that users have to follow in order to register to the proposed carsharing interoperable service. This diagram differentiates between new carsharing users and users that are already registered in one of the carsharing operators of the city of Munich (the ones that are considered in this document).

Both types of user can decide if they want to use the interoperable carsharing service or not. It is important to remark that the users that were already registered could sign the interoperable contract either online or per post (because they have already shown their information to a carsharing operator who can further the information to the corresponding parties). As it can be deduced from Figure 28, the new users that want to use the interoperable carsharing service can do so in any of the involved carsharing operators.

The second diagram, which is illustrated in Figure 29, shows the processes of the whole service taking into account the main functions that the user can execute when using the common service provider platform (mobile phone app).

These functions are the reservation of the car, the access to the car and the log out of the car. In means of simplicity, Bluetooth technology has been represented for access and logout because the Wi-Fi technology is already used for the booking process (so it would be similar on the access process) and because Bluetooth technology can be as well used when users have no internet connection (but it would be possible as well to use Wi-Fi technology for the access and logout processes).

One of the most important aspects to consider for the proposal of the model is who is going to charge the money. As it has been already explained, this document proposes two differentiate between the existing carsharing service and the interoperable carsharing service. For the interoperable carsharing service the common service operator would be responsible for charging the money to the customer and forward the money to the carsharing operator.

In fact if such an interoperable system were to be made the common service operator would act as well as a financial organization because of the fact that it would assume the financial risks (as deduced from the expert interviews).

The common service operator would then charge the user with both and send later the usage fees to the corresponding carsharing operator. It may be argued that the carsharing operator that owns the client should be paid as well, but in order to make the system simpler and more efficient it is proposed like this. Moreover, it is believed that, by reciprocity, the carsharing operators would perceive similar profits by both methods. The Billing Process diagram is shown in Figure 30.

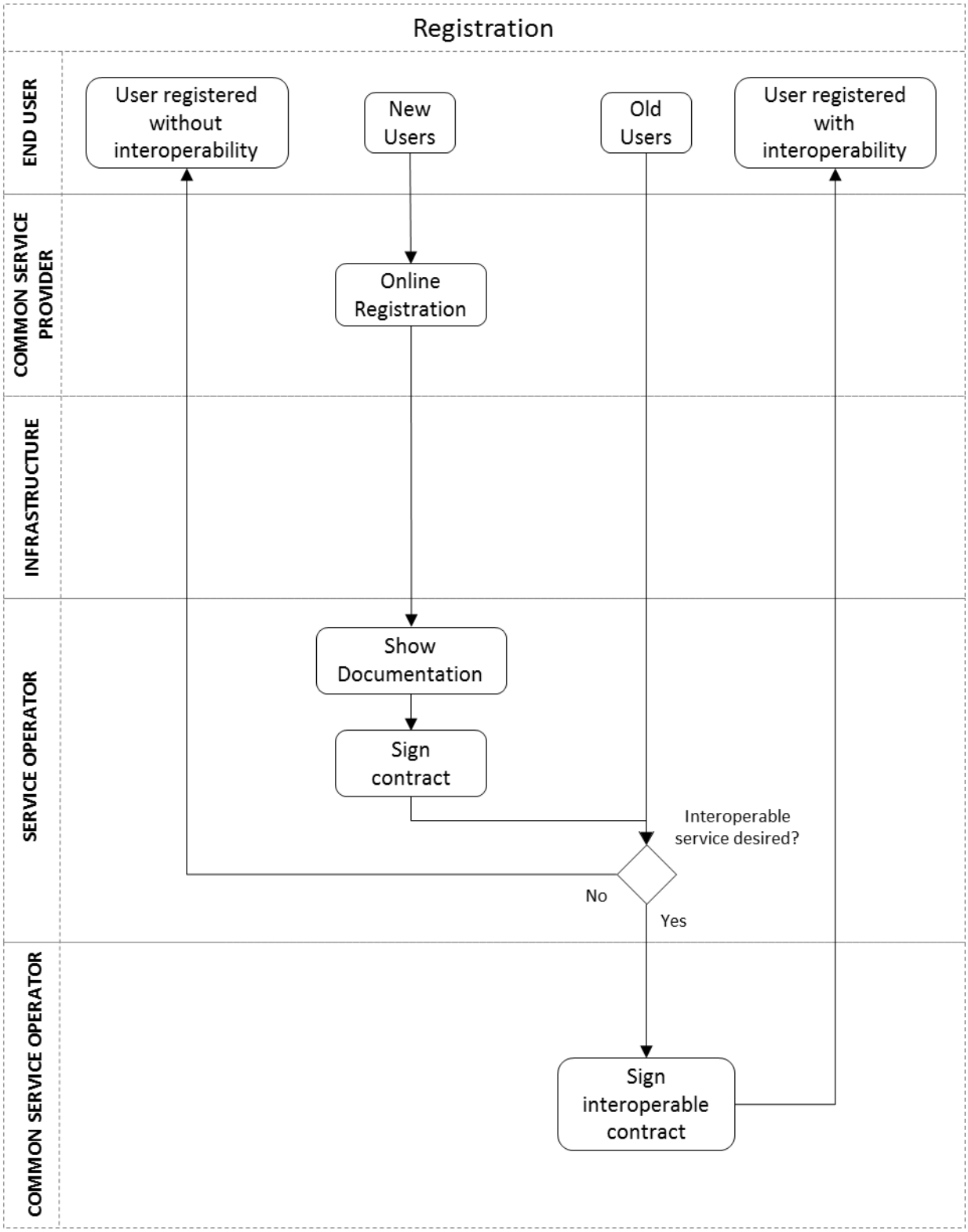

Figure 28: Process diagram of Registration operation.

