Aalto University
School of Business

Future Internet in the European Union - Case FI-WARE

Information Systems Science
Master's thesis
Lasse Tuominen
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AALTO UNIVERSITY SCHOOL OF BUSINESS **ABSTRACT**

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The purpose of this study was to analyze the managerial aspects within the FI-WARE project, which is a part of the bigger Future Internet Public-Private Partnerships program initiated by the European Union in the 7th Framework Program. The managerial aspects were divided into communication mechanisms, analysis of the overall program characteristics, and developing an understandable framework for the program.

FI-WARE is a program that is intended to revolutionize the European ICT environment. It is characterized by its large amount of partners who provide the project with latest ICT technologies. The purpose is to be a technology transition that will ensure the competitive advantage of European SME's as they will be able to build products and services from a shared resource pool.

The study was conducted as a single case study within the pan-European project that will offer a new technology platform for European SME's. Seven semi-structured interviews were carried out with managers and reviewers of the project. Qualitative data analysis was performed to process and summarize the results and findings.

Findings of the study suggested that there is a severe lack of unified and coordinated communication within the project. This may harm the outcome in the future. Also, there was no single framework that was shared among the participants causing more irregularities in the interpretation of the project. Although there is already much written material on FI-WARE, the initial release of the actual platform has only recently been published and still it lacks a clear definition of business models. A high-level framework of the FI-WARE project relations was created to illustrate the relations of all the participants.

FI-WARE is heavily dependent on the willingness of the partners to continuously provide the project with their time and technologies. FI-WARE core management team will have to contribute much time and effort to ensure the future dedication and it is important that more SME's are taken in to give their opinions on how the project should be modified in order to comply with their needs.

Keywords: Future Internet, FI-WARE, FI-PPP, system-of-systems, platforms,

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1 INTRODUCTION

This study focusses on the FI-WARE or Future Internet Core Platform project, which is a part of the Future Internet Public-Private Partnerships Programme funded by the European Commission. The aim is to analyse the environment of the current ICT industry and how FI-WARE would fit in to that. Also, the intention is to study how literature regarding relevant models can be applied to this particular project. Furthermore, interviews of experts on the area have been conducted to deepen the understanding on the subject. Finally, the specifics of the FI-WARE project management are discussed.

1.1 Background

The Internet and computing in general has become a commodity and a basic utility similar to for example water or electricity according to Buyya *et al.*(2009). People expect to have access to the World Wide Web or Voice over Internet Protocol services wherever they are. To further increase the phenomenon, the recent boom in Cloud computing has brought the expectation of mobile workstations, that you no longer need to have a specific laptop to work on but rather can access your material from any data terminal with a connection to the Internet, which is nowadays considered a given especially in western countries. There are enormous challenges with the future of the Internet but there are also immense opportunities.

What was the world like before the Internet? This is a tough question for almost anyone today. As the Internet is becoming ubiquitous and reaching more people, it is also becoming more important to think about what the world of the future Internet is going to be like. As Huttner (2008) observes, there is no area of economy where the Internet is not prevalent. Furthermore, the rise of technologies such as the Internet of Things or IoT has increased the connectivity of everything. The IoT inevitably increases the need for larger data storages and analysis tools. This will require massive investments from all companies that wish to remain in business if they cannot find a way to buy these as a service. Thus, there is a need for new models and innovations in the Internet environment.

Platforms are one clear success story that has been enabled by the rise in these Internet technologies. In recent years companies such as Google, Amazon, and eBay have become huge global entities in the Internet by providing their services through their own exclusive platforms. One of the biggest reasons for companies adopting platform approaches in their businesses is that they can modify the services and products that they offer in real time, thus eliminating the necessity of continuous upgrades and investments by consumers. Therefore, it is no wonder that consumers favour the platform providers.

The goal of the FI-WARE project, as described by the project wiki, is to build the Core Platform for the future Internet. This core would consist of Generic Enablers, which are elements of the platform that can be used to build future Internet applications. FI-WARE is seen as a basis for the future of European ICT companies and it is expected to increase innovation of new products and services by enabling the combination of several technologies that are considered to be the core of the future Internet. The providers of the foundations for the technologies are large European companies who already have a stake in the industry and wish to increase it through the FI-WARE project.

1.2 Research Problem

Predicting the future is always an extremely difficult if not impossible task. To determine what the future Internet could look like, it is natural that the past is studied and hypotheses made from that.

The Internet was created in the 1960's for researchers as a knowledge exchange network. It was followed by the commercialization in 1995, which made exponential growth possible. The third turning point has been the transition from Web 1.0 to 2.0 (to use simplified terminology), of which we are still seeing the effects. This has been a long process from the packet switching theory to what the Internet is today. It is unclear how the next transition to the next future Internet will happen and models are being created to ensure that everyone would be ready for it.

A common phenomena in all the steps that have led to today's Internet, is that they were executed from the need state. There was nothing similar to what the Internet had to offer and thus it had to be created to fill a gap. As the Internet has evolved without clear regulation and users have found utilizations that were not originally intended by developers (piracy, fraud, theft etc.) a discussion on whether it should be regulated has emerged. The causality of closure should be studied in order to assess the feasibility of top-down models in the Internet.

FI-WARE is a project that aims to build an open core platform for the future Internet. This platform is aimed to create more innovation and competitiveness in the European ICT sector. FI-WARE architecture will consist of specific building blocks (Generic Enablers), from which complementary businesses can pick the ones they feel are required for their processes. As such, the architecture of FI-WARE relies in closure - meaning that it is built with a clear structure and constraints defined by the developers. Thus, the future Internet platform would be developed from a top-down perspective. The developers of FI-WARE are assuming that creating a platform will increase innovation in the

ICT sector, but have not necessarily thought about whether there is an actual need for this kind of model.

The Internet has spread to include a third of the world's population and According to the International Telecommunication Union 72.2% of Europeans have access to the Internet (ITU, 2011). The race to come up with the next "killer application" that could define the evolvement to the so-called Web 3.0 is going on and projects such as FI-WARE aim to build the future Internet for Europe. The Internet has traditionally encouraged and supported grass root level innovation and FI-WARE is aiming to force a certain innovation model to the whole ICT sector of the EU.

Platforms have become a significant business strategy and the use of platforms is increasing. The rise of Software-as-a-service has led ICT companies to change the orientation of their business from products to services. Platforms are a way of implementing this shift. The European Commission has funded the establishment of an EU wide core platform FI-WARE that is intended to become an industry-wide technology foundation for Europe. However, this platform differs significantly from the platform models described in academic literature as it is more of a technology foundation than a single platform-as-a-service. Thus, it is essential to understand what the implications of such a platform could be and how to describe it.

1.3 Research Questions

The purpose of the study was to define the FI-WARE platform and its implications as a technology platform for the future European Internet. The structure of the platform is given much consideration as it is considered as a definitive aspect of the operation of the platform. This approach was considered most suitable as the project presents an ambiguous theoretical foundation upon which to reflect the possible outcomes.

How can FI-WARE's platform be defined and does it comply with the basic requirements of platform success factors described in academic literature?

After defining what the FI-WARE platform is and how it is constructed the managerial implications can be considered. As the project is extremely broad, there are likely to emerge managerial challenges. For the benefit of the project it is necessary to try and identify at least some of these challenges.

What are the managerial challenges for FI-WARE?

There has probably never been a project such as FI-WARE in Europe before. The closest that can be considered is the GSM/UMTS project, which was of different scope and level. Therefore, it is difficult to know how to measure the success of such a project. Theories and concepts from academic literature have been studied to aid the identification of success factors, but these may not be adequate.

What are the success factors for FI-WARE and how can the success be measured? What forms do they take, in what context?

1.4 Definitions

In this study there are numerous concepts that are used in the analysis phase and when formulating the results. They are described in the text but for the ease of following and reading, the key concepts that emerge most often are also listed in Table 1.

Concept	Definition
API's - Application Programming Interfaces	API is an interface used to enable communication between different software components. Through them different software languages can understand each other.
FI-PPP - Future Internet Private Public Partnerships	A programme launched by the European commission to address the challenges from the future Internet. FI-WARE is a part of this programme.
FI-WARE	The technology foundation for the European future Internet. Constructed out of Generic Enablers
GE's - Generic Enablers	The Generic Enablers (GE's) are the building blocks of the FI-WARE architecture. They are commonly shared and used in various usage areas across different sectors.
GSM/UMTS - Global System for Mobile	The pan-European mobile communications project. Similar to FI-WARE in its scope and purpose.
IoT - Internet of Things	Refers to the upcoming structure where almost everything can be connected to computers and the Internet.
Platforms	Platforms are services or products that bring together parties with common interests through a shared infrastructure.
SoS - System-of-systems	SoS's comprise of complex elements that are systems in their own and operate in collaboration with each other sharing a common purpose.
Use Cases	There are eight use cases that are separate projects. The aim is that the UC's would identify the technologies required from the future Internet platform.
Web 2.0	The "second version" of the Web. Content is created through users and collaboration. Social networks, wikis, and blogs exemplify Web 2.0.

Table 1: Concepts and Definitions

1.5 Structure of the study

The study is organized in the following manner:

Section 2 provides a critical review of existing academic literature on related theories. It will cover essential topics and provide an insight to the

Section 3 is the description of the case FI-WARE and introduces the research methodology of how the case was designed and conducted.

Section 4 introduces and assesses the key findings that were made through the interviews that were conducted for the study

Section 5 discusses the findings in more depth and critically assesses them through combining the findings from the theoretical and empirical parts.

Section 6 presents concise conclusions of the key findings and contributions, assesses the limitations, and provides suggestions for further research.

2 LITERATURE REVIEW

Although the Internet as we know it can be considered young, there is a large amount of studies conducted about it. The Internet has changed the world in numerous ways: business methods, ways of communication, and information flow to name a few. The World Wide Web has become a socio-economic organism that evolves constantly. From the early history to the future predictions, the literature tends to emphasize the importance of keeping up with the challenges. The current trend is to try to shape of the future Internet from a top-down perspective. IT companies and associations are racing to find the next step in the evolution of the Internet. The relevant literature concerning this study is analysed here. First the evolution of the Internet is discussed, followed by how platforms and innovations are an integral part of the Internet.

2.1 Evolution of the Internet

The history and evolution of the Internet are studied in this section. The changes the Internet has faced from the very beginning to this day provide a clear image of how it is likely to evolve in the future. As the common phrase tells us: to understand the future one must understand the past. Furthermore, to be able to predict what the future might be like, we must study the present because there are multiple possible futures in the present (Aaltonen, 2010).

First the very early stages are discussed in short and then followed by the transformation from Web 1.0 to Web 2.0 and the present day Internet. Finally literature concerning future Internet predictions, models and trends is analysed in more detail.

2.1.1 Early stages

The first efforts towards an interlinked computer network were articulated by J. C. R. Linkleider, in the form of a Galactic Network where computers would be connected to a collective information base. After this he was named as the head of the Advanced Research Projects Agency but the Galactic Network was never established and it took many different projects to finally launch a network that connected several computers. (Kleinrock, 2008)

A big step was taken in 1962 when Leonard Kleinrock finished his doctoral dissertation that introduced the concept of packet switching. Instead of using circuits to transfer information, Kleinrock suggested the use of packets. This was the next step in the formation of the ARPANET, which can be thought as the first version of the Internet. From the very beginning the Internet was planned so that the "control of the network should be vested in all the people who were using the net… [t]he gratification for us was not one of proprietary ownership, but rather was the broad use of our creative works by others." (Kleinrock, 2008, pp. 12).

By 1985 the Internet had seen several innovations that enabled the wider use. These included the personal computers, the transmission control protocol over Internet protocol, and Ethernet technology. This made Internet a supportive technology for larger communities of researchers and developers whom widely used email. There had also emerged several other networks than ARPANET of which one that must be mentioned was the National Science Foundation's sNSFNET. The NSF encouraged the funding from commercial customers (Leiner *et al.* 1997).

Leiner *et al.* (1997) also present similar ideas with Kleinrock (2008) about the function and purpose of the Internet in saying that the success is mainly caused by the efficient adoption by communities that push the infrastructure to adopt and evolve.

2.1.2 From Web 1.0 to Web 2.0

The terminology made popular by O'Reilly Media in their 2004 Web 2.0 conference that consists of the concepts of Web 1.0 and Web 2.0 has faced controversy most notably from the inventor of the World Wide Web, Tim Berners-Lee. He was interviewed by IBM's developerWorks where he stated that "If Web 2.0 for you is blogs and wikis, then that is people to people. But that was what the Web was supposed to be all along" (developerWorks Interviews: Tim Berners-Lee, 2006) giving the expression that the Web is only now beginning to fulfil its original purpose.

The reason the terminology invented by O'Reilly Media is used in this paper is because it represents a clear and simplified concept for the evolutionary change in the history of the Internet. Instead of meaning a change in the technology used or a definite point of modification, it offers a mind-set on the differences in the Web from the commercial launch to the state that it is in today.

In the era of web 1.0 the web was already considered to be a platform. It was only accessible through your computer that had certain software installed on it, most prominently the web browser software by Netscape. The company's initial strategy was to establish a "web top" where everything is done with a traditional laptop through their browser. This would have enabled Netscape to dominate the server markets by forcing providers to produce their products through Netscape's servers. What happened was the opposite as browsers and servers became commodities and the value of applications went up (O'Reilly, 2007).

O'Reilly (2007) continues to provide some aspects of what the Web 2.0 is compared to its predecessor. In the Web 2.0 installed software is losing markets. Instead, everything is being made available as a service. Google is the prime example of how a company has taken everything as a service to the normal web user. Google Accounts gives the possibility of several different services that have before been purchasable software (word editing, presentation software, web page creation etc.). Considering how the big successes of the current Web - such as eBay and Amazon – operate "the Web 2.0 lesson" can be said to be true: "leverage customer-self-service and algorithmic data management to reach out to the entire web, to the edges and not just the centre, to the long tail and not just the head" (O'Reilly, 2007, pp. 21). Google and others like it have begun operating in the "between-space", the part that happens between two different computers connected to the Internet instead of operating software on each computer. Thus, enabling each individual computer to become a server, which in turn is what peer to peer technology is based on. Nevertheless, Google and others like it must have large servers of it's own to be able to have all the software as a service.

In the early 2000's a new kind of trend started to emerge. Web 2.0 as introduced by O'Reilly (2007) relies heavily on the user created content. People started to write their own material on the Web and wanted to interact with others through it. This gave rise to social network sites or SNSs that enabled people to create a profile in to a network and interact with others who had created profiles within the same network. Social networks are defined as web services in which an individual can create a profile, choose to share information, and interact with others who have created a profile (boyd & Ellison, 2008). Today social networking has taken a large portion of the time individuals spend on the Web. According to a research made by ComScore (2011) the time an average Web user spends on SNSs is currently 19%. Another statistic depicting the growing popularity of SNSs is the rise in Facebook users. Facebook Statistics (retrieved Jan. 2012) provides a rough number of registered users: 800 million. This means that if Facebook was a real country, it would be the third largest by population. Although these SNSs possess great opportunities for companies, especially for marketing, 83% of 1,700 Chief Marketing Officers feel their company is underrepresented (IBM CMO Study, 2011).

2.1.3 Future Internet

The Internet has changed and evolved to a great extent in the 40 years since its introduction. Leiner *et al.* (1997) state that the Internet must keep on modifying itself in order to keep its status of relevancy as it is. In his article Shenker (1995) explores the fundamental issues that the future Internet will face. His predictions are that the Internet will change to have much more data traffic – generated by the public users – and thus the infrastructure must evolve to cope with this future. As such, this viewpoint does not take in to account the innovation that happens in the user generated content and applications. Nowadays researchers have noticed that they must take other design issues than infrastructure into consideration.

Although the Internet is considered as a network that grows on its own and evolves through the innovativeness of its users who co-create material, Leiner *et al.* (1997) claim that the Internet will fail if a collective direction for the use cannot be found. This "one right way" may be difficult to generate by some entity that is located in the very heart of the Internet, such as governments who try to regulate the use of the Internet. Instead of this centralized innovation and clear supervision from the core, it is the edges of the Internet where innovation and directions for the new Internet are being formed (Kleinrock, 2008).

Kleinrock (2008) continues to elaborate about the nomadic user that the writer considers to be a future Internet user. This type of Internet user is someone who travels and uses the Web through various devices and different computing platforms. The Internet-nomad will also receive large amounts of data from all embedded networks he or she belongs to. These could include the house and work place networks, which would recognize the person joining them and provide status updates. The future Internet user will also be able to access the Web from anywhere at anytime as it becomes more ubiquitous. To enable the user to fulfil his or her needs, there will emerge software and hardware with which vertical integration will be automatic.

The predictions on how the Internet will evolve have commonly focussed on the infrastructure that is required for the predicted uses (Shenker, 1995; Kleinrock, 2008). A descriptive explanation on how the anticipated features rely on infrastructure is provided in the text of Kleinrock (2008).

> *"…infrastructure is far easier to predict than are applications and services. In fact, looking back over the history of the Internet, it has been the applications and services that have surprised us, have come out of the blue, and have been totally unanticipated. Examples are email, the World Wide Web, peer-to-peer file sharing networks, social networking, blogs, photo and video generation and sharing, and so on. It is safe to predict that we will continue to be surprised with the sudden appearance and explosion of as yet unanticipated applications and services." (Kleinrock, 2008, pp. 17)*

This also relates on the evolution that happens on the edges instead of the center of the Internet. Shenker (1995) strengthens this view by saying that the structure and use of the Internet are not mandated by a certain elite, but rather by the large community.

However, the infrastructure of the Internet is changing. Keshav (2004) claims that probably the most noticeable change has been the emergence of mobile devices that allow people to access the Internet. Smartphones and tablets have made the access and use of the Internet more ubiquitous than ever and mobile phones are the dominant platform for Internet access in the world. As the providers of mobile devices are generally holding a large user base, they can push costs down and at the same time offer high quality networks. The author even goes as far as to predict that in the future some users may never log in to the Internet using a laptop. Although the use of mobile devices gives users easier and faster access, it poses a challenge for the infrastructure.

2.2 Platforms

In strategic management a company may take a core competency approach in coming up with the strategic positioning of the company. Metters *et al.* (2006) provide a three-point test to determining on what are core competencies. It must: “1. Provide access to a wide array of potential markets, 2. Contribute to the customers’ perceptions of the benefits of the end product or service, and 3. Be difficult for other competitors to imitate” (pp. 18). They continue to describe how describe what are general competitive priorities i.e. the competences that make the service of a company competitive and furthermore, more desirable to end users than the competitions services. These competitive priorities are: cost, quality, time, service, flexibility, and the natural environment. To some degree these theories can be applicable to platforms as well, but they must be modified, as this section will describe.

Platforms are services or products that bring together parties with common interests through a regulated infrastructure that is built on a set of invariable components that support an environment consisting of variable components that constantly evolve (Eisenmann *et al.* 2006, Gawer 2009). These do not necessarily have to be physical products such as game consoles or activated by them e.g. credit cards. The Internet has enabled platforms to be established as services that are hosted in remote locations accessed via computers and where value is often created through networks of users (Keller and Rexford, 2010).

Platform architectures commonly consist of fixed core components that provide the basis for the whole architecture. A more specific definition of what platform architecture usually is built from, is offered by Whitney et al. (2004, cited in Gawer, 2009, pp. 23):

> *"(1) a list of functions; (2) the physical components needed to perform the functions; (3) the detailed arrangement and interfaces between the components; and (4) a description of how the system will operate through time and under different conditions."*

Gawer and Cusumano (2008) provide another definition on what a platform is. They conclude that there are two distinct prerequisites that must be met in order to fulfil the definition of platform. These are:

> *"(1) It should perform at least one essential function within what can be described as a "system of use" or solve an essential technological problem within an industry, and (2) it should be easy to connect to or to build upon to expand the system of use as well as to allow new and even unintended end-uses." (pp. 29)*

By combining these two similar definitions it can be concluded that a platform must address an industry need by providing components with functionalities not available through other means. Also, a platform should be easily accessible, expandable with complementary components, and usable beyond the initial intentions i.e. flexible.

Companies are constantly involved in a race against the quickly evolving technology. The struggle to always produce services and products that take advantage of the latest versions of appliances makes production expensive for companies and end products high priced for consumers. Also, the forecasting of future technology trends can be difficult for most companies (except for Apple) and this leads to products and services that have no actual market (Adomavicius *et al.* 2007). Platforms address this pace of continuous change through their architectural properties. They are built to be evolvable and adaptable. While the core components remain constant, the majority of usage is performed with complementary components making the consumption heterogeneous and enables the system to adapt to environmental changes (Gawer, 2009).

The potential benefits of platform strategies are discussed in the case of the automobile industry by Muffatto (1999). The studied benefits can also be implied to other platforms, as the basic theory is similar regardless of target use (Eisenmann *et al*, 2006). Platforms increase the responsiveness to market changes while reducing costs. Products can be made more customizable due to the easy addition of complementary components. On the other hand, the core components that do not vary reduce manufacturing costs, development time, and increase productivity (Muffatto, 1999).

To become a platform leader Gawer and Cusumano (2008) indicate four mechanisms that are common in industry platforms that have gained a market leader status. These are (1) company scope or what components or activities to produce in-house and what to leave to complementors or third parties, (2) technology design and intellectual property or how open the platform should be and what function to include, (3) external relationships with complementors or how to manage them and incentives to be an active part of the environment, (4) and internal organization or how to give assurances to complementors regarding the platform owners commitment. Eisenmann *et al* (2006) also note the importance of pricing in platform strategies. It is important to decide on a pricing strategy that benefits all parties: platform owners, complementors or providers, and buyers.

Pricing strategies include for example royalty pricing, which is common in the game console market. Here the Platform is not the main source of revenue to the owner, but the products the complementors sell through it. They then pay a certain royalty of the products price to the platform owner (Eisenmann *et al*, 2006). Another example of pricing is the freemium model that is common among Software-as-a-Service providers. The idea is to provide a simplified version of the service for free and if the users want additional attributes they have to pay a certain amount or subscribe to monthly payments (Teece, 2010).

The value of a platform is created through user networks. Value networks are the extent of interdependencies between users or how one user creates value to the other (Stabell and Fjeldstad, 1998). Thus, to provide value to users platforms must establish a solid user base. Stabell and Fjeldstad (1998) provide the example of a club. In the platform case the provider would be the club owner who admits memberships to both service providers and end users. Then the platform provider brings members together creating relationships between members but does not intervene in their interaction. The more members the club has the higher its value. Eisenmann *et al.* (2008; 2006) describe a similar environment to the club metaphor in their articles. Platform-mediated networks are models where the platform owners make and uphold rules and architecture, which users then abide to and do business in. Architecture of parts in a platform mediated networks are depicted in Figure 1.

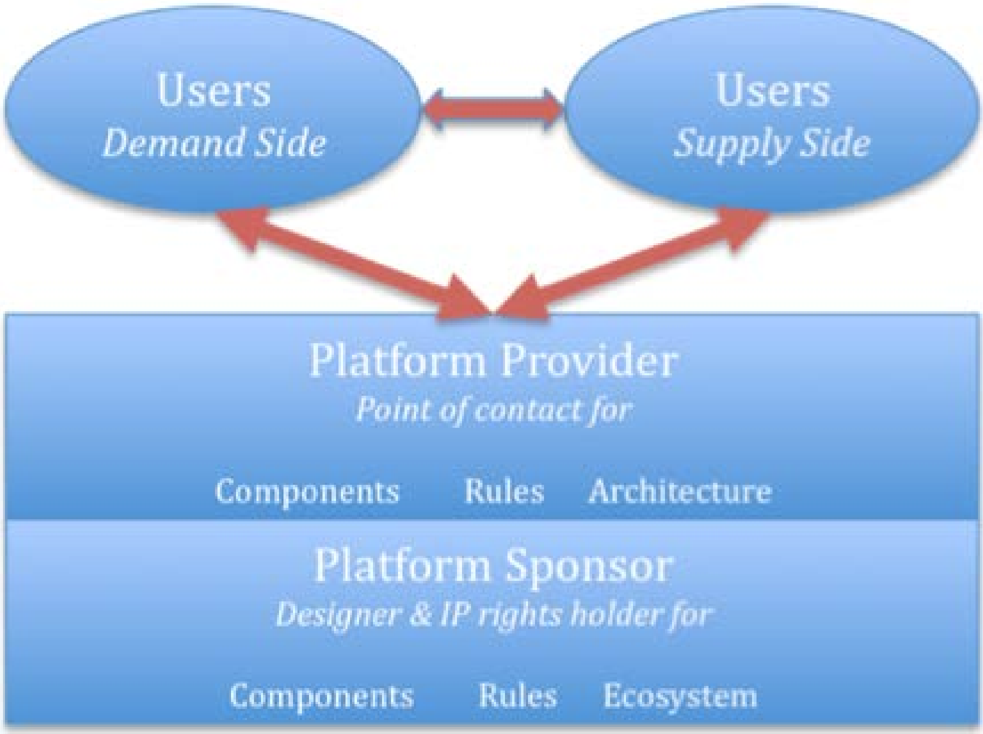

Figure 1: Elements of a platform-mediated network (Eisenmann *et al*., 2008)

Economides and Katsamakas (2006) claim that there can be either proprietary or shared technology platforms but Eisenmann (2008) describes four models for platform organization. Proprietary and shared platforms are the most common types, but also licensing and joint ventures are possible. In proprietary platforms there is only one company responsible for and owning the technology. This strategy is most appropriate when the provider has a clear advantage over its competitors e.g. technological or user experience. Shared platforms are a combined effort built by many companies who then compete within the platform by providing complementary products or services. This model is advantageous to the end user, as it creates a standard that operates in the same way regardless of consumption point e.g. Visa.

Eisenmann *et al.* (2009) describe the shared IT platform model where the core technology is owned and upheld by one organization but then licensed to partners who create products and also variants of the platform reducing research and development costs. This in turn may lead to better products at lower prices for the end users. The authors also note how formal standard setting organizations might have a negative effect on the robustness of platforms.

Economides and Katsamakas (2006) write that proprietary platforms can apply two-sided pricing with users and complementors. In this strategy the provider sells the platform to the end users and then the third party producers license the platform to include their products, which the end users buy, thus creating revenue for the initial provider from two streams. The authors claim that shared platforms cannot follow two-sided pricing due to the nature of open sourcing but they also do not have the constraints of mandatory profitability. Furthermore, the open source platform can even rise to become more profitable for the complementary producers than proprietary especially when the proprietary is not vertically integrated.

2.2.1 Openness and Innovation

When deciding on whether to follow a proprietary or shared platform strategy the providers must consider the issue of openness. Platforms owned by a single company that has a clear competitive advantage can be kept closed from other providers and profits do not have to be divided. Shared platforms, on the other hand, rely on the technology to be upheld by all participants who also wish to gain economic profits. These are what West (2003) gives examples of through cases from Sun, Apple and IBM. The author concludes that when possible, companies should aim for the proprietary platform due to the possibilities of high profitability and difficulty of immigration. Providers should come up with strategies where they carefully balance the amount of openness so that user expectations and needs are met, but profitability also maintained.

Innovation and its correlation with platform design, specifically the factor of openness, have gained attention among research. For example, Boudreau (2006; 2010) has found through case studies that there is a clear correlation between openness and innovation. Opening the platform increases the innovation of complementors. This is due to diversity of the complementors when they are motivated and ready to invest on the platform (Boudreau, 2010). To achieve the commitment to the platform the owners must show dedication through for example organizational actions as noted by Gawer and Henderson (2007). Boudreau (2010) also found that giving up platform control has a small but positive effect on innovation whereas rendering access to complementors had an inverted U shaped relationship to innovation suggesting that there is an amount of openness that can be considered to be too much. This is at least partially explained by the lack of clear coordination from a strong single entity, which leads to ambiguity in strategic decisions (Boudreau, 2006). Meyer and Mugge (2001) discuss the importance of continuously innovating within the platform by its owner and not only complementors. This notion is in line with the need for clear leadership in the ownership of the platform.

Boudreau (2006; 2010) notes that there are always trade-offs when regarding the openness of a platform, which lead to the inverted-U shaped diagram of correlation with innovation and each company must decide what is the best level of open access. Generally the highest innovation rates are found in platforms that are only partially open.

2.2.2 Network Effects

Although the network effects are most often considered from the consumer point of view, i.e. the addition of one person to the network increases the value of that network for the next person (Weitzel *et al,* 2000; Weitzel *et al,* 2006; Parker and Van Alstyne, 2005). Parker and Van Alstyne (2005) also widen the scope to include the network effects created from diverse firms producing material to a platform. They note that there is always a proactive want for consumers from the producers but also vice versa. The entry of new or substituting product to a platform makes it more attractive to consumers as it increases options while also lowering prices. Nevertheless, this effect is not necessarily carried over to platform level as the availability of multiple similar or substitutive platforms may lead to the others failing completely as in the case of VHS and Betamax.

Although the extent of the platforms network is a critical success factor, there are others that are also required for success. When a new multi-sided platform enters a market there must be some action that can be performed through it in a manner that exceeds the former methods or is completely new. If this requirement is not met the platform will not generate new value to the sides it is targeting. Also, there must be a monetary incentive that attracts all parties to contribute i.e. enough profits to go around (Evans, 2009).

New platforms that wish to become successful face the “chicken-and-egg” problem (Evans, 2009; Caillaud and Jullien, 2003; Rochet and Tirole, 2003). This term refers to how new platform providers must have the buyers to attract product producers but also need the products available on the platform to attract buyers. Evans (2009) provides several strategies companies can follow to successfully obtain the critical mass on both sides or achieve “catalytic ignition”. The most prominent strategies are:

- *Zig-zagging*: the process is to step by step persuade participants from all sides to take in the platform. This may require a long period of time and heavy financial investments. After the first step the subsequent should be easier as the value of the network increases after every step.
- *Pre-commitment to Sides*: here the developer must obtain contracts from all providers that are dependent on each other to ensure the creation of networks.

- *Two-step strategy*: this means the acquiring members on one side before opening to others. This is common in Web based platforms that operate on advertisement income. First acquire a mass of users that will attract the advertisers.

Rochet and Tirole (2003) present the possibility of multihoming in platforms. For example, consumers may have many different credit cards, or game consoles. Producers on the other hand can choose to accept multiple credit cards and decide to make games for various consoles.

2.3 System-of-systems

System-of-systems (SoS) is a research area that is still relatively new and researchers agree that there is a lack of a clear definition for SoS (Gorod *et al.* (2008), Maier (1998), Keating *et al.* (2003)) and Sage and Cuppan (2001) note that "In a formal sense almost anything could be regarded as a system of systems" (pp. 327). Although many principles and practices regarding SoS theories are still fragmented and scattered, this section will try to bring together some of the most relevant regarding this study.

A system is defined by Ackoff (1971) as

> *"a set of interrelated elements. Thus a system is an entity which is composed of at least two elements and a relation that holds between each of its elements and at least one other element in the set. Each of a system's elements is connected to every other element, directly or indirectly. Furthermore, no subset of elements is unrelated to any other subset" (pp. 662).*

This definition is not sufficient to describe a system of systems as it is constructed and managed using very different methods. Keating *et al.* (2003) point out that there are numerous definitions of what exactly system-of-systems are. For example, Kotov (1997) describes a SoS as a widely distributed organization comprised of multiple complex systems. Eisner *et al.* (1991) define a SoS much more in detail as a multi-functional environment of several independent systems, each with its own specified engineering process. The systems are interdependent and their combined operations present solutions to overall missions.