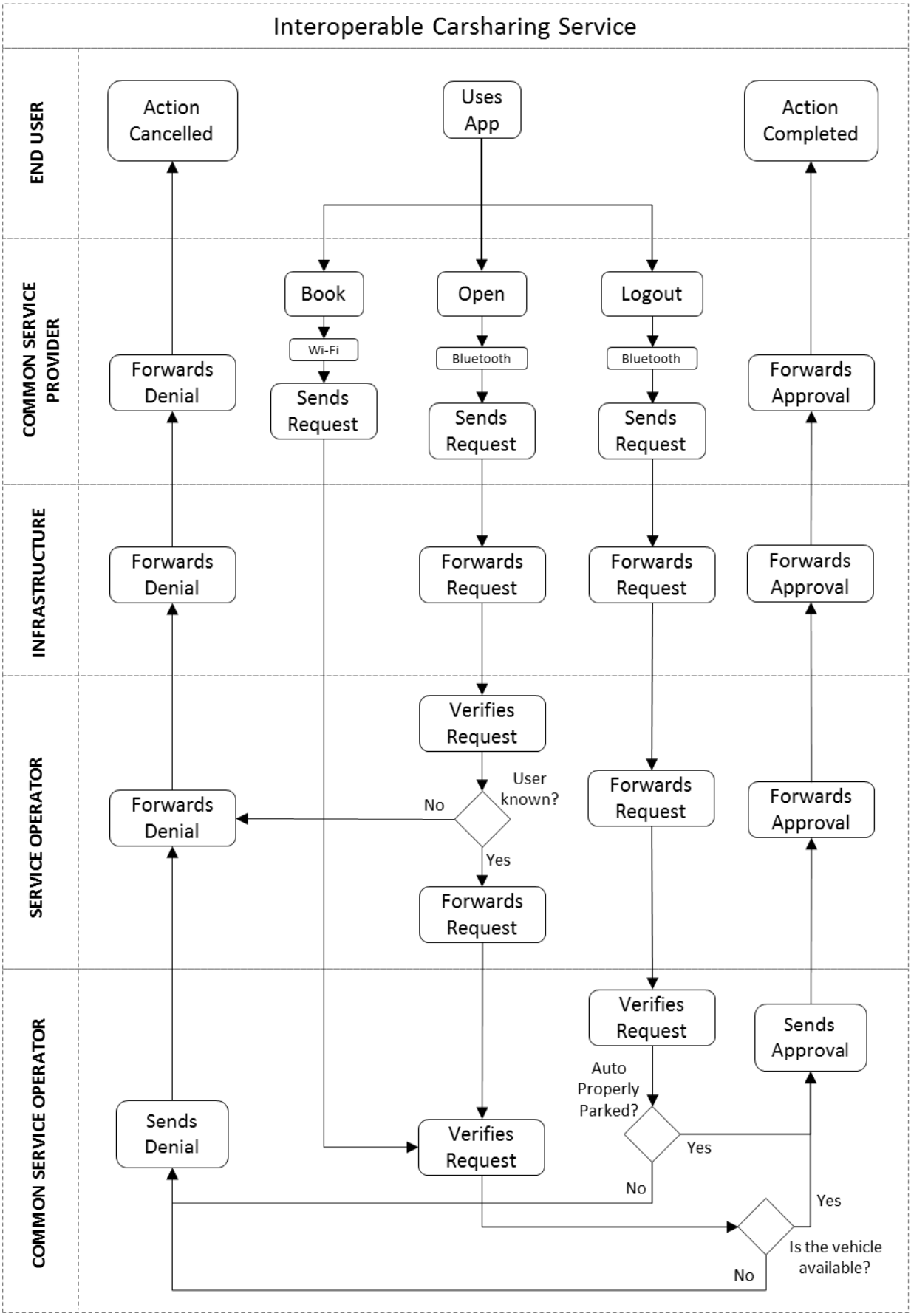

Figure 29: Process diagram of the carsharing interoperable service functions.