Maier (1998) provides another explanation on what a SoS is. It comprises of complex elements that are systems in their own and operate in collaboration with each other. Nevertheless, all the parts of a SoS are capable of operating independently and are expected to do so in order for the SoS to benefit. He further proposes that the term “system-of-systems” be used on “collaboratively integrated systems” (pp. 271). These systems have in common two distinguishing criteria:

> “Operational Independence of the Components: *If the system-of-systems is disassembled into its component systems the component systems must be able to usefully operate independently. That is, the components fulfill customer-operator purposes on their own.*
>
> Managerial Independence of the Components: *The component systems not only can operate independently, they do operate independently. The component systems are separately acquired and integrated but maintain a continuing operational existence independent of the system-of-systems” (pp. 271).*

Kotov (1997) and Maier (1998) both note that SoS’s may have higher costs for an independent system as it must fulfill its own initial purposes and also help other elements' purposes. Cost reduction can be achieved through optimizing production with other components so that overlapping is eliminated allowing elements to benefit from each other's products and services. This redundancy could also be addressed by simplifying the SoS as much as possible as Kotov (1997) suggests. He presents that to achieve this, the SoS should define clear objectives, which should be targeted and identify the individual features that are necessary in order to achieve those objectives. Furthermore, he emphasizes the importance of common terms and concepts in order to make communication between the elements as efficient as possible.

There are some thought processes, such as the regulation of the SoS that must be attended in order to ensure that the loosely managed structure will adjust in necessary ways as the environment changes, and as knowledge and information flows are dispersed. Sage and Cuppan (2001) suggest that the SoS should approach this issue through the political principles of federalism. They argue that this concept is particularly suitable for systems thinking as it aims to building a sustainable ecological balance in the system through methods of command and control. According to Sage and Cuppan (2001) this is achieved by three points:

1) Instead of having a single clear control base, the system should establish many semi-autonomous elements;

2) Encourage this autonomy but emphasize the limits both in process and architecture standards;

3) "Combining variety and shared purpose, individuality, and partnerships at national and global levels."

In order to achieve the benefits of federalism the SoS must adopt the points "inside-out". Furthermore, the point is made that the true control of such an organizational body as SoS lies with the agents. Thus, alteration and new principles should come from bottom-up as “any attempt to drive an incompatible solution down from the top will be thwarted” (pp. 330).

Although there is no clear definition of SoS and declaring something to be one is easy, researchers have come up with tools to analyze whether a certain structure of cooperation is a SoS or not. Probably one of the most notable tools is the characterization by Boardman and Sauser (2006). They have studied more than 40 definitions from various SoS related literature. These characteristics are defined shortly below and Table 2 presents how the five characteristics relate between systems and system-of-systems:

- **Autonomy:** The SoS exists to have a certain purpose. This purpose is shared and made out of separate parts that find benefits from operating in cooperation with other elements. On the other hand, all the elements function independently so that the SoS does not regulate their actions in excessive amounts. Thus, they should have independence in their management and operations and this should lead to the common purpose of the SoS.
- **Belonging:** The idea of an SoS is based on several unique systems willingly deciding to cooperate and share a new “supra” purpose that is achieved by using each participants existing abilities and at least partially withholds the participants’ own purposes. Thus, the belonging creates higher value to both SoS and individual system. This should be achieved without rendering the elements’ autonomy.
- **Connectivity:** All the participants of a SoS must be able to operate with each other seamlessly. This kind of connectivity can be achieved through common interfaces. Furthermore, this

enables new entrants to the SoS will have quick access to all constituent systems and vice versa.

- **Diversity:** A SoS must be extremely diverse in its architecture. The SoS must be able to address a large variety of functions far outreaching a single participant system's ability. The possibility to access a variety of functions on an as-a-service basis when actually needed gives a SoS the capability of robustly addressing uncertainty and also actualize innovation.

- **Emergence:** The four preceding characteristics lead to the fifth. Emergence implies the progress with in the SoS through formation of new processes and properties. This attribute also presents a great challenge to the SoS nucleus: how to create an atmosphere where emergence is high and the whole organization is robust?

Element	System	System-of-systems
Autonomy	Autonomy is ceded by parts in order to grant autonomy to the system	Autonomy is exercised by constituent systems in order to fulfill the purpose of the SoS
Belonging	Parts are akin to family members; they did not choose themselves but came from parents. Belonging of parts is in their nature.	Constituent systems choose to belong on a cost/benefits basis; also in order to cause greater fulfillment of their own purposes, and because of belief in the SoS supra purpose.
Connectivity	Prescient design, along with parts, with high connectivity hidden in elements, and minimum connectivity among major subsystems.	Dynamically supplied by constituent systems with every possibility of myriad connections between constituent systems, possibly via a net-centric architecture, to enhance SoS capability.
Diversity	Managed i.e. reduced or minimized by modular hierarchy; parts' diversity encapsulated to create a known discrete module whose nature is to project simplicity into the next level of the hierarchy	Increased diversity in SoS capability achieved by released autonomy, committed belonging, and open connectivity
Emergence	Foreseen, both good and bad behavior, and designed in or tested out as appropriate	Enhanced by deliberately not being foreseen, though its crucial importance is, and by creating an emergence capability climate, that will support early detection and elimination of bad behaviors.

Table 2: Differentiating a System from a System-of-Systems, adapted from Boardman and Sauser (2006, pp. 4)

Gorod *et al.* (2008) further studied these characteristics and concluded that they are interdependent meaning that alterations in one inevitably affect at least one other but possibly even all of them. This same observation was made by Sage and Cuppan (2001) when they presented their own set of SoS attributes and stated that "Clearly, the notions of autonomy, heterogeneity, and dispersion are not independent of one another. Increasing geographic dispersion will usually lead to greater autonomy and consequently also increase heterogeneity" (pp. 328).

Another useful method for distinguishing SoS properties is introduced by Maier (1998). His taxonomy of architectural principles consists of three categories and their applicability:

1) Discriminating factors i.e. operational and managerial independence;

2) Design principles i.e. on what ideas the architecture is based on and;

3) A classification that is based on the purpose of the whole SoS.

The first category has been presented in more detail earlier but the second and third need to be addressed in more detail in order to comprehend the taxonomy framework.

The design or architectural principles (policy triage) are defined by Maier (1998) as regulatory action that can be paired with success. Thus, a SoS should have certain attributes regarding their design. The first principle is ***Stable intermediate forms***, which means the stability at the technical, economical, and political levels of the SoS ensuring agility in the operations among individual elements also making them more detachable without causing much damage to the SoS purposes. ***Design guidance*** is the principle of how much control is carried out by the development team of the SoS. It is a very delicate line where both over- and under-control are likely to eliminate possibilities of success. ***Leverage at the interfaces*** is the amount of weight that is put on the interface standards by the overseeing parties. The more independent the individual parts, the more leverage should be put on the interfaces. The final principle, ***Ensuring cooperation*** helps to address the autonomy of participants. In an SoS the elements can continuously choose to participate or not. Thus, the option to collaborate must be made economically more attractive than individual operations' costs and benefits.

Maier's (1998) final part of the taxonomy is the classification of SoS and he argues that there are three basic categories. In a ***Directed*** SoS a core team tightly controls the management and the components are clearly demanded to work towards a central purpose, although they are also capable of independent operations. A ***Collaborative*** SoS is constructed through voluntary collaboration and the development team does not have ultimate power to force the operations. Purposes are met through collaboration to establish standards. The ***Virtual*** SoS lacks both central management and collectively agreed purposes. Standards in these environments evolve through success in the market instead of a controlled way.

3 Case FI-WARE Description

To understand what FI-WARE is about, it is necessary to understand what it is related to. FI-WARE is a project aiming in the construction of a core platform for the Future Internet Private Public Partnerships (FI-PPP) project, which is part of the Seventh Framework Programme (FP7) of the European Commission. FI-WARE will be the technology provider for all areas of the FI-PPP and is therefore vital for its success.

Besley and Ghatak (2001) argue that Private-Public Partnerships or PPP's are an increasing form of collaboration between the government owned public sector and private ownership. They continue to explain that as a result of this, the risks and benefits are shared between the parties. This in turn raises questions about whether or not there are controversies within the interests of the financing private parties. Spackman (2002) analyses the relationships between PPP's in the United Kingdom and what the benefits, risks, and outcomes for these are. They cannot conclude with certainty that PPP's are better options than keeping the parties separate, although it seems as the PPP's in the UK have mostly been successful. The FI-PPP was launched in 2010 as a Private-Public Partnership project to ensure the future success of the European IT sector through collaboration between public sectors and private companies. It is based on the notion that the current Internet is being used in ways that were not meant by the original goals by the research that built it and this is causing it to not be used with its full potential. The Internet was designed in the 1970's and the FI-PPP program is set on the mindset that it should be redesigned in order to get full benefits from it (FI-PPP, 2012)

The FI-PPP project consists of eight Use Cases (UC), which are projects within the FI-PPP framework. These UC's have individual goals and work independently. Their aim is to apply methods that derive from the FI-PPP program and use them to solve issues affecting the public sector. The eight UC's are as described by Havlik *et al.* (2011, pp. 2-3):

- **FINEST -** Future Internet enabled optimization of transport and logistics business networks.
- **INSTANT MOBILITY** - In the Instant Mobility vision, every journey and every transport movement is part of a fully connected and self-optimizing ecosystem.
- **SMART AGRIFOOD -** Smart food and agribusiness: Future Internet for safe and healthy food from farm to fork.
- **FINSENY** - Future Internet for smart energy: foster Europe's leadership in ICT solutions for smart energy, e.g. in smart buildings and electric mobility. Coordinator: Nokia Siemens Networks
- **SafeCity** - Future Internet applied to public safety in Smart Cities: To ensure people feel safe in their surroundings.
- **OUTSMART** - Provisioning of urban/regional smart services and business models enabled by the Future Internet: water and sewage, waste management, environment and transport. Coordinator: France Telecom.
- **FI-CONTENT** - Future media Internet for large-scale content experimentation e.g. in gaming, edutainment & culture, professionally and user generated content. Coordinator: Technicolor.
- **ENVIROFI** - to leverage the Future Internet for environmental monitoring and management applications

Havlik *et al.* (2011) describe FI-PPP as a project that has two-folded objectives: (1) it aims to increase the effectiveness of overall operations in the IT sector of various European industries, and (2) through this increase the competitiveness and innovation of these industries. The programme consists of three phases and has four building blocks (Havlik *et al.,* 2011, pp.3) (Figure 2):

- The technology foundation, also referred to as the Core Platform, should provide a platform to support Generic Enablers in an open and trusted way (FI-WARE);
- The use cases and trials aim at identifying these Generic Enablers deriving from their particular use cases and provide a testing infrastructure on which the platform can be validated through large scale trials (eight use cases);
- Infrastructure support block aims at identifying existing and future experimental infrastructures across Europe and to incorporate them in the large scale trials (INFINITY);
- Finally, the fourth building block facilitates coordination and support to the program (CONCORD).

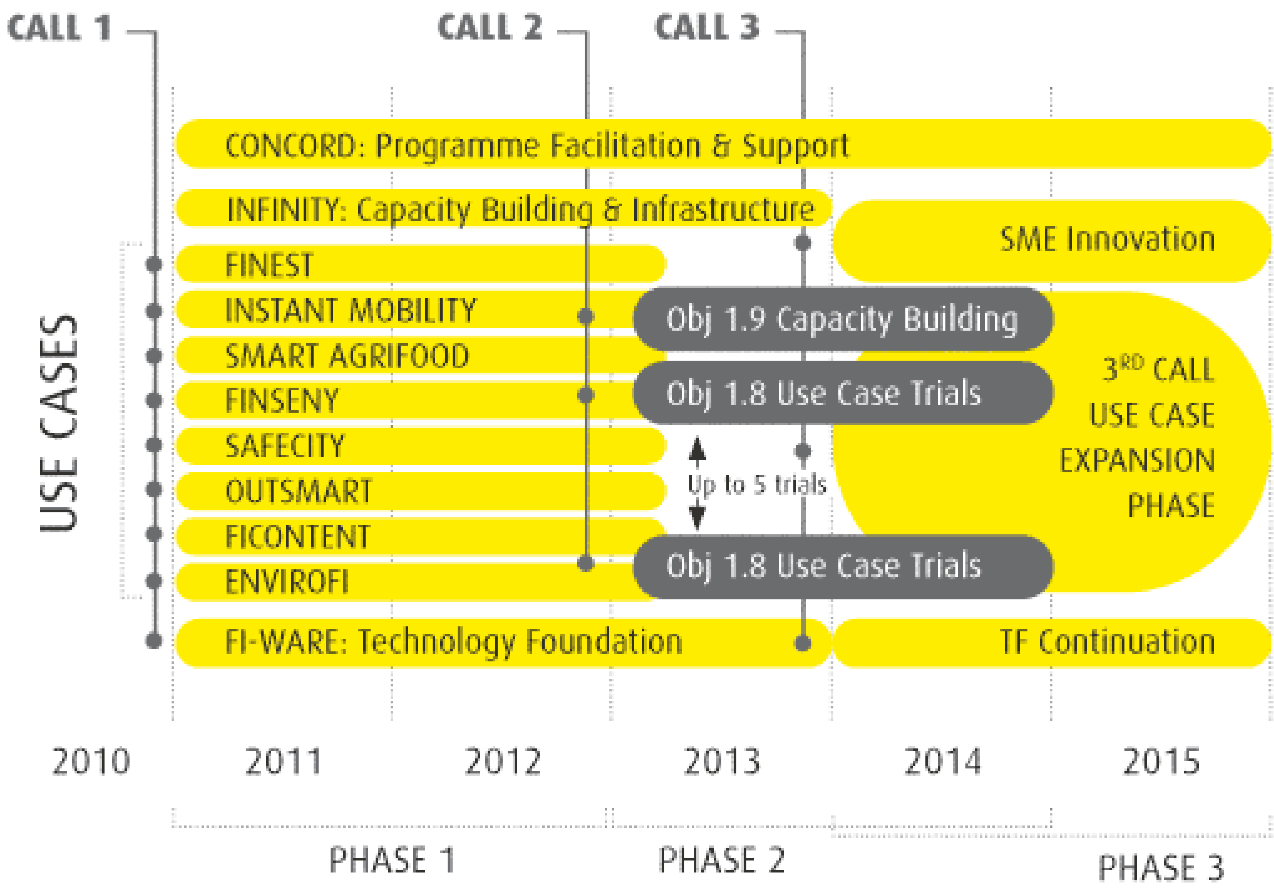

Figure 2: FI-PPP project overview (FI-PPP, 2012)

The technology platform (FI-WARE), on which this research paper concentrates on, is meant for the use and development of new ICT innovations by using Generic Enabler's (GE's). GE's are parts of architecture that are aimed at a certain use. Although they are divided into six subsets based on their architectural purpose (Applications/Services Ecosystem and Delivery Framework, Cloud hosting, Data/Context Management, Interface to Networks and Devices (I2ND), Internet of Things (IoT) Services Enablement, and Security) the GE's can be used freely among various usage areas. The architecture will be flexible and allow immigration enabling the use of GE's in a wider range of environments.

As stated before, one of the main tasks of the UC's is to identify the technological requirements that would be needed in order to be able to achieve their individual goals. These GE's would then be used by all the UC's in their projects as well. They would pick the GE's that they feel are required from the FI-WARE platform making this on of the culminating points in the PPP**.** Figure 3 depicts this event.

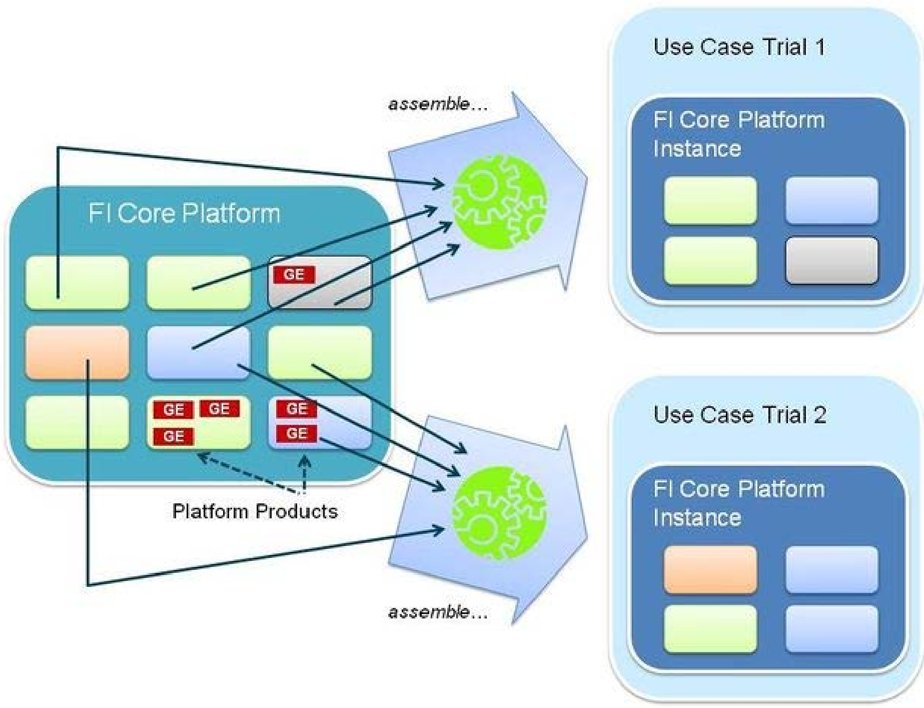

Figure 3: Use Cases use Generic Enablers. (FI-WARE, 2012)

The identified contributors that are required for the success of FI-WARE are Telecom and ICT industry companies. The platform needs these companies to include FI-WARE as a part of their business models. Thus, they would begin developing events that would happen via the platform, called instances. This platform would be open to all and not only partners of the project that include such companies as SAP, IBM, Intel, and Telefonica to name a few.

3.1 Generic Enablers

The Generic Enablers (GE's) are the building blocks of the FI-WARE architecture. They are commonly shared and used in various usage areas across different sectors within the ICT environment. In other words, they are the pieces that form the body of the FI-WARE platform. From the platform the Use Cases can choose which GE's they wish to use and mix in order to complete their purposes. The GE's are divided in to six categories: Applications/Services Ecosystem and Delivery Framework, Cloud hosting, Data/Context Management, Interface to Networks and Devices (I2ND), Internet of Things (IoT) Services Enablement, and Security. For example, if the Use Case ENVIROFI needs to build a network of data collectors in a wide geographical area, it will probably need to build the network using GE's from at least Cloud hosting, Data/Context Management, Interface to Networks and Devices (I2ND), Internet of Things (IoT) Services Enablement, and Security in the manner that is depicted in Figure 3.

The GE's are also reusable and can be mixed in ways desired by producers. Havlik *et al.* (2011) describe the GE's as a set of components "allowing: (1) creation, publishing, managing and consuming the Future Internet services; (2) deploying the Future Internet services on the cloud, i.e. using cloud computing technologies; (3) accessing, processing and analyzing massive data streams, as well as semantically classifying them into valuable knowledge; (4) leveraging the ubiquity of heterogeneous, resource-constrained devices in the Internet of Things; and (5) accessing the networks and devices through consistent service interfaces." (pp. 1)

3.1.1 Applications/Services Ecosystem and Delivery Framework

Applications/Services Ecosystem and Delivery Framework comprises of a set of generic enablers that are meant to provide a complete business environment for future Internet applications and services. Thus developers can reach the end users via the same platform where they create their products. The Applications/Services Ecosystem and Delivery Framework is a provider of an infrastructure that will allow the components that are made available through various providers to be composed in to a mash-up. This end product can then be accessed through various devices in order to create added value through crowd sourcing.

The high-level architecture (Figure 4) shows the basic concept and operating within the framework. There are four internal roles (Aggregator, Broker, Gateway, and Channel Maker) and four external roles (Provider, Hoster, Premise, and Consumer). Each of these high-level roles is further divided into more specific actual GE’s. For the Business Framework these include such as the USDL (the unified service description language) service descriptions, repository, registry, marketplace, SLA management.

The revenue model used in the Applications/Services Ecosystem and Delivery Framework is based on a flexible revenue sharing model. This model would be similar to the model used in Apple’s Application Store where a certain percentage is paid for all the parties involved with a certain service or application.

The Provider supports those partners that produce and own the services and applications as their business. Then the products are made available to the Broker from which they will find their way to the end users. The Provider is operating as a link between producers and the Broker framework ensuring that the demands and needs of both parties are fulfilled.

The Broker is provided with detailed information of products in the Providers network so that it can match the customer inquiries it gets through the Channel Makers. The Broker, although dealing these services and applications, does not execute them. It can be considered as a market place environment for the external stakeholders in services and applications. It has much power on the purchase decision as it suggests the most appropriate option based on its interpretation of the consumers need.

The Hoster is a standardized interface for the representation of various cloud providers of which the service and application producers choose the best suited for their purpose. This will increase the possibility of migration for the Providers application and services producers among cloud providers. Furthermore it employs revenue sharing possibilities between the producers and cloud providers.

The Aggregator's mission is to compile services and applications in ways that were not necessarily originally intended by the provider. Thus, Aggregators do not necessarily operate or own the services and applications they use to assemble the mash ups they supply.

The Gateway operates in between the Providers and Aggregators helping them find solutions to interoperability issues. Different Gateways also make it possible for all parties to understand each other beyond standards.

The Channel Maker is the point where the consumer can search for the service or application needed. The Channel Maker interacts directly with the Broker. Examples of Channel Makers could be web sites, networks, other applications, and devices. This is the point where the service is consumed and the Broker is the point of accessing various channels.

The Consumer is the "last mile" of the whole value network. It is the various environments where the applications and services are consumed. The Consumer finds the channels in the environments where the integrated services and applications can be consumed. Then through the Channel Maker takes them from the Broker.

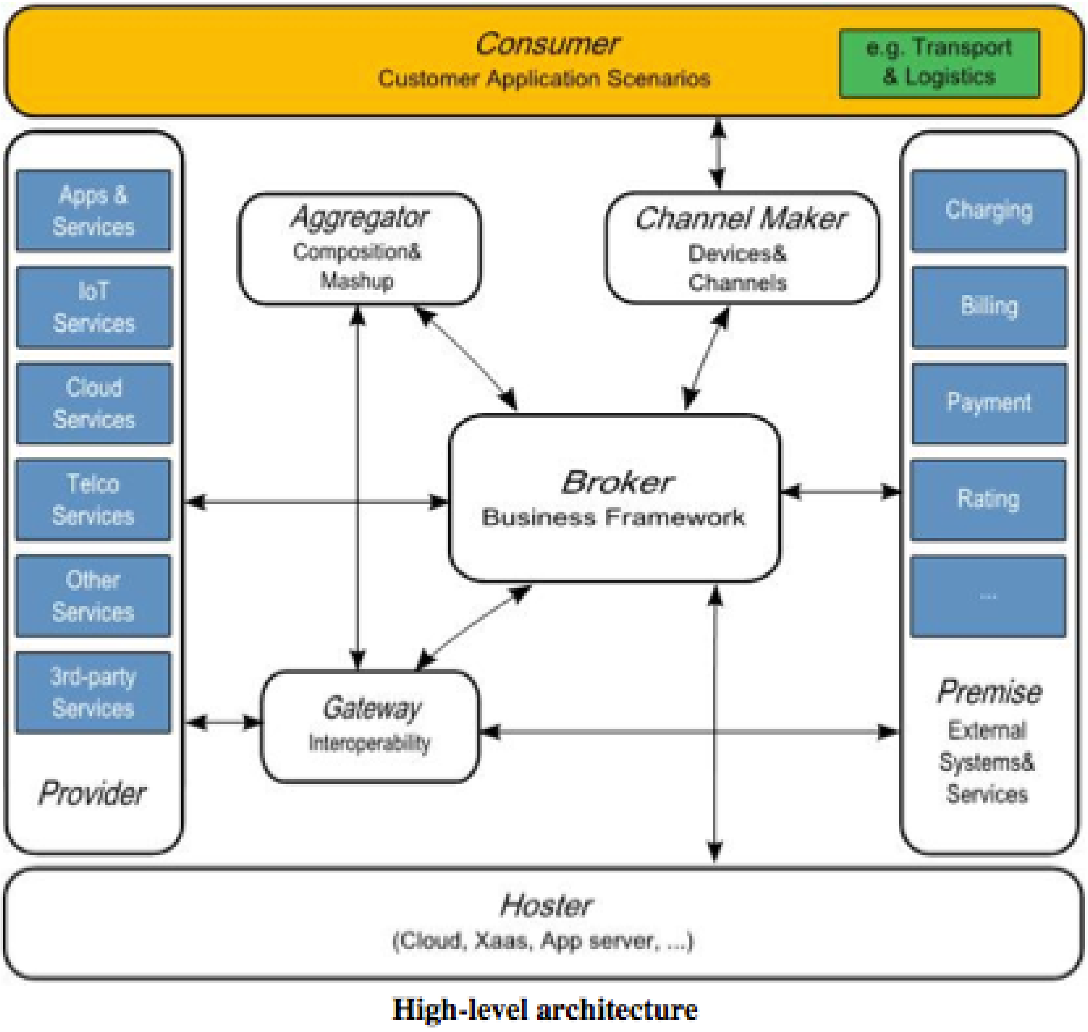

Figure 4: High-level architecture of Applications/Services Ecosystem and Delivery Framework (FI-WARE, 2011)

3.1.2 Cloud Hosting

The companies hosting cloud operations tend to become an essential part of the customer's business. This creates a potential for an undesired lock-in with the single provider. FI-WARE's Cloud Hosting is intended to be built in a way that emphasizes open standards, interoperability and portability. In the FI-WARE Cloud Hosting project this method is believed to bring technological and functional advantages that will differentiate it from competition.

The FI-WARE Cloud Hosting recognizes two main parties in the business model: the providers i.e. FI-WARE instances owning the physical infrastructure required, and the users of the service who lease the cloud from the providers.

The operation method is based on the Cloud Service offerings defined by the National Institute of Standards And Technology. These are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). In FI-WARE Cloud Hosting these three models are intended, but not restricted, to be used in an integrated stack model (Figure 5) that will be virtualized enabling a flexible environment. Furthermore, the three have their own specific GE's such as DataCenter resources, Service management, Object storage, and Monitoring.

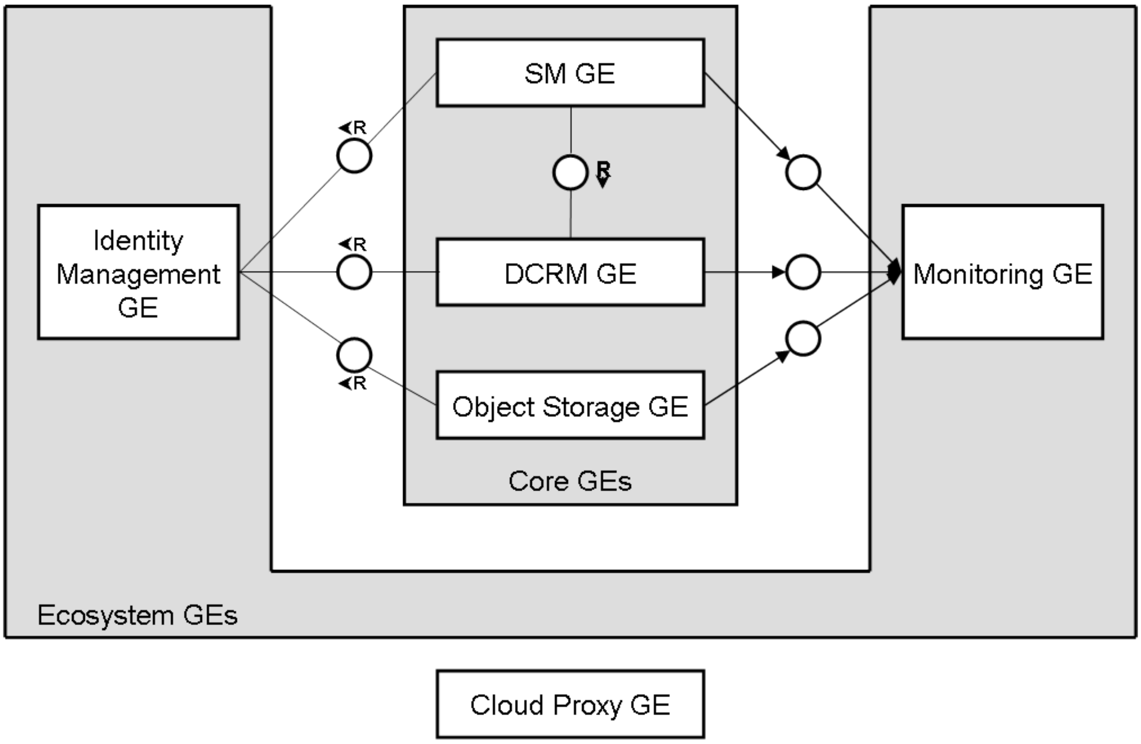

Figure 5: Cloud Hosting Architecture in first release with GE's (FI-WARE, 2012)

The first release of the Cloud Hosting chapter consists of six GE's but as the project grows, more GE's will be added on according to the needs of Use Cases. The initial six are (FI-WARE, 2012):

- **DataCenter Resource Management**

"Offering provisioning and life cycle management of virtualized resources (compute, storage, network) associated with virtual machines".

- **Service Management**

Automates the repeatable recovery tasks.

- **Cloud Edge (Cloud Proxy)**

Operates as an agent between the consumer and the service itself. It offers a public interface: the Service Platform Management Interface.

- **Object Storage**

Provides the users with storage capabilities for digital objects.

- **Monitoring**

Collects information from all the other GE's and offers it to other GE's that are interested in the given information.

- **Identity Management**

Provides a unified user management system that other GE's can use to authenticate all users.

3.1.3 FI-WARE Data/Context Management

All the events that take place in the FI-WARE environment create data and as the transactions grow the data grows as well. Events are certain occurrences that take place within any system or domain and both data and context events may occur. FI-WARE Data/Context Management is going to be built to address “gathering, processing, interchange and exploitation of data at large scale” (FI-WARE 2011). This in turn will enable the meeting of expectations set on the other elements of FI-WARE, for example the development of robust new applications and services.

FI-WARE Data/Context Management is the set of tools that enable FI-WARE’s consumer analysis through social medias and overall consumer behaviour. This in turn gives the Broker the possibility of offering the consumer the products that best seem to comply with the behaviour.

Figure 6 shows the high-level architecture for FI-WARE Data/Context Management. There are still question marks within the system mostly related to security issues at different points. For example, these include the gathering of personal data and concerns of distributing it. There should be a method of doing this in a way that users have control on what information they want to be accessed by other parties.