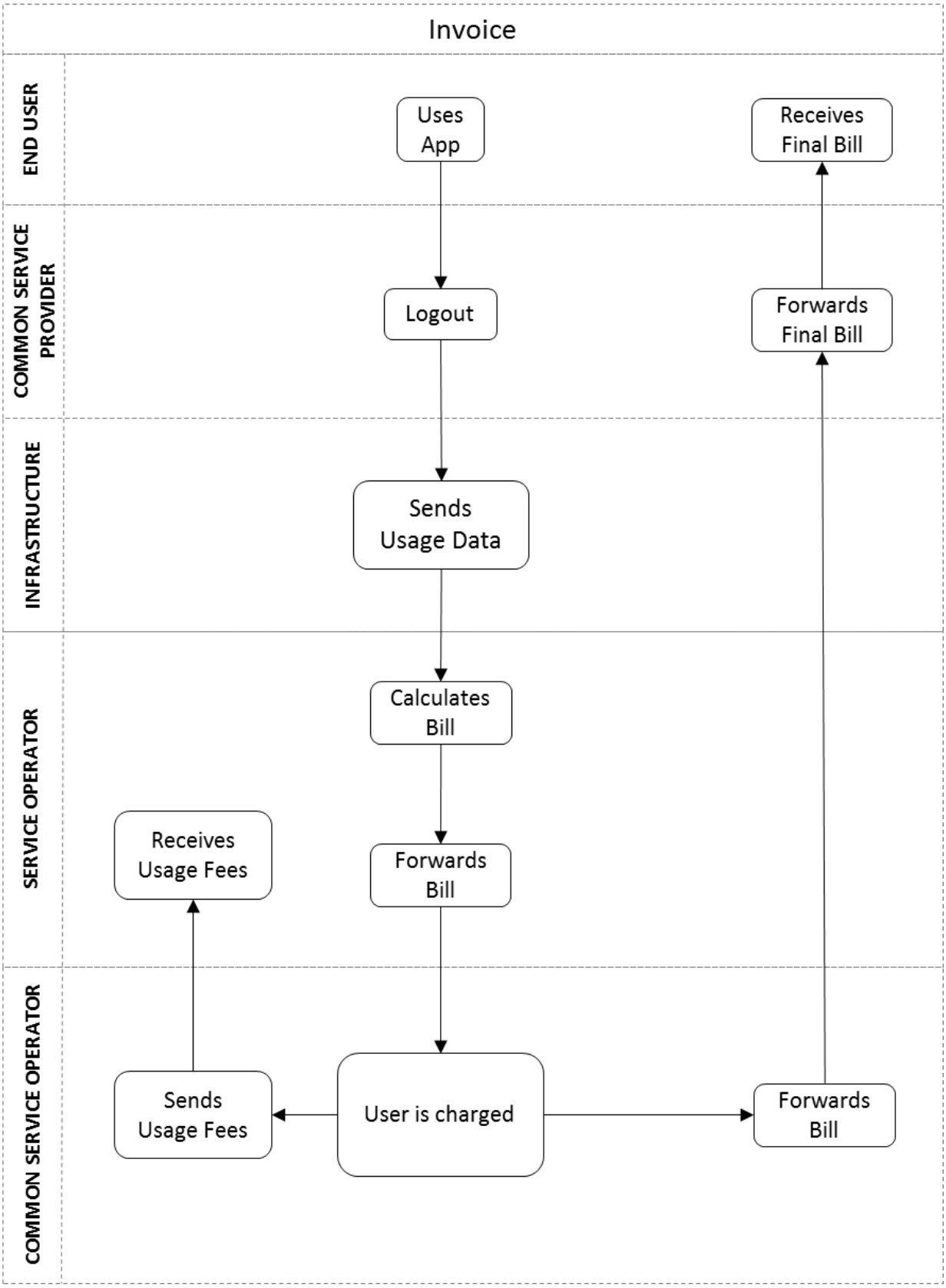

Figure 30: Process diagram of the Billing operation.

8.4 Summary of the Evaluation of the Interoperable Model

In this section the interoperable model has been further detailed. Thanks to the literature research and the opinions of the experts it has been possible to describe this interoperable model focusing on three main aspects: organizational, economic and technical.

On the organizational aspects it has been commented how would be the profile of an appropriate candidate to fulfill the functions of the central operator. These recommendations are based on the interviews with the experts (chapter 7).

Thereafter, the most relevant economic matters have been discussed. Firstly, the fact that registration costs can act as access barriers to hinder interoperability is considered. Secondly, the possibility of implementing extra usage fees for the use of an interoperable carsharing system is argued. Thirdly, it has been figured who could be interested on the investment of such an interoperable network. Last but not least, the matters relating to insurance have been reviewed.

Finally the technical aspects of the model have been examined. Here the importance of having a single accessed device has been pointed out. Moreover, and with the aim of giving a global view of the project, diagram processes have been defined to show the possible situations that a user would undergo in the different key processes of the interoperable carsharing model.

9 Conclusions

It is interesting to judge to which extent has the defined interoperable model reached the expectations that where set at the beginning of the present master's thesis. In order to carry out the evaluation of the model, it is of a great interest to develop a strength and weaknesses analysis. Moreover, once that the scope of the project has been covered it is as well thought provoking to give recommendations or steps towards further research.

Finally, and with the aim of giving an outlook of the present document, the goals shown in the introduction are going to be recalled and it is going to be evaluated to which extent they have been accomplished.

9.1 Strengths and Weaknesses

With the aim of making a critical analysis of the model presented in this master's thesis, its strengths and weaknesses are shown in this section.

9.1.1 Strengths of the Model

First and foremost, the methodology of this document has consisted on the interviews to experts on the carsharing world. These interviews have given a great insight and perspective to understand the topic of interoperability in Germany and in Munich. It has been seen that interoperability is not only a present topic but also one that the carsharing operators consider paramount for the future of carsharing.

Moreover, four representatives of the five studied carsharing operators have been interviewed (car2go, CiteeCar, DriveNow and STATTAUTO). All the carsharing business models of the two categories that are present in Munich are considered through the interviews: the free-floating model (car2go and Drive Now) and stationed-based model (CiteeCar and STATTAUTO). That gives a lot of consistency to the methodology because practically the overall panorama of the city of Munich in regard to carsharing has been contemplated.

Through the literature research and thanks to the expert interviews it has been seen that such an interoperable model is technically possible and that there already exist interoperable systems in the carsharing world and other industries.

Additionally, some enterprises that have been mentioned in this master's thesis could make the investment to develop the network infrastructure necessary to enable interoperability among the carsharing operators and to settle a procedure to assure the maintenance of interoperability for the operators that want to join the system later.

Furthermore, it has been understood that the main problem are the high level of agreement costs. Thereby, the most relevant organizational elements have been defined as well as the relation among them. Through the proposal of this interoperable model, the first milestone for the development of an interoperable system for the carsharing industry has been reached.

9.1.2 Weaknesses of the Model

There are some aspects of the methodology that reduce the relevance that this model could have. First of all, it would make a lot more sense to consider a national or international level to establish an

interoperable model because if every region makes its own independent interoperable model then they have to be made interoperable with one another again.

The dictation of the guidelines for an interoperable carsharing system at an international level would avoid lots of unnecessary harmonization efforts. However, with the means at reach it was only possible to analyze the situation in Munich. The good thing is that the proposed model can easily be extrapolated to the whole extent of the German territory.

In addition, some of the carsharing organizations that are involved in the model are global players that could exercise a great influence to achieve this goal.

Another weakness of the model is that the figure of the common operator is not fully defined. Some organizations have been proposed for playing this role. However, the main problem is to find someone that could be interested in developing such a system. The goal of implementing interoperability is ambitious and to take the first step it's decisive in order to achieve it.

The goal of this master's thesis was the conception of an interoperable model. Therefore, many economical, technical and organizational factors go not a lot into detail. In this way many of the problems that would have appeared when enabling interoperability have not been encountered.

Finally, the structural definitions of the situation, the relationships among the elements and the scenarios have been simplified. In this way, the proposed interoperable model loses a bit of realism.

9.2 Need for further research

As it has already been said, the main goal of this project has consisted on the conception of an interoperable model in the city of Munich. Thereby, it makes a lot of sense to deepen on some of the aspects considered in this project.

Economically, and with the aim of getting an idea of the profitability of interoperability, the number of customers that would be attracted through the implementation of interoperability (for example in the city of Munich) should be calculated. Additionally, estimate the costs for the implementation of the model, taking into account the necessary hardware and software and compatibility among access devices among others.

Organizationally, and in order to further detail the structure of the model, expert interviews with the proposed candidates for the figure of the central operator could be made. Another possibility would be to further define the relations of the different elements of the model to make it more realistic.

Technically, the interfaces needed among the carsharing organizations and the central operator could be defined. Moreover, the hardware elements needed to implement such a system could be described (that would help to estimate the investment costs as well). Finally, it could be of interest to define system architectures for the implementation of the system.

9.3 Summary and Outlook of the Master's Thesis

The purpose of this master's thesis was to conceive a solution that enabled a client of one carsharing provider to use cars from other carsharing companies in the city of Munich. In this city carsharing plays a paramount role in the mobility sector with many organizations offering their services.

These companies have the potential to be complementary to each other and make the mobility offer even more attractive. Therefore, the need for a cooperative network to create synergies among carsharing operators has been identified. With this purpose in mind, this master's thesis has tried to describe how should be the overall organization among operators and which carsharing processes should be harmonized in order to achieve interoperability.

Through the development of this master's thesis it has been seen that the establishment of interoperability is an ambitious goal to accomplish. Moreover, it seems a relevant challenge to find an investor who is whiling to fulfill the figure of the central operator.

However, there are reasons to be optimistic with the future implementation of an interoperable carsharing system. The carsharing organizations believe that it is a logical step towards the further development of the carsharing market and there are already organizations that could play the role of the central service operator.

The reality may be that the carsharing market is still not in the point of making its system completely interoperable. The first priority is to reach the maximum number of customers possible. Once this situation becomes a reality and the carsharing market is saturated, interoperability could help to provide an attractive carsharing mobility offer.

Nevertheless, the actual carsharing market shows that interoperability is becoming a reality. Examples of that are the different approaches to implement interoperability like for instance the ones that have been shown in this master's thesis (in chapter 4).

The ultimate goal of interoperability is to help make the mobility offer more appealing and to foster modes of transportation that are more respectful with the environment. Moreover, carsharing has turned the use of the car wiser and interoperability has the potential to maximize this effect.

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Annexes

Annex1: Expert Interviews Reports

In this section it is shown the reports that were a result of the interviews with the experts. Furthermore, there are commentaries and conclusions from the opinions and facts to the opinions of the experts.

The structure of every report is very simple. At first, the reason for choosing every interviewee and a little introduction of every one of them is given. Thereafter, the main characteristics of the interviewees are shown. Lastly, the report of the interview is presented.

In these reports there is essential information that has been used for the development of the project. There are also confirmations of some of the ideas that have also been used. It can bee of a great interest for the reader to read this chapter to fully understand some of the conclusions reached on other chapters.

Car2go

Car2go is a subsidiary of Daimler AG, which provides carsharing services in European, North American and Asian cities. In Europe the company is a joint venture between Car2go GmbH and the car rental enterprise Europcar. The company started operating in Ulm, Germany in October 2008. (Autoblog, 2008) As of June 2015, Car2Go operates over 13.500 vehicles (from which 1300 are electric vehicles), which serve eight countries and 30 cities worldwide with over 1.000.000 customers that make it the largest carsharing company in the world. In Munich they have a fleet of 500 vehicles. (car2go, 2015).

Andreas Reiter has been working in the Car2go offices for two years now and his experience as sales director gives consistency to his opinions. He has also 8 years' experience on the car rental business that is closely related to the carsharing one.

Interview Details:

- Interviewee: Andreas Reiter
- Position: Sales Director in Car2go Munich.
- Date of the interview: 06.11.2015
- Length of the Interview: 00:35:44
- Corresponding Audio File: EI1_Car2goAndreasReiter_06112015_FrC

Interview Summary

First of all, the interviewee received a brief introduction of the carsharing model that is exposed in this Master Thesis. In this introduction the different scenarios for achieving interoperability were presented. The comments on these scenarios were:

- Scenario 1: It is rather unrealistic because companies either do not want to share their data or they are not allowed to do so.

- Scenario 2A: It is not more than a central service provider so it would not be able to edit data or incorporate new mobility services.
- Scenario 3A: **It is the best scenario to implement interoperability**, because of the fact that there is a central organizer that would be able to organize and edit data and would lower the agreement costs if properly implemented.

When talking about the data protection it was agreed that **the central operator could create IDs** for the customers in order not to share the data of the customers with the organizations in which the user is not registered. This would be like the cooperation between Flinkster and car2go.

Once the model was presented to the interviewee, he expressed his concerns about the difference of value that every carsharing would offer when joining such an interoperable model: "The presence of two players in this model (Car2go and DriveNow) with other operators that have fewer clients and a fleet with lower cars. These two players have invested a lot in Munich in order to achieve this great number of users. **The bigger benefit is going to be perceived by the smaller players**. Something really great has to be offered to Drive Now (80.000 clients) and Car2go (25.000 clients) in order to join this interoperable system while joining their clients."