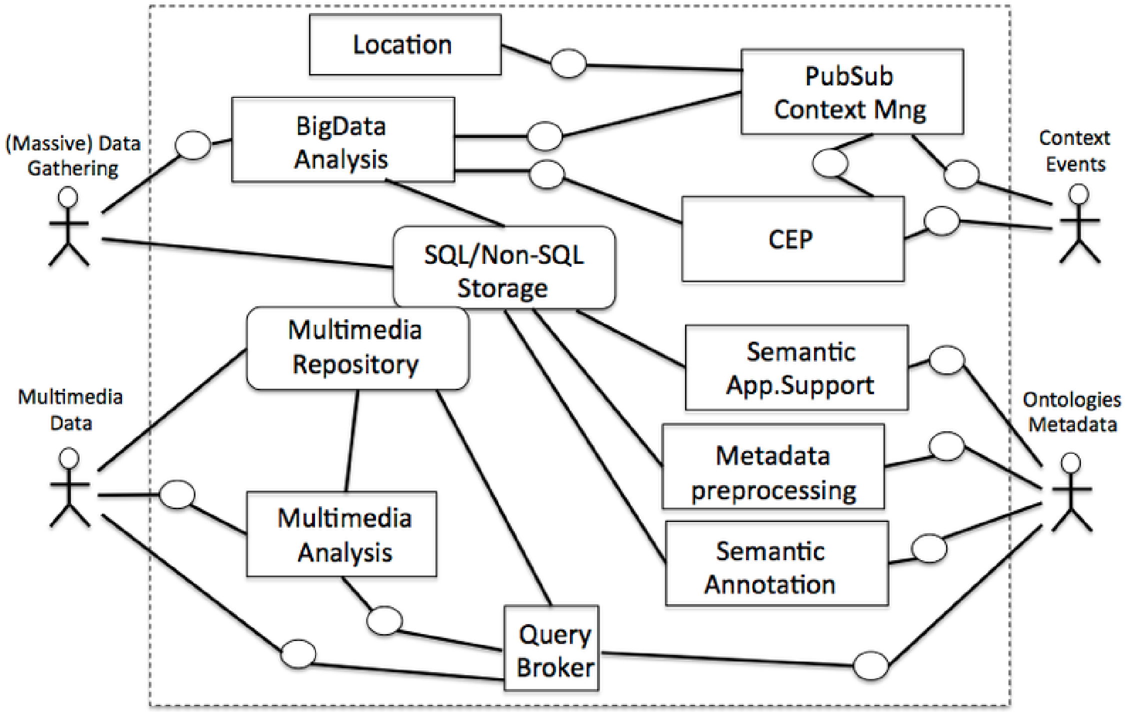

Figure 6: Architecture of Data and Context Management Architecture in first release with Generic Enablers (FI-WARE 2012)

The first release of the Data/Context Management chapter will consist at least the 11 GE's that are shown in Figure 6. These are (FI-WARE, 2012):

- **Big Data Analysis**

  Allows the end user to analyze data that may have been too large with the technology previously at hand.
- **Location Platform**

  Enables location based services through third-party applications.
- **Publish/Subscribe Broker**

  Allows context producers to publish their services and makes it available for context consumers.
- **SQL/Non-SQL Storage**
- **Multimedia Repository**
- **Semantic Application Support**

Meant to help the implementation of Semantic Web use in the European ICT environment.

- **Metadata preprocessing**

  Scans metadata from a given device and makes it interpretable for other components that are required to work with the given metadata. Ensures interoperability.
- **Multimedia Analysis**
- **Semantic Annotation**

  Enables the adding of more useful data in to content. Also, eliminates meaningless information from the data results.
- **Query Broker**

  Focusses on the multimedia queries. The Media-enhanced Query Broker is a means of interpreting various types of multimedia data making the retrieval of different data types interoperable.
- **Complex Event Processing (CEP)**

  A real-time event analysis tool that allows instant responses to changing conditions in events.

3.1.4 The FI-WARE Interface to Networks and Devices (I2ND)

The FI-WARE Interface to Networks and Devices (I2ND) aims to build a standard interface for all the different devices used to connect to its platform. The existence of various script, interpreted, and native programming technologies combined with the ever increasing options on hardware choices creates a fragmented environment where users do not get equal quality of experience.

The architecture in FI-WARE Interface to Networks and Devices (I2ND) will consist of three layers: Service structuring, Policy and control, Packet handling (Figure 7). These layers or stratum will be what the GE’s are built on. The first is the end-to-end-service supply, the second is the network provider level on intertechnology control, and the last is the technology used in the information traffic (e.g. DSL or WiFi).

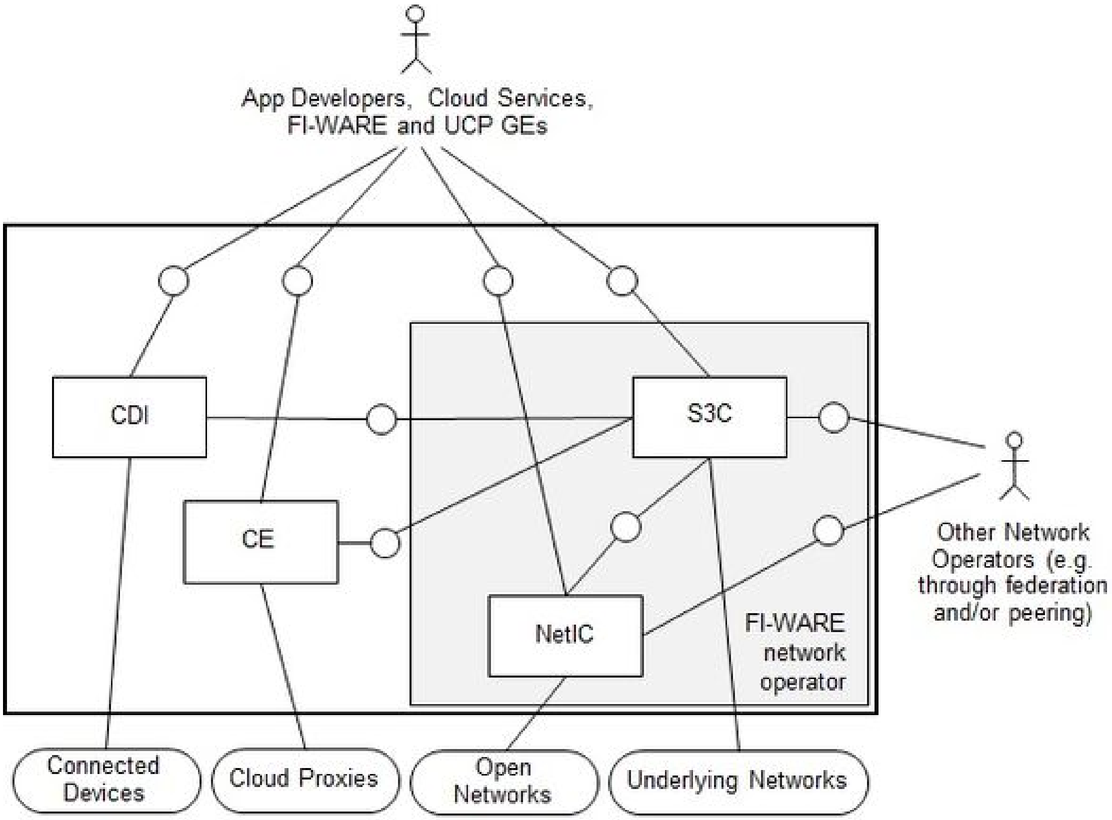

Figure 7: I2ND Architecture in first release with GE's (FI-WARE, 2012)

The first release of the I2ND chapter consists of 4 GE's. These are (FI-WARE, 2012):

- **Connected Devices Interface**

  Enables the FI-WARE Use Case projects and other chapter GE's to detect which kind of electronic device is used to connect to it and optimize the services accordingly.

- **Cloud Edge**

As the Cloud Edge operates as the agent or interface between the end user and the Cloud Hosting chapter, it can be considered as a GE in both instances

- **Network Information and Control**

Offers a limited amount of means to manipulate networks that situate between the providers/operators and the consumers. The NetIC optimizes the capabilities of the network.

- **Service, Capability, Connectivity, and Control (S3C)**

All the GE's in the I2ND chapter are interconnected through interfaces and the S3C is the central control and management entity in the environment. It provides a scalable and controllable connectivity of devices over networks and technologies.

3.1.5 FI-WARE Internet of Things (IoT) Services Enablement

The Future Internet services will be based on physical environments that are connected to information networks. FI-WARE believes there are considerable opportunities in value creation in the Internet of Things (IoT) and therefore includes Generic Enablers that are required for its implementation in the architecture of the whole platform. The FI-WARE project sees IoT resources as a necessary need and currently it is too challenging to be fully implemented. At the moment there are various technologies and protocols that provide IoT functions in an unstandardized way making it more inefficient and unappealing to users. The target of FI-WARE IoT is to homogenize the way these functions are made available and consumed. By providing scalable i.e. easily expandable schemes IoT will be made available for all types of applications and allow the parts functions of IoT to become essential parts of the Future Internet environment.

IoT will generate large amounts of data that will be managed efficiently. To successfully analyse and handle the information other parts of FI-WARE e.g. Data/Context Management GE's, will take a big role in the functionality. This emphasizes the reusability and openness of the whole platform. Open GE's in communications will enable interaction with physical things regardless of protocol. Resource management GE's will provide access and mapping of things, identification, and finding them. Data handling GE's will include support for various models in real-time and in large amounts. FI-WARE IoT will also include a set of process automation GE's. The high-level architecture is provided in Figure 8.

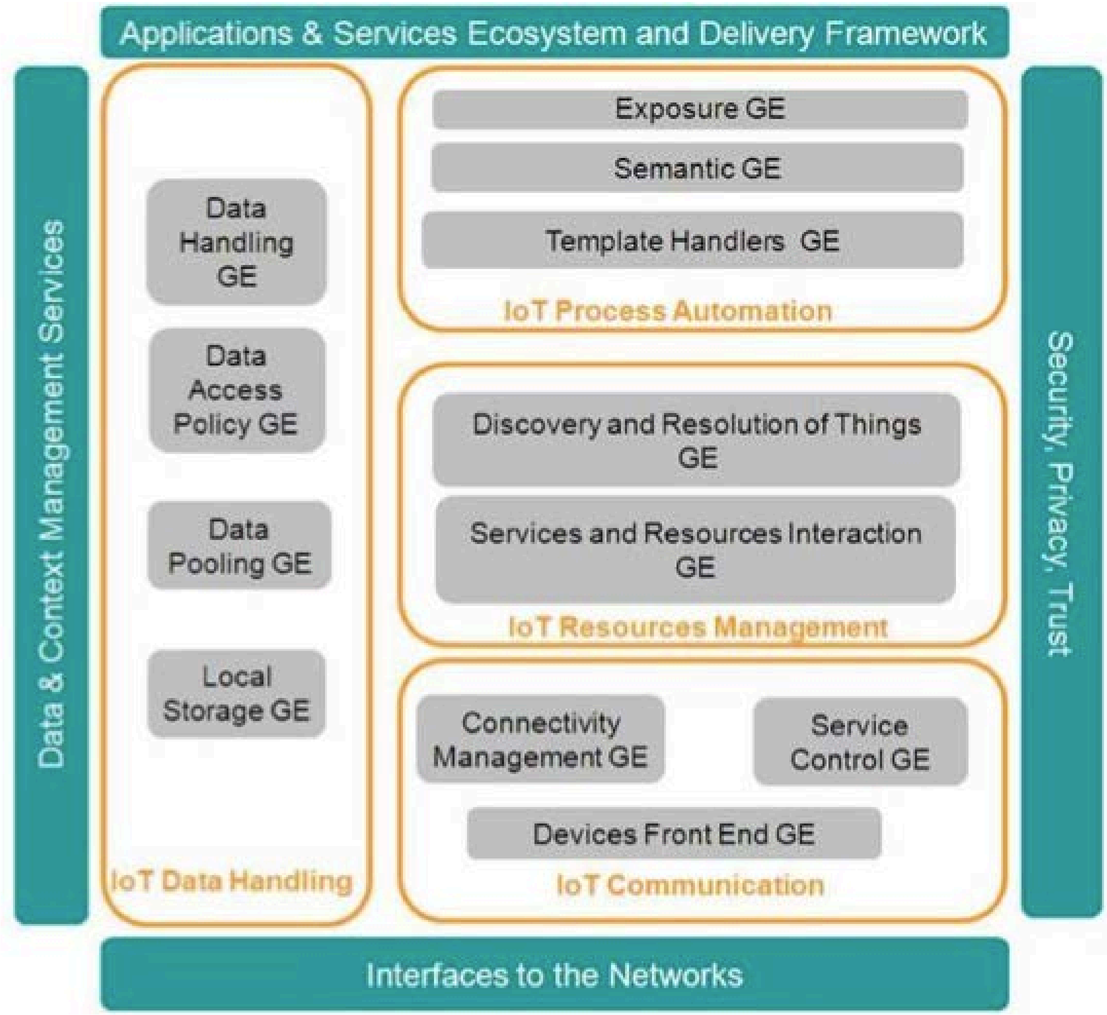

Figure 8: IoT High-Level architecture (FI-WARE 2011)

3.1.6 FI-WARE Security

As cyber-security is becoming more relevant every year, it is necessary to address these issues from the very beginning in a project such as FI-WARE. The project designers are aware of the risks and problems that may rise from the architecture of the Core Platform. As there are numerous service providers and partners included, the end users are in contact with much more entities than they might originally expect.

Due to the high respect to a person's individuality and the users' rights to control their own personal information, these have been made the main emphasis in the FI-WARE security. Users will have the ability to control what information is available and who can access it. This will make the environment more attractive for end users as they feel safe when using services in FI-WARE. Nevertheless, the functions will not be limited to the end user level, but also the high-level risks facing service providers are taken in to account. FI-WARE security will be built to be an open and generic "secure by design" model to which consumers (both end users and providers) can make extensions. FI-WAREs objectives are to address both high-level risks and domestic common security problems. Figure 9 depicts the initial security chapter.

The first release of the Security chapter consists of six GE's. These are (FI-WARE, 2012):

- **Security Monitoring**
  Monitoring is a part of each instance that takes place in the FI-WARE environment and is composed of five functionalities. It is meant to be a pro-active security system that continuously assesses the real security state.

- **Context-Based Security & Compliance (Will be included in the 2nd release)**

  Allows instances to deal with unpredictable context changes. It also enables protection of data in different compliances so that the same instance can be protected in various degrees depending on the end user.

- **Identity Management**

  Enables a more user friendly and simple method for authentication and sharing of private information through the web. Each user profile could be securely hosted as a “tenant”, or a single multi-purpose profile, instead of multiple profiles scattered over the web.

- **Privacy (Will be included in later releases)**

  Is meant to enhance the functionality of the Identity Management and Data Handling GE’s.

- **Data Handling**

  Provides a mechanism to control the usage of specific data. When an application makes a request for the data, the GE verifies that the intended use is within the specifications.

- **Optional Security Enablers**

  Complementary services that can be added to original Core GE’s. These will be added with future releases of the project.