Possible arguments were presented to the interviewee in order to overcome this situation and to show the benefits that can represent even for the bigger players, these were:

- **Set different interoperability fees** for the customers that want to join the system, according to the organization they belong to (organization with fewer clients would pay higher interoperability fees in order to use the interoperable system).
- These customers would be shown to a (neutral) central service operator but not to the other carsharing organizations. **Their users are not fully shared** (the other organizations do not receive the data from this customers).
- There is a **greater client attraction** because of a more attractive carsharing offer that combines different types of carsharing business models.

The interviewee made the following comments to these recommendations: "It is necessary to establish different fees for the different carsharing operators. Free access should be offered to the DriveNow and Car2go members, while the customers of other carsharing organizations should pay to use other services than their own. It is going to be harder to convince DriveNow and Car2go to join so a more attractive offer should be made to them" (the statement about free access for the Drive now and Car2go users is not realistic because then all users would register to these two carsharing companies). "**Take into consideration the customer base**. The association of Car2go with the Detusche Bahn (Flinkster) is very interesting to Car2go because of the customer base. The number of customers that every carsharing association can bring in to the interoperable system is what is going to make the offer more attractive in order for the other organizations to join. **The customer base of CiteeCar or STATTAUTO is not so attractive**."

The interview was then asked if he thought that in 10 years from now the only surviving carsharing organizations in the city of Munich would be Car2go, DriveNow and Flinkster. The interviewee answered the following: "No. **I think if an interoperable system works, is because all the carsharing organizations are involved**. I believe that STATTAUTO for example is a very important part of such a model because free floating is all right for the inner city, but if you want to go outside the city the models that are stationed based are more economic for doing so. **The objective is to make such an attractive carsharing offer that the citizens of the city of Munich decide to get rid of their cars**.

The conversation shifted into the actual relationship between MVG and Car2go and the other carsharing organizations of the city of Munich. "**The MVG has a contractual relation with all the carsharing organizations considered in this document except for Flinkster**. Little steps are being done in order to achieve interoperability. MVG is an attractive partner because they have about 300.000 clients who would an Isarcard." When the interviewee was asked if he thought if MVG was a good candidate to serve as a central carsharing operator he said: "**It could be great to have MVG as a central operator and develop a combined offer of carsharing and other public transport services** like the MVG Rad for example. The objective is to register only once and be able to use all the mobility services of the city of Munich."

Then the interviewee suggested that another possible option for the figure of the **central service operator was Moovel GmbH**. He said that many mobility services had already joined that system (Deutsche Bahn, VVS, Car2Go and Flinkster among others) and that it would be great to incorporate all the other carsharing operators of the city of Munich. However, he agreed that the other carsharing operators (especially DriveNow) would not agree to join the Moovel system because it is a subsidiary enterprise of Daimler (high level of competition with BMW).

The interviewee also suggested that **it was fundamental to equalize the access and metering accounting systems** in order to enable interoperability. He also shared his opinion that **the mobile phone is the most appropriate technology to access the cars**: "The Smart-Card Technology is from yesterday, the new Car2go vehicles can only be accessed by Smart-phone". On the one hand, because when users book a vehicle they already need to use the mobile phone so there is no sense on introducing another device. On the other hand, because it is more convenient when implementing new services (users just need one device and not many Smart-cards). He added that **other barriers for joining an interoperable system are the maintenance of a deposit system or the monthly fees (STATTAUTO).**

Later on the he was asked if he thought Car2go would agree to join an interoperable system with MVG as a central operator and which where Car2go intentions in this direction. "**The plan is to get closer together with MVG, who would be very attractive to join because its great number of clients they have**." Then he was asked if they have had relationships with the MVV. "We have contacted them but MVG fits us better."

Then he was further asked about the Moovel app and how does this function. The interviewee explained that the Moovel app was a tool to enable Flinkster and Car2go customers to use the vehicles of the other organization.

Further on, the interviewer answered the following to the question of what has to be done with the insurance of a carsharing organization in case of accident, when a user of another organization is making use of it: "**Users have to accept the terms and conditions of the carsharing operators that they want to use** and they would be treated as an original user in case of accident. The central carsharing operator should then forward the contact information to the particular carsharing organization in case of necessity."

The interviewee was then asked of how were the interoperable fees to be divided. He confirmed the proposal of dividing the interoperable fees between the carsharing central operator and the carsharing organization whose vehicle was being used. He added that these fees should be higher for smaller organizations and lower for the greater ones.

Finally, the user was asked if **Car2go was thinking in settling their service in the city of Barcelona** (not relevant for this document but interesting for the readers of the author's home university). He answered affirmatively but he said they did still not have any datelines.

CiteeCar

CiteeCar is carsharing enterprise that was founded in Berlin in 2012. They are now also available in Hamburg, Munich, Frankfurt and in the Ruhr region. They have a fleet of about 800 cars (CiteeCar, 2014) in Germany and 150 vehicles (MVG, 2014) in Munich.

Birger Holm has worked in many carsharing organizations since 1998 and has founded some of them. He has worked in carsharing since it was no more than a niche in Germany until his present expansion. Since 2012 he is working in CiteeCar.

Interview details

- Interviewee: Birger Holm
- Position: Cooperation & Business Development in CiteeCar Berlin.
- Date of the interview: 10.11.2015
- Length of the Interview: 01:07:19
- Corresponding Audio File: EI2_CiteecarBirgerHolm_10112015_FrC

Interview Summary

The presentation was shown to the interviewee in order to introduce him in the matter. He made some remarks from this presentation:

The term Content Provider has to be used cautiously (that is used in this document as the vehicles that give the information of the service to the Service Operator). This is because it can give the impression that it is the only provider of information and the users are as well content providers.

He confirmed the possibility of creating secret IDs for the users that want to use other carsharing companies through the Common Service Operator: “There is no need to show any personal data that is protected. If a certain Car2go user uses a Flinkster vehicle, no personal data is sent from Car2go to Flinkster or from Flinkster to Car2go. The data of the trip is sent but not the personal data.”