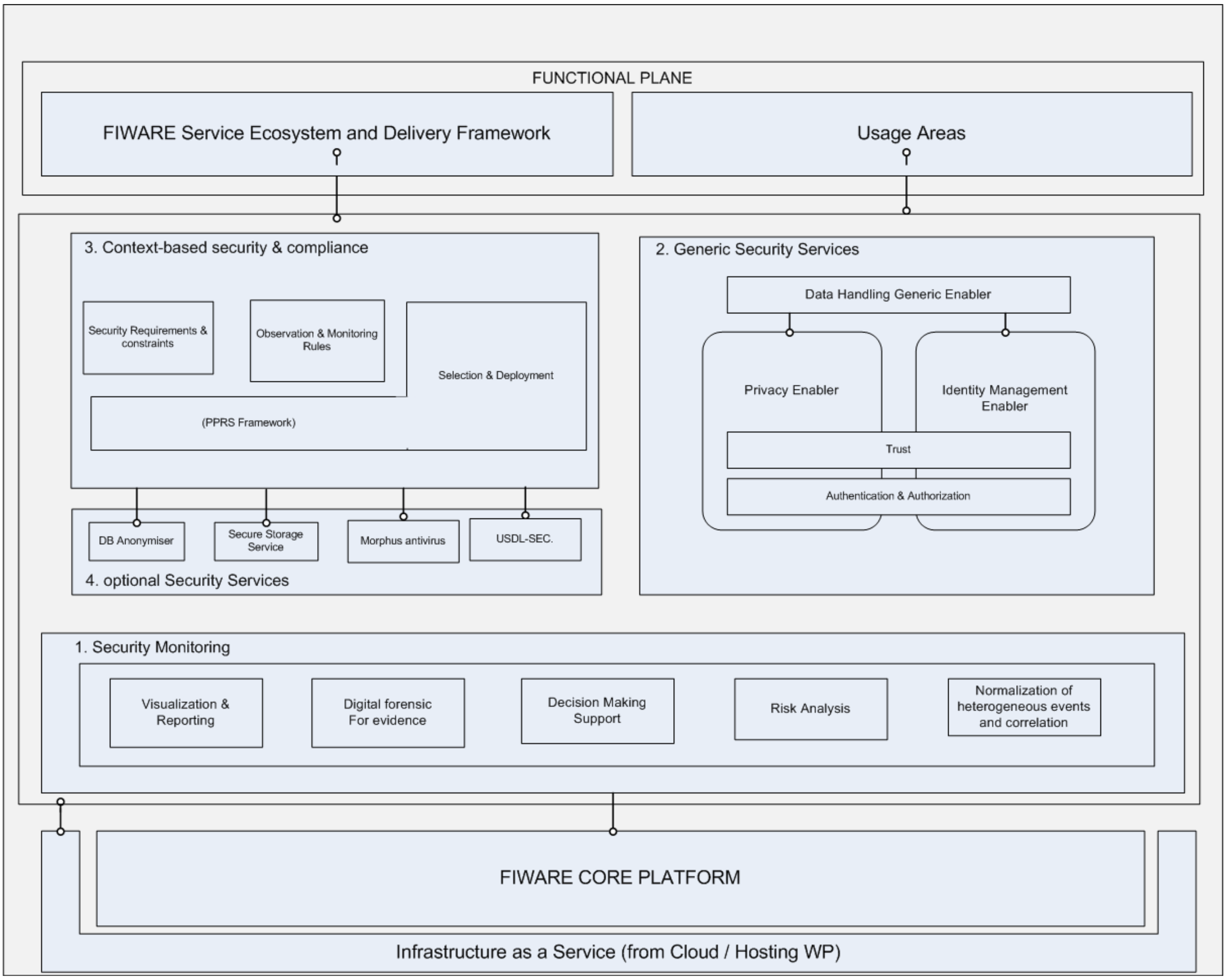

Figure 9: Security Architecture in first release with GE's (FI-WARE, 2012)

4 METHODOLOGY

This study has been conducted primarily as a qualitative research as the nature of the issues is more relevant than the extent. The objective was to determine whether a new Internet technology platform with a top-down approach is a feasible business model. As the thesis has a focus on a real life phenomenon in scope and aims to gather opinions from various parties relating to the FI-WARE project funded by the European Commission, the study is conducted in a case format.

The justification for a case study format comes from Yin's (2003) description for a case study:

> *"A case study is an empirical enquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (pp. 13)*

Eisenhardt (1989) is in the same line with the definition of a case study:

> *"The case study is a research strategy which focuses on understanding the dynamics present within single settings." (pp. 534)*

In the article Eisenhardt (1989) focuses on how case studies are most effective when there are 4 to 10 cases in the research. Thus, the value of single case studies is underlined as ineffective. The guidelines provided are useful and comprehensive especially for multiple case studies. However, Eisenhardt has received criticism for the somewhat demeaning attitude towards single case studies. Dyer and Wilkins (1991) strongly defend the position of single case studies and emphasize that there are clear examples of how single case studies have provided good results. Nevertheless, the notion is made that both methods should be used in the case study research field.

4.1 Objectives of the Study

Kothari (1985) explains that while research is meant to answer scientific problems and unveil unknown knowledge in specific areas, there are certain groups into which most research objectives fall:

1. To gain familiarity with a phenomenon or achieve new insights into it (studies with this object in view are termed as *exploratory* or *formulative* research studies);
2. To portray accurately the characteristics of a particular individual. Situation or a group (studies with this object in view are known as *descriptive* research studies);
3. To determine the frequency with which something occurs or with which it is associated with something else (studies with this object in view are known as *diagnostic* research studies);
4. To test a hypothesis of a causal relationship between variables (such studies are known as *hypothesis-testing* research studies).

The clearest way to determine the objective of this study would be to say the research is a descriptive one (Kothari, 1985). The aim is to describe the issues regarding implementation of a new Internet technology platform from a top-down model and provide information on the key success factors regarding this activity. Also, to ensure that the findings would not be predetermined the goal is to discover whether there is a clear relation and to explain why there is such on the construction model of platforms and the success of them. This on the other hand gives the research also a somewhat correlative and exploratory.

4.2 Design of the study

Yin (2003) explains that there are two distinct types of case studies. There are single case studies, which are only focusing on one case at a time and there are multiple case studies, which in turn focus on many cases at a time. For the benefit of this study, the single case method is used. The justification is that as the FI-WARE project is unique in its type and takes place in an area of research of which the theory has been well studied beforehand.

There are two rationales to choose a single case study. These are that the case “represents the *critical case* in testing a well-formulated theory” or that the case “represents an *extreme* or a *unique* case” (Yin, pp. 40, 2003). Thus, considering the unique nature of FI-WARE as a platform technology case, it is eligible for the use of single case methods.

The research will primarily be based on personal, single interviews that will be conducted either face to face or via voice over Internet protocol (VoIP) tools such as Skype. The interviews will not have many predetermined questions but rather the aim is to allow the interviewee to speak as freely as possible to allow a flexible explanation on their views. Nevertheless, there are certain issues, which are wanted clear answers to and thus some specific questions will be asked. Therefore, the interviews will be a mixture of unstructured and non-directive interviews (Kothari, 1985).

Yin (2003) describes five key components to a case study. (1) *A case study’s questions* should give a relevant direction to which research strategy is being used. (2) *Study propositions* guide the study to what should be studied. (3) *Unit of analysis* is what the results for the research questions will measure. If too many units emerge, the questions may be too vaguely defined. (4) *Linking data to propositions* relates to the gathering and analyzing of relevant data as a reflection of the initial study propositions. And finally (5) *The criteria for interpreting a study's findings.*

This study is conducted in a manner that complies with the criterion for study components Yin (2003) distinguishes:

1. **Study questions**

   In this study the focus of enquiry is on how platform business models are developed and what the key success factors in the process are. This is analyzed from the viewpoint of the FI-WARE project. The questions can be answered through existing theories on platform models and interviews. Primary sources for the quantitative data will be the interviews conducted and material produced by the FI-WARE project. Secondary data will be the existing research literature.

2. **Study propositions**

   Yin (2003) describes that study propositions keep the study within scope in order to keep the research meaningful. In this study the aim is to test the proposition of the feasibility of building a successful Internet technology platform with a top-down model from the viewpoint of FI-WARE.

3. **Unit of analysis**

   The study questions are linked to the requirements defined in research of platform model theories. Thus, the units of analysis are closely linked to the key success factories and core components that have been defined for platforms.

4. **Linking data to propositions**

   The gathering of empirical data that is directly relative to the propositions of the study is a crucial element of succeeding in the analysis. In this study, data had to be gathered from various research areas in order to provide a wide enough understanding on the area and sufficient knowledge for making analyzes. The requirements of the interviews however were more clearly formulated after the literature review and thus more accurately related interviewees were contacted.

5. **Criteria for interpreting the findings**

   According to Yin (2003) this is the most difficult aspect of the case study methodology. To aid with this problem Yin (2003) provides four principles as tools for researchers to use. (1) Show that the analysis relied on all the relevant evidence, (2) Include all major rival interpretations in the analysis, (3) Address the most significant aspect of the case study, and (4) Use the researcher's prior, expert knowledge to further the analysis.

4.3 Reliability and Validity

In quantitative research reliability is often considered the idea of repeatability of the results of a study but this should be extended to include consistency of tests through a certain period of time. Although, this kind of test-retest method can prove that results are consistent and repeatable and thus more reliable, it is not perhaps the most valid one. This is because some characteristics of the respondents in the study may change throughout time. (Golafshani, 2003). To address this issue Tesch (1990) highlighted the use of computers as a factor that increases reliability as the same data can be used more efficiently over again.

Validity in quantitative research relates to whether the study is actually measuring what it is intended to and if they are accurate (Golafshani, 2003).

However, Winter (2000) notes that the difference between precision and validity must be made. This means that for example excess precision, too vast samples, or over categorization does not increase the validity of a research.

The reliability of qualitative research is a result of the validity (Golafshani, 2003). However, Winter (2000) presents the notion that many qualitative researchers do not feel that the concept of validity can be applied to the qualitative field. Nevertheless, Stenbacka (2001) notes that there is a need for a method of defining the trustworthiness of the research. One suggested concept is the generalizability of the research, which is also used in quantitative research. This is also the debate that can be seen in the differing views of obtaining sufficient knowledge through the amount of case studies between Eisenhardt (1989), and Dyer and Wilkins (1991).

The requirements for reliability and validity were tried to apply when constructing this study. When conducting the interviews, the effort was made so that all interviewees understood the concepts in similar ways. The interviewees were limited to members of the project and the number was kept concise but the scope broad. Furthermore, the execution of the study was reported in as much detail as possible.

5 FINDINGS

The findings in this chapter are based on the interviews that were conducted in order to get specific expert knowledge on the FI-WARE platform and the overall processes regarding the project. All interviewees are or have been part of the project either from the Use Case's perspective or directly under FI-WARE.

5.1 FI-WARE and Key success factors

All interviewees have been part in the process of building the Future Internet core platform FI-WARE. Their views on what the platform is varied a bit according to the functions the interviewees saw as the key purposes of FI-WARE. It is understandable that a clear definition is difficult to give at the moment when the platform has not been completely built and still exists more in paper and idea format. Furthermore, the definition varied due to different choices of terminology. For example, while others talked clearly about a platform, some interviewees used a system-of-systems terminology. This provided a clear indication that it is not enough to analyze FI-WARE only from the literature regarding platform research.

The inclusion of system-of-systems models in to FI-WARE provides a more comprehensive overview on the project. Platform models as described in literature are not as pervasive as SoS models. This may also explain why it was difficult for the interviewees to explain in a single unified view what the FI-WARE platform actually is. By expanding the theories to include both SoS and platforms, a more detailed framework could be built. There are clear problems in the FI-WARE project communication and thus the overall purpose is easily lost. Therefore, it is important to determine what the project is actually about and how it is constructed.

“Basically FI-WARE is an attempt from a number of European companies to try to produce a platform…to build services upon.”

“Don’t assume that there is one FI-WARE platform. FI-WARE in the end will be a system-of-systems.”

A common consensus among the interviewees was that the FI-WARE project is extremely useful for the future landscape of European information technology companies. While little criticism was shown towards the core platform project itself, the interviewees did critically assess some individual parts of how the project has been executed. For example, there might be too high expectations towards the project when considering the size and funding.

“So FI-WARE would be a new version of the Internet. But a whole new version is impossible to build with a project of 50 million.”

“It’s a dangerous assumption that essentially after three years a project of a few partners … will come up with an entirely new Internet”

“It is definitely not too early to build FI-WARE.”

Identifying key success factors is critical for a project’s success. Therefore, it was necessary to discuss the views of the interviewees regarding FI-WARE’s success factors. Below is listed some key factors that the interviewees identified regarding the success of FI-WARE:

- Open standards

  "The idea is to use open standards … and build a system which is more capable, gives you more flexibility, [and] better performance"

- Open and royalty free specifications

  "All components, innovations, everything that is developed in FI-WARE, conceived, implemented and then consumed will be published in so called open and royalty free standards. That means that no matter what company you are with later, if you go to the FI-WARE specifications … you can access these specifications and re-implement exactly the same thing."

- Application programming interfaces or API's and their adoption

  "Open interfaces is indeed one of the key aspects of FI-WARE"

  "Adoption of API's is also a key success factor… the most important thing they could deliver is this kind of coherent overarching ecosystem…that actually delivers the view of how you can piece all of this [different API's] together."

- Marketplace

  "I see the marketplace as the central point and I feel it has huge market potential"

All interviewees agreed that the open nature of FI-WARE is the most important factor if adaptation is expected to spread throughout Europe. Openness is the key differentiating factor and also provides the possibility of new business models.

The interviewees often compared the FI-WARE project to other platforms and projects. The comparison was used to describe both similarities and differences. In some cases a different interviewee used the same comparison to describe an opposite view. These included the GSM/UMTS network standardization project, marketplace platforms from Apple, Google and others, and the current Internet.

As FI-WARE is building the core technology platform for the Future Internet, it is natural that it is heavily compared to the current Internet. The interviewees did not agree completely on how well FI-WARE is comparable to the Internet.

> *"The existing Internet is just a communications mean so you don't have this kind of platform."*
>
> *"At the moment you have to consider the whole Internet as the platform… FI-WARE would be a new version of the Internet."*

One interviewee provided an explanation to why the comparison between the Internet and FI-WARE is not consistent all the time:

> *"There is no uniquely or equivocally agreed definition of the Internet … it's not perfectly clear what [the] Internet means to who"*

The GSM network is a pan-European standard that was successfully implemented through the cooperation of network and device providers.

“The idea is for FI-WARE becoming a standard platform for the future Internet similar to the GSM network. Of course the GSM [project] is something much more larger and complex … but the whole philosophy is somewhat similar. What we are trying to do here is to develop some interfaces and provide implementations in a way [that] it resembles very much the way it was done with the GSM.”

FI-WARE is intended to be a new technological platform for European companies, so that they can increase their competitiveness in the ICT industry worldwide. The success of FI-WARE is easily compared to that of the GSM/UMTS project. This means that there should be an actual platform, if not physical then at least in an ICT architectural form. At the moment there have been problems in establishing the actual platform and even the managers of the project disagree whether it should be a platform or only a research project. However, when the purpose of FI-WARE is reflected upon, one of the key points is that it should somehow increase the business possibilities in the European ICT industry. Members of the project do not always seem to realize that the FI-WARE project has already achieved this by bringing top European ICT companies together to plan the future landscape of their operations.

“The success of FI-WARE can be measured in many ways. I mean what is the purpose of EC funded projects and initiatives? It’s not just about creating new ideas. It’s about strengthening the role of Europe in the world in an ICT point of view, as we are talking about ICT. Having European operators that are leading the vanguard of the next generation business models for communications companies is not a bad thing. That is achieving the objective of making Europe relevant from a business point of view on the global stage. For an initiative that

is driven by technology transfer, this is highly relevant. So you do want these companies to take something out of their involvement with FI-WARE that is relevant for themselves. FI-WARE is not just about what it will leave as a legacy that is FI-WARE, the platform that you can access via the web page or whatever else. It's about generating and sustaining growth for Europe and god knows Europe needs that right now."

5.2 Partners and business models

Partners of the FI-WARE project hold a principle role in the actual building of the platform. They are the ones who provide the technology and suggest standards to be applied through the whole FI-WARE. Thus, the partners will be the initial providers of the Generic Enablers on which the usage of FI-WARE is built. In the FI-WARE Overall Vision the GE provider is described as "Any implementer of a FI-WARE GE. The open and royalty-free nature of FI-WARE GE specifications will allow parties other than partners in the FI-WARE consortium to develop and commercialize products that are in compliance with FI-WARE GE specifications" (FI-WARE, 2011). Being an initial partner gives companies an advantage in the business aspects provided by FI-WARE. The interviews raised questions and debates on whether the partners of the project have been correctly chosen and will they have enough leverage to push the Future Internet core platform forward.

In general, the interviewees agreed that the current amount of partners to the project is insufficient. The need to increase both large enterprise partners and SME's participation was recognized. Also, the interviewees shared the opinion of the importance of partners as the key resource in building the core platform.

"*We were always telling that in fact the project should be larger and should [have] more partners"*

“The current partners of the project can maybe make this a Europe-wide standard, but more additional small companies could be needed.”

“Some of the stuff [FI-WARE] is aiming for may be better left for smaller players [instead of big companies]”

The project has already taken steps to ensure the participation of SME’s. The whole program is divided into three phases of which the first one has only recently ended. The aim would be to include more companies in the project in the second phase and also to enable them to test the actual core platform.

“The small companies that are invited to join in and to test the platform will be partially funded by the [European] Commission, so this is a strong reason for them to see what we have … because they will get at least half of the expenditure of testing. So we hope that quite a lot of companies, small in particular, would like to test what we have.”

In addition to partners, FI-WARE has the eight Use Cases from the FI-PPP project that provide scenarios in which the core platform could be used. The interviewees describe the relationship between the Use Cases and FI-WARE with less importance than the relationship with the partners. On the other hand, FI-WARE is not seen as a necessity by the Use Cases.

“Use cases are providing specifications and requirements but they are not producing any pieces. These are produced by the platform itself. Of course they are also helping us build the business models but they are essentially building requirements and not applications.”

"The success [of this Use Case] is not necessarily dependent on the success of FI-WARE. I would say that if FI-WARE doesn't do [what we need], somebody else will."

As can be seen from the comment above, there is a threat of competitors that FI-WARE is facing. However, competitors were a topic that the interviewees often left vague. Many claimed that platforms such as Google's Android, Apple's iTunes or Amazon are not competitors for FI-WARE, yet many of them compared them together in an almost benchmarking way. The argument was often made that FI-WARE is making something so much larger than any of these companies, that comparison is difficult. Nevertheless, the counterargument that these companies can grow their platforms to be as comprehensive as FI-WARE can also be made. The clearest differentiator between these was found to be the openness of the future Internet core platform. Comparing FI-WARE with platforms developed by Google or Apple divided the opinions of the interviewees. Some saw similarities between them, while others didn't see the common ground so clearly.

"To compare FI-WARE research project to what Google Android applications market or Apple's iTunes [and App Store] is doing is a slightly wrong assumption."

"I feel you cannot even compare FI-WARE with Google or Amazon. They are companies, FI-WARE is not a company, there's no business model behind it. There's no entity that wants to earn money with it."

"Instead of just being a place where applications are put and you simply get revenue out of them, you not only have the possibility to see the application you also have the possibility to access other Internet services [cloud, IoT etc.] so it would be something much more advanced and much more flexible and

would allow small companies, enterprises, and cities to develop new services more easily."

"If FI-WARE gets it right, then the breadth of the ecosystem will be the differentiating factor to competitors like Google and Amazon."

5.3 Building FI-WARE

The planning and building of the future internet technology platform FI-WARE began at the same time with the Use Case projects. The idea was that the UC's would provide specific technological requirements to FI-WARE and the platform would have been built following these requirements. Thus, it was clear that extensive and active communication between the counterparts was needed. From the interviews it became clear that there was a consensus that FI-WARE should have been built in a slightly different method.

Now that FI-WARE has gone through the first phase, it is easier to critically assess the process of the whole project and the interviewees were happy to do this. Two somewhat different schools of thought rose from the interviews regarding the building of FI-WARE and how it should have been done. The first is that the Use Case projects should have been started beforehand so that they would have had time to specify their requirements more.

"The UC projects started at the same time so they were in the same situation at that time and I suppose they had no idea themselves what they were up to, so how could they influence FI-WARE at that time. You could now say that maybe to deal with the problem the UC's should have been started one year earlier so then they would know exactly what to do…but that would have also had problems. "

The other way of thinking - and the one that had gathered more support - is that FI-WARE should have been started at least six months earlier than the UC's in order to be able to define the tools they could be able to provide and also to establish a more effective communications channel.

> *"Do those UC projects understand what the future internet is as defined by what will be produced by FI-WARE. Because it is FI-WARE effectively that are defining what the FI-PPP means by the future internet."*

One interviewee argued the case of both situations:

> *"It's a valid point of view to say that the UC's should have been built before FI-WARE. You could argue it that way sure. The UC's start up, they figure out what they want to do, and then put some requirements on FI-WARE. The problem with that is do they understand what future internet technologies are, do they understand and appreciate what FI-WARE exists for, what will be somehow actually created from FI-WARE. Because if they don't understand that, then maybe they can't actually shape their UC's in a way that fits into the integrated view of the entire program. You risk ending up getting UC's that are not relevant to future internet technologies. That there's something that the UC's think is very relevant for their field of interest, their domain but is really at the periphery of future internet. So at least by having access to FI-WARE and understanding what FI-WARE were building out in terms of these different generic enablers and technologies it allowed them to frame their UC's in a way that was relevant to the overall argument of the program of why the FI-PPP exists. You could argue that maybe they didn't need*

FI-WARE there to do that, that the document saying this is what FI-WARE will do when it starts is enough. But I would say that there are arguments, pros and cons in both directions. The UC projects starting first, FI-WARE starting first, there are benefits and problems in both directions."

Although there has been some slight disagreement on how the FI-WARE project should have been organized it is clear that not everything has gone as initially planned. Most of the interviewees noted that there has been a clear lack of communication in the process. The UC's and FI-WARE have faced a knowledge gap that has caused problems in understanding between the different projects. The biggest gap seems to have been between the UC's objectives and those of FI-WARE. This has interfered with the whole building process and may have slowed it down. The current methods of communication have been seen as insufficient for a project as large as FI-WARE and FI-PPP as a whole.

"Successful is not a word that I would apply to describe communication in FI-WARE. It is periodically effective but there are a lot of problems."

"I would say that either we find ways to change something in the communication or we will fail due to the lack of communication."

"A recommendation that I made was that for perhaps the future program structures, there needs to be a separate board that deals with impact related issues. So this is not a forum for technology, it's a forum for business. It's for understanding how to use this technology in a way that has business or commercial relevance that actually results in something useful, not just about connecting the technology level."

This problem within the whole FI-PPP is something that should be attended to in order to make FI-WARE as efficient as possible. As can be seen form the interviewees comments, the communication failure has led to a situation where the perceptions of what the actual objective of FI-WARE is i.e. is it a research project or an actual technology platform that will be the basis of the future Internet in the EU.

6 DISCUSSION

In the discussion chapter, the findings from existing literature and the interviews conducted for the study are analysed to provide in depth analysis on topics that have risen to be most relevant to the study.

6.1 Comparison of FI-WARE and GSM/UMTS

As FI-WARE is intended to become a Europe-wide technology platform and a standard for IT business models, it is necessary to compare it to a similar technology standard that was established during the 1980's and 1990's: the Global System for Mobile or GSM and UMTS that followed. The establishment of GSM was highly successful and was also a reoccurring comparison in the interviews conducted for this study. Therefore, the next section provides an overview on how GSM was established and discussion on how the issues are comparable to FI-WARE. First there will be a short history of the GSM project followed by discussion on the comparison of the two.

6.1.1 GSM

O'Mahony (1998) provides a brief introduction to how the GSM network was established. As mobile networking technologies began to emerge, Europe began to plan how to establish such a network for the pan-European region and in 1982 the Conference for European Post and Telecommunications (CEPT) was held and in this conference the *Groupé Speciale Mobile* (GSM) was given the task of formulating a pan-European standard for mobile telecommunications. The subsequent result was the he Global System for Mobile (GSM), which was validated in 1988. In 1989 the responsibility of the GSM network was passed to the European Telecommunications Standards

Institute (ETSI) took the responsibility of deciding on a commonly shared wireless standard. The ETSI task force included members from areas in which the standard was believed to hold a significant interest and all these were European. The GSM network standard quickly obtained popularity and became the *de facto* standard. It replaced such wireless technologies as the Nordic Mobile Telephony (NMT), which was used in Finland, Sweden, Norway, and Denmark.

Nevertheless, the success was not evident from the beginning. As Bekkers *et al.* (2000) note that the manufacturers of mobile devices were initially vary of the situation, as they feared that a common standard would give competitive options the opportunity to enter the market and the European manufacturers could not respond. This problem was handled by following a strategy, which Evans (2009) calls *Pre-commitment to sides*. In this particular case Bekkers *et al.* (2000) describe how fourteen network operators signed an agreement where they committed themselves into using the GSM standard. This was enough to convince the manufacturer side to support the standard as well.

The GSM was not a quickly established standard. The whole process from planning to actual launch took ten years from 1982 to 1992, thus the speed of establishment cannot be considered as a major success factor. On the other hand, GSM was made a political issue by engaging governments instead of only the companies providing networks. Therefore, national level influencers could enforce the standard (Selian, 2001).

6.1.2 Discussion on FI-WARE and GSM

The notable thing is that the GSM was developed at the very beginning of mobile technology's emergence in wider use. Thus, the development of a standard was more likely to succeed than it would have been if the mobile communications market had already existed in its current state. This is a major issue that FI-WARE is facing. The use of the Internet has already spread worldwide and companies such as Google and Amazon have built well-established platforms that are almost as widely used as the Internet itself. Therefore, for FI-WARE to come and introduce a new pan-European standard from a top-down perspective, it can be said that they are late in the game. If FI-WARE had been established at the same time as the Internet began to emerge as a communications and business model the possibilities of succeeding would be much higher.

In the establishment of the GSM standard 14 notable network operators agreed upon using that particular mobile communications technology (Bekkers *et al.,* 2000, pp. 8). This meant that the manufacturers had the promise of a large market in advance and could thus commit themselves to the standard as well. FI-WARE currently has 22 partners that, although being large companies, would not produce enough content to ensure that competing platforms would depreciate in value. To be sure of the success of FI-WARE, the project should have, in addition to the large technology companies, pushed the pre-commitment of those third party companies that would produce the actual content. Although, according to the interviewees this issue is being targeted by providing partial funding for the testing of the platform, it may not be enough to persuade companies to start producing mainly on FI-WARE.

Unlike GSM, FI-WARE is not a project with political implications. Instead, it is completely dependent on the partner companies. Of course it would be very difficult to have countries enforce a new Internet commerce standard at the moment as the use of the Internet has spread so wide already. Compared to the GSM, the building of which began approximately hand in hand with the adoption of mobile technology, it seems like an almost impossible task to confirm FI-WARE the position it is aiming for. As one interviewee pointed out, the lack of government participation in the project may likely be due to there being little need for infrastructure building when in the GSM there was heavy infrastructural developments needed.

6.2 Traditional Internet and Competitors

The closest project that can be compared to FI-WARE in a worldwide scope would be the Internet. Unlike the Internet the FI-WARE platform is attempting to target a large proportion of users simultaneously. This is an extremely challenging task especially when considering that the Internet is still growing fast and experiencing radical structural changes. However, this is also the reason why FI-WARE initially has been established: to address the challenges of the rapidly changing ICT environment and ensure that the ICT industry of the European Union remains competitive.

The Internet is approaching the next milestone in its history. The launch of the Internet Protocol version 6 is expected to change the Internet and how it is utilized considerably. After the launch of IPv6 it is possible to attach an IP address to almost everything, which will enable the actualization of the Internet of things. Commercial giants such as Google and Apple are likely to begin their own projects regarding the IoT and this poses a great challenge to FI-WARE. It must be well established to be able to provide the required services for companies that need the IoT before the large companies can take over the entire market.

In the interviews companies such as Amazon, Apple and Google were only considered competitors in certain areas. This is a slightly underestimating point of view. These companies have been in the heart of modifying the Internet to the point at which it is now. They have already extensive cloud computing capabilities, large user networks, and vast amounts of funds at their exposal. The companies are competing hard to ensure the leader position in the Internet. Although FI-WARE has an advantage of being an open standard based project, it will face fierce competition. Furthermore, many of the interviewees highlighted the IoT as a competitive advantage for FI-WARE as it is taken in to account from the very beginning. Nevertheless, it must be considered that this is not necessarily the situation. As IoT is highlighted as the next big step in Internet computing, much like Cloud or Social networking, it must be assumed that the big commercial companies are also developing their own IoT services.

6.3 Platform or System-of-systems

Platforms and System-of-systems are two distinct yet similar methods of approaching business models. This study was started on the premise to analyse whether the key success factors as described in platform research literature apply to the FI-WARE project as a case study. As Gawer and Cusumano (2008) explain there must be two aspects a business model must meet in order to be a platform. These are:

> *"(1) It should perform at least one essential function within what can be described as a "system of use" or solve an essential technological problem within an industry, and (2) it should be easy to connect to or to build upon to expand the system of use as well as to allow new and even unintended end-uses." (pp. 29)*

FI-WARE does address these requirements as it solves an essential need in the European IT sector for a method or architecture for combining several technologies without having to spread the providers too much. Also, the second premise is fulfilled through the open standards and API's so that any company can connect to FI-WARE and use the technologies provided. Figure 10 depicts the relationships in a FI-WARE platform model.

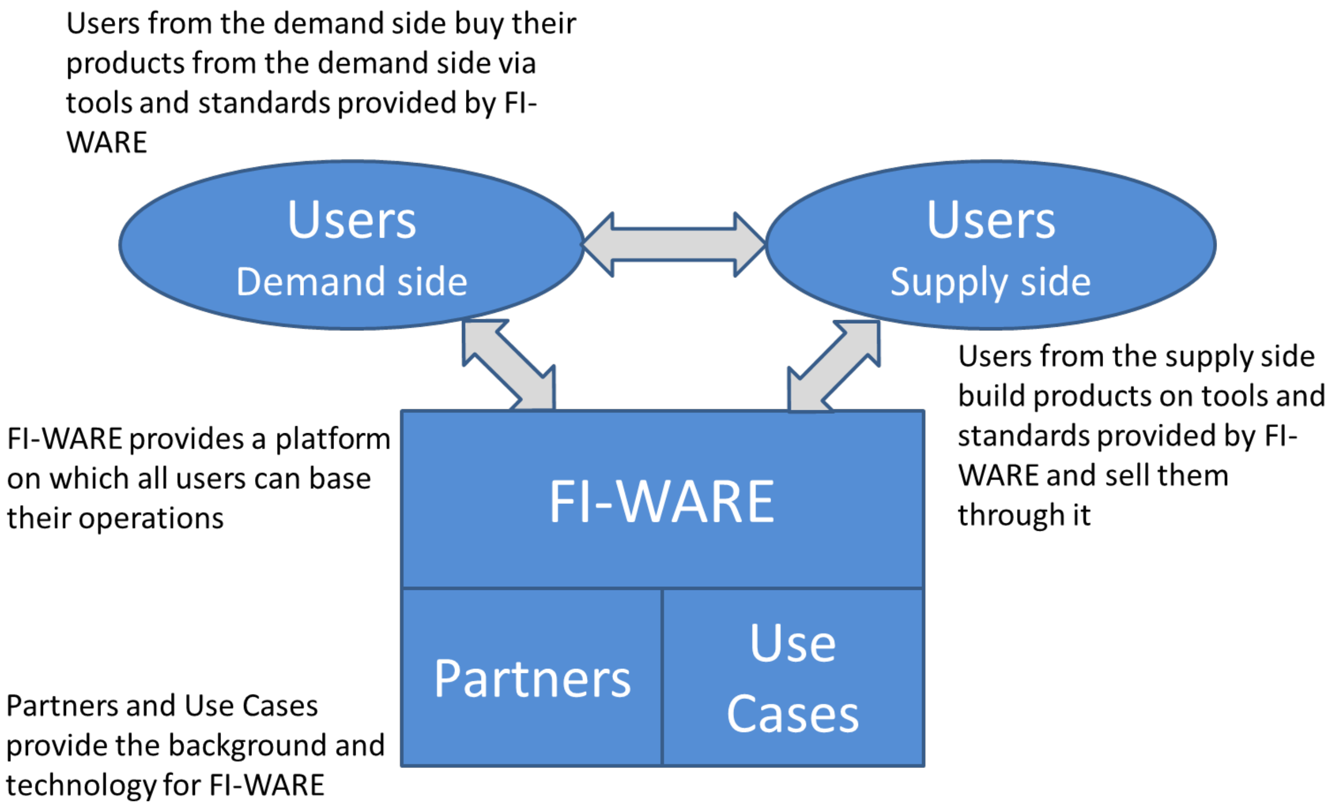

Figure 10: FI-WARE project relationships as a Platform Model

The interviews conducted for this study revealed a fundamental problem with the original premise of studying FI-WARE as a platform and as such applying findings from research literature on platforms. The interviewees mostly agreed that the FI-WARE platform cannot be studied sufficiently by only using theories regarding platforms. The notion was made that FI-WARE should also be studied from the system-of-systems theories as well.