He expressed his opinion about technical and agreement costs: “From my point of view there is no need to talk about technical aspects, because **technically is all of this possible**. Take a look for example on the airplane companies, they share a common reservation platform but they are completely different companies. From a technical perspective it is absolutely possible to have a joint network. **The biggest problem is about psychology and trust**.”

Then the interviewee confirmed the **scenario 3A as the most appropriate scenario** to enable interoperability in the city of Munich and he added: “There are cases where there already exists such a common platform like Flinkster and Car2go or STATTAUTO and the Deutsche Bahn so it is technically possible”.

The conversation followed on talking about carsharing companies without an own network: “**There are companies that do not have an own network**. STATTAUTO has always used the network from Flinkster but since some years there is no further relation among them. They had then to decide if to

create their own network or to join another one. They decided to join the Cambio carsharing company from Bremen."

The topic of the conversation shifted to the companies that through roaming enable interoperability among companies from different cities. "In the past the users from Flinkster could use the vehicles from STATTAUTO. This kind of relationship normally entails the share of the IT and network but they are completely independent enterprises. The carsharing organizations that want to use the network pay a renting fee for using the network. Interoperability among carsharing organizations from different cities is for a long time already been implemented (Stadtmobil Hannover with Stadtmobil Hannover for example). However, **there is until now any city with many carsharing operators that has enabled interoperability among them**."

At this point of the conversation it was discussed of the different business models of the carsharing organizations of the city of Munich. Over the business models of Flinkster and CiteeCar it was said: "There are 64 license zones (inside the Middle Ring) for parking in the city of Munich. **In the Flinkster and CiteeCar business models every vehicle has a designated zone** (that can be about 300m x 300m) where a car is picked up and has to be returned to this exact area so they are stationed based." About the DriveNow and Car2go business models it was said: "**Car2go and DriveNow** have the permission to park in all of these 64 zones (that are within the designated area). They **offer a free float model**, in which all users can pick up the car and park it where it best fits their necessities." Finally about **STATTAUTO** it was said: "They are as well stationed based and where offered the same system than CiteeCar and Flinkster but they were not interested. That is because of their infrastructure with strong-boxes to keep the keys of their cars. That is why **their users have to take the cars back in the same exact parking spot where they picked up the vehicle**. This about to change because STATTAUTO wants to automatize its system and it will then be interested in having the same business model than CiteeCar and Flinkster".

The interviewee was then asked about how an interoperable system could be implemented in the city of Munich. The first remark that was done was that **it is vital that the users accept the terms and conditions of every single carsharing organization** they are whiling to use. As a possible way of doing so he exemplified the following: "MVG tried to start a service where users would register their personal information (name, address, bank account, etc.) in the MVG registration points and then the users could decide which carsharing services they wanted to use. These users would have to accept the terms and conditions of these services." A drawback of such a system is that a user who would want to use interoperability would have to pay the registration costs of every single carsharing (as long as the operators would not agree on a common fee for all). Therefore the accessing costs would be too high and would hinder interoperability.

The already proposed model was then proposed to the interviewee where users would have to pay interoperability fees per trip when using other carsharing companies. Then he answered that the principal problems come from the legal aspects when trying to organize all the carsharing organizations together. "There are 2 major issues from a legal point of view. Firstly, who should communicate with the customers (owner of customer information). Secondly, how should operators organize their systems together (in legal terms)." He insisted then that technical aspects are doable but **the biggest problem is to organize legal matters**.

Then the interviewee was asked if an interoperable offer was proposed with MVG as the common service operator if he thought that CiteeCar would consider joining such a system. Prior to answer he explained: "**MVG is very appealing to the carsharing operators because of its customer base and the possible implementation with public transport**. In fact, MVG is the most valuable partner from CiteeCar in Munich. We have any customer point so we have to make partnerships with the local transport organizations. In Munich this function is fulfilled through the MVG." The he answered to the question: "Yes. **It would be very appealing when MVG as a neutral operator would implement an interoperable carsharing system**. However, **it is crucial that the central operator**, in this case MVG **does not offer himself a carsharing service**."

Then the interviewee made some remarks over some features that this central operator should present: "This central operator has to enable the users to register through its own service provider. At the same time, **the central operator must have access to the information of the particular carsharing operators** from the city of Munich to avoid situations where cars are booked twice." The interviewee remarked that paramount questions were who had to pay for the infrastructure of the interoperable system and who had to occupy the figure of the central operator.

He added that "**the problem in Germany was that there was a lot of mistrust because of the Deutsche Bahn AG**. The DB let many carsharing organizations to use their booking platform in exchange of a rental fee. They had a contract that the DB would not establish a carsharing organization itself. However, the DB did not respect these contracts and used the information from the carsharing organizations to ground their own carsharing organization nowadays called Flinkster. That is why there is mistrust in Germany concerning interoperability."

Then the interviewee remarked **some issues that had to be solved in order to enable interoperability**, concerning the central operator and the interoperable network (from the point of view of business organization):

- Who should pay the network and the interoperable system?
- Are the operators to pay themselves for the modernization of their fleet and the compatibility with the central operator in order to enable interoperability?
- Who wins money from where?
- How do operators communicate with the customers?
- Who has access to the big data? (that can lead to misuse, so it has to be very trustful)

After the interviewee had made so many considerations **he was asked if could make a proposal to enable interoperability**. Firstly, he used the following example to answer the question: "In Cologne the public transport agencies in Germany have create an enterprise that serves as a central operator for establishing interoperability among public transport agencies for the owners of a public transport subscription (Kern Application GmbH)." Secondly he made the following proposal: "Users could pay registration fees for the desired carsharing organizations and accept all the corresponding terms and conditions over the same platform. The users would then pay interoperable monthly fees for using this service. They would receive monthly a final bill detailing all the services used from every carsharing operator (this would be organized through the central service operator, that would have to be fully neutral).

He was then asked if he thought if the MVG was a good figure for being the common service operator, and he answered the following: "**MVG is a good idea for the city of Munich but we must think on a national level**. In that case, MVG is not appropriate. That is because the software that is needed for implementing interoperability is only once need, but if every city starts implementing its own system we will have again a problem of harmonization when trying to settle interoperability on a national level. That is really difficult to implement. In the case of Switzerland, they do not have this problem because there were at the beginning only two carsharing enterprises that decided to merge into one in the whole country."

Last but not least, he was asked if it was better to establish the already mentioned system where all users could register through a common platform to the desired organizations the corresponding registration fees plus monthly fees or register to the desired carsharing organization and pay interoperability fees when using the other companies per use. He answered: "Actually, **it is better to pay interoperability per used trip because users only pay for interoperability when they perceive an added value**. It makes more sense."

DriveNow

DriveNow is a joint venture between the car manufacturer BMW and the car rental company Sixt that provides carsharing services in some cities of Europe (especially in Germany) and in in the USA. The company started operating in Munich in June 2011. (BMW Blog, 2011) As of June 2015, Drive Now operates over 3.200 vehicles, which serve 8 cities worldwide and over 460.000 customers. (DriveNow Blog, 2015) In Munich there are a total of 490 vehicles. (DriveNow, 2015)

Christian Bäres has been working in DriveNow for almost a year now and he had as well worked in moovel. He suggested bringing Katrin Lippoldt into the interview because of her experience in the business operation of the company. The interview was not allowed to be recorded because of strong enterprise policy about privacy.

Interview details

- Interviewees: Christian Bäres and Katrin Lippoldt
- Position: Business Development Manager and Operational Business Development
- Date of the interview: 20.11.2015
- Length of the Interview: about 30 Minutes
- Corresponding Word File: EI3_DriveNowChristianBäresKatrinLippoldtInterview_20112015

Interview Summary

First of all, the interviewers started talking about if it was a good idea to settle interoperability fees or not. The interviewees were completely against this proposal. "**It is not a good idea to implement Fees. Users are really price sensitive.**" The problem of setting fees is that users can consider paying registration costs anyway and registering to the systems that they want in order to avoid pay interoperable fees per usage. They suggested as well that **such a business model could lead to misuse of the service**. "I would download the interoperable app, look which car is the most convenient for me and then book it through the service provider of the particular operator." Moreover they added that they considered that the implementation of such an interoperable system through fees could endanger the whole business model because of users being so price-sensitive.

About the access device it was said that DriveNow vehicles can be both accessed with smart card and mobile phone. **The mobile phone technology is very convenient but the smart card technology serves as back up device** in case of having problems with the battery of the mobile phone.

The conversation turned into looking after a good candidate for the figure of the common service operator. MVG as a candidate was proposed and they outlined the following advantages and disadvantages: "MVG is an attractive idea because they have an interesting customer base. However, we do not consider MVG to be a good candidate to act as a central operator because working with public companies is extreme slow. Furthermore, when trying to establish it in at a national or international level the relations between the different public transport operators would last too long. Moreover, we believe that they do not agree to cooperate if they would not perceive money from the customers and we know that the customer is very price-sensitive so that could make the whole carsharing service model fail. Last but not least, the competition with Flinkster would be very tough at a national level and we would like to have all the participants to join such a system." Shortly, they thought **MVG is not a good candidate because it would take too long to come to an agreement, and because made no sense at a national level.**

In their opinion**, a good idea for the figure of the central operator would be someone complete out of the game, someone who would take the risk of the financial aspects** (insurance and payments) and would do that because of being interested in the customer base and use the information as a research project. Good candidates would be Bosch or Siemens who have already show interest in such cooperation. Another possible candidate would be probably PayPal because of his financial possibilities and expertise. A perfect candidate would be Google for example who is as well trying to enable ticketing in their google maps functions and is always interested in having customer information. Social networks are as well a good candidate because of people's reliance and confidence on them (Facebook). In this way the carsharing companies (DriveNow) could agree to share the information of their clients with this central operator**. The new clients would then choose to which carsharing service operators they would like to register and agree their terms and conditions in order to be able to use their services.**

The next step was to decide how could be improved the situation with the multiple registration costs. "We maintain registration costs as an access barrier so the customers do not have instant access to the service and make a misuse of it (register for the sake of so and not using it)". But **they agreed on turning registration costs down if that would help to enable interoperability**. It could be also settled a common registration cost offered as an added value for the central operator to organize everything depending on the services the user wants to use. They added that **another problem hindering interoperability is in-person registration**. "The problem with registration is that because of the German law the driving documentation cannot be 100% online". That is way users (old and new) would have to show their documentation at least to the central operator.

They were asked what they thought about interoperability and whether it was realistic to think that this could be implemented in Munich or Germany. "**Interoperability makes a lot of sense in the actual carsharing situation**. It is actually sort of happening. We are aware that lots of our users are registered to more than one carsharing service operator and very often they combine the stationed-based model with the free-floating model. Enabling interoperability would be a logical reaction to the present situation".

To the previous question they added in which projects DriveNow had already been involved, regarding interoperability. "**DriveNow has already considered establishing interoperability and intermodality through the development of a common offer with public transport and shared-based systems**. A prove of it, is the project called Molecules." The project Molecules was at first stage thought as an intermodal route planner for sustainable mobility among carsharing electric vehicles and other modes of transports respectful with the environment (European Comission, 2012). "Moreover, DriveNow is now involved in a project to implement intermodality in the Münchener Freiheit (Munich U-Bahn interchange station in the Munich borough of Schwabing-Freimann)."

To put it all in a nutshell, **interoperability it is an interesting idea that can be very beneficial if implemented properly**. It has to be considered at a national or international level, standardization and harmonization are a priority. Consumers cannot be charged more for using the service and the perfect candidate would be someone outside the game with the capacity of assuming risks and costs. **In that case, the carsharing operators (DriveNow) could agree to share their customers.**

STATTAUTO

STTATAUTO is a carsharing organization that was founded in Munich in the Eastern of 1992. It offers its services only in the city of Munich and now has a fleet of almost 430 vehicles with about 11.000 clients. (Carsharing News, 2015)

Olaf Rau is the former managing director and present Head of Customer Care and Customer Service of STATTAUTO München.

Interview details

- Interviewees: Olaf Rau
- Position: Authorized officer STATTAUTO München (former Managing Director)
- Date of the interview: 26.11.2015
- Corresponding Word File: EI4_ EI4_STATTAUTOOlafRauInterview_26112015

Interview Summary

1. When will you achieve complete automatization of your fleet (telematics technology for opening the vehicles and metering and accounting of the driven kilometers)? At this moment which percentage of your fleet is automatic?

- 33% of our Fleet is already automatized.

This shows that STATTAUTO is automatizing its fleet and that **it would be than possible for them to join an interoperable carsharing model.**

2. Have you thought of eliminating the deposit, as it is a barrier to enable interoperability? Why?

- We have thought of the abolition of our deposit and we have already implemented an offer called “Young mobility” for apprentices and students (there is no deposit, no monthly fees, but with 10% higher usage fees in exchange).

The **deposit and monthly fees are access barriers** and this is well known by STATTAUTO managers. The young mobility offer shows that they are making steps to overcome this situation.

3. Do you believe interoperability is worth it for the carsharing world? Which threats and opportunities do you see? Do you think it can be achieved in the city of Munich?

- For the users of carsharing it would be interesting for sure because their mobility would then be more flexibly shaped. However, I believe that right now cooperation between all the operators of the city of Munich is a bit unrealistic because the interests among them are too dissimilar.

Interoperability is a present topic that would be very beneficial for the enhancement of mobility. Nevertheless, agreement costs are nowadays too high. Therefore, all the efforts to overcome the situation are welcome.

4. Who would be a good candidate for being the central operator of an interoperable system within the city of Munich? Would you consider the MVG a good candidate to do so?

- The city of Munich itself would certainly not do something like that. However, I could easily imagine the MVG, in its role of municipal society, as a central operator because they have already collaborations with the carsharing operators and they have the required competences as well.

In terms of knowledge of the sector and existing agreements with the carsharing sector **MVG could be an interesting central operator**. However, as we have seen in the interview with DriveNow, **MVG is not further considered** because not being efficient and being irrelevant at a national level.

5. Do you think fees are to be established for using an interoperable system in Munich? Why?

- To operate an interoperable system like that costs money, which at least partly would have to be financed through higher tariffs or fixed costs.

That it is a fair argument. However, through the expert interview with DriveNow, it was made very clear that **the user is extreme price-sensitive**. Therefore, if we do not want to expose the whole carsharing model, the implementation of interoperability cannot come at the user expense. Thus, it is vital to search an investor that can assume the cost in exchange of marketing data.

6. New STATTAUTO vehicles use a member card to access the vehicles. Which are the benefits and drawbacks of choosing smart card technology or mobile phone technology to access the vehicles?

- I do not see any drawbacks for the user when the access to the vehicles is done by card instead of mobile phone app. However, in cooperation with all the operators there could be difficulties when different access systems were used that are not compatible.

It is vital that a single access device is implemented for the convenience of the users and because of coherence with what interoperability tries to achieve (lower access barriers to all carsharing platforms). As later discussed (in chapter 8), the mobile-phone will in future stand as the dominant access device for the carsharing business.

7. Who should be responsible in case of accident when using another carsharing provider? How are insurance conditions to be implemented?

- Nowadays it is organized in such a way that the user has to abide the conditions of the carsharing organization whose service is being used. Nevertheless, in an interoperable system it would certainly be meaningful to settle a unified insurance.

The investor(s) in the interoperable model should assume the financial aspects such as insurance (this is further discussed in chapter 8). That is why **it would make a lot of sense to establish a common insurance plan.**

8. Do you think that STATTAUTO would accept to join such an interoperable system? Under which circumstances?

- STATTAUTO could imagine participating in such an interoperable system when it was demonstrated that the use of the free-floating carsharing model (DriveNow and Car2go) per se is sustainable. STATTAUTO is going to participate in the program "Parkraummodel 1" as of 2016.

Interoperability is a topic in which all carsharing operators are interested. However there are different interests among them. It is true that if we analyze the free-floating model alone, because of its clientele and the use they make of carsharing it can be argued that it is not really sustainable. However, if we look at the whole carsharing package (which is certainly sustainable) the free-floating model is vital to satisfy the mobility demand of its users.

9. How do you see the carsharing situation of Munich in the 10 years?

- On principle, carsharing will further develop itself. How this development, in Munich and also in other big cities, will look like in 10 years will depend above all on politic decisions. The release of free parking spots for carsharing services would certainly be a first step, which would accelerate its development.

Through the development of this master thesis it has been seen that **the problems to develop an interoperable system have to do more with bureaucracy and agreement costs** and not so much with technical problems. That is why in order to foster the evolution of carsharing political measures have to be conducted.

Annex 2: Statement

I hereby certify that the content of this report is the result of work done by me, except where otherwise indicated. I have only used the resources given in the list of references or provided in the annexes. This master thesis was not submitted for a higher degree to any other university or institution.

Munich, December 16th 2015

Francesc Cases Guijarro

This research was carried out at the offices of MRK Management Consultants GmbH from July 1st to December 16th, 2015.