System-of-systems are a larger concept than platforms. They comprise of several independent systems that operate with an own agenda. These individual purposes of the autonomous systems are parts of a greater overall purpose that is fulfilled through the various parts. This is also how the FI-WARE philosophy is built. There are 8 different projects (systems) that have their own purpose that they wish to achieve. These purposes are pulled together in FI-

WARE that has the purpose of providing the future Internet technology platform. In the FI-WARE SoS the partners of the project provide the platform with the required technologies that are then divided within the platform in to the six subsets of Generic Enablers. From these subset categories the Use Cases can then pick the pieces they need to complete their objectives. The UC's then provide feedback on the usability of the technology pieces to the FI-WARE platform which then continues the loop to the partners. A simple model of the FI-WARE SoS is depicted in Figure 11. In this figure FI-WARE is considered an independent entity that does not belong to any environment and is only considered to be a SoS.

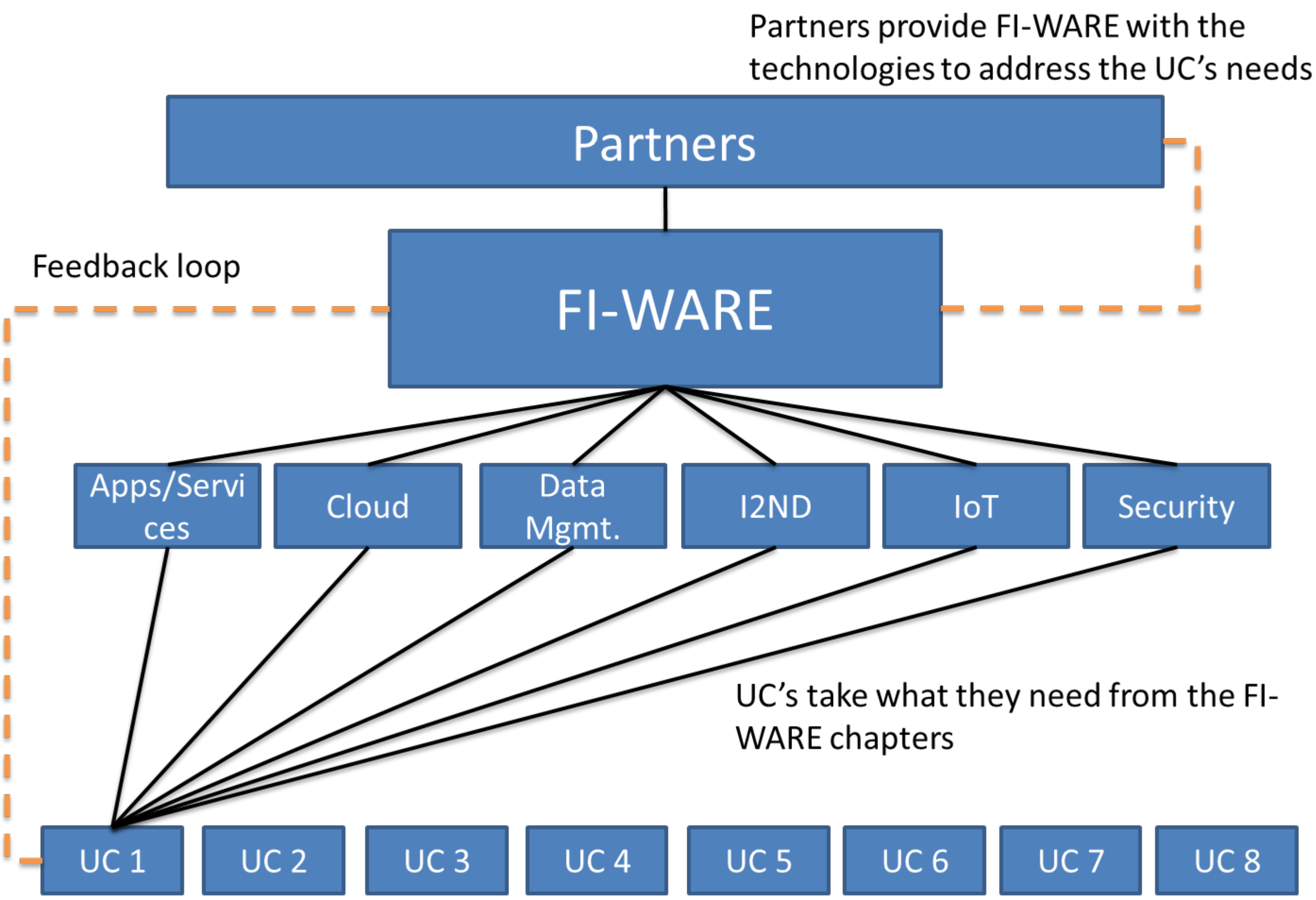

Figure 11: FI-WARE relationships as a SoS model

As the interviewees see FI-WARE as a combination of platform and SoS models, it is necessary to analyse it as such. A table was built by adapting the table presented by Boardman and Sauser (2006) to describe typical SoS characteristics. Here it also includes the view of platform models to clarify how these two models differ and how they both apply to FI-WARE. In Figure 12, the characteristics are explained from both points of view and the FI-WARE logo indicates which of the characteristics more suite FI-WARE. A more detailed explanation for each characteristic can be found in part 2.3.

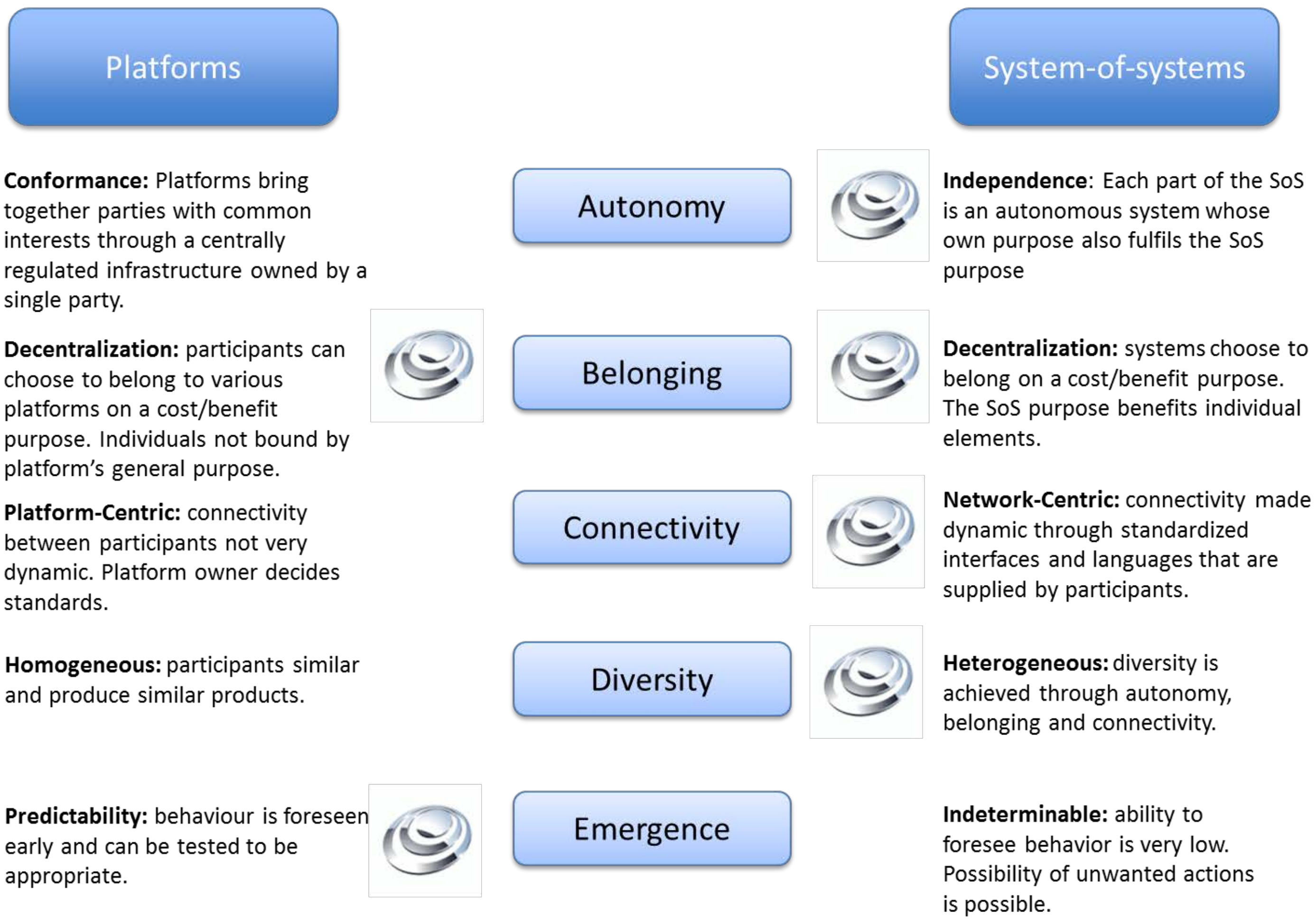

Figure 12: Comparing platforms and SoS. Adapted from Gorod et al. (2008)

In Figure 12 it is clear that more characteristics of FI-WARE are on the SoS side than on the single platform's. Therefore, it is clear that a System-of-systems approach is needed to analyze FI-WARE. Nevertheless, there is at least one characteristic that is considered to be more suited for as a platform approach. Also, a platform point of view is required as FI-WARE is intended to operate as a technology platform for the European ICT environment.

After combining the two approaches and analyzing the interviews it becomes clearer that the FI-WARE project is more about technology transition than it is about developing new technologies. The partners provide FI-WARE with their existing technology that has been requested from FI-WARE by the Use Cases after which the FI-WARE platform makes the technology available for other players in the European ICT Environment.

Figure 13 depicts the FI-WARE SoS/platform model. What is most notable in this construct is that the partners of the project would mainly be connected to the whole European ICT environment through FI-WARE and not vice versa. Thus, one of the key project objectives of becoming the new foundation for EU's Internet technologies would be fulfilled. The partners would provide the core platform with new technologies, which would then be made available to the users in the ICT environment. Partners are here considered to be a mash-up of technology providers without any clear division of which partner is providing which service. The UC's express their requirements to the FI-WARE platform through which they are put forward to the block provided by the partners. From here the needed technologies are then divided to the UC's, without any correspondence between the UC and the providing partner necessary. Hence, the possibility of lock-in to specific services is made more difficult.

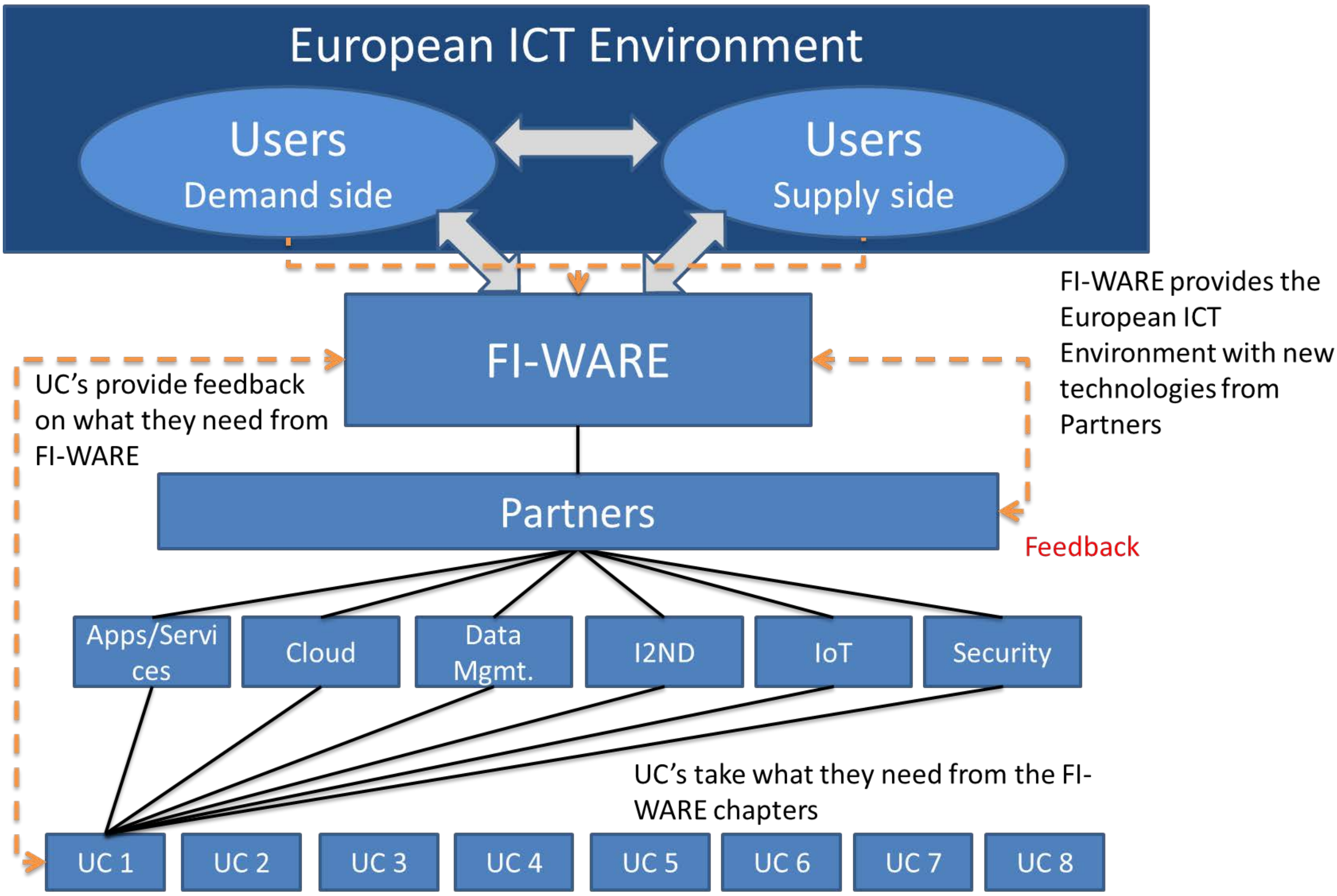

Figure 13: FI-WARE relationships in a Technology Transition project

6.4 Building FI-WARE

The future Internet core technology platform project is very ambitious. The intention is to build a platform that would enable organizations to combine various IT technologies easily and cheaply to ensure new innovations. One common expression of the project's goal is to construct a new version of the current Internet, as it is felt that it is inadequate as a business platform. The intention is also to ensure that the competitiveness of European IT companies stays high.

How does one start to build a completely new Internet? When the history of the Internet is studied, it is clear that innovations come more from the bottom of the pyramid than the top. The latest large scale transformation that has been called Web 2.0 is a prime example of this. The manner how crowds began generating content to the Internet ignited a tremendous shift in how companies could and should approach potential customers. It also gave the consumers much more power through popular social sites where a single comment could be seen by potentially unlimited amounts of people.

Even when considering the birth of the original Internet, it was not something that was intended to be what it is today. The original Internet was intended to be a packet exchange network more similar to the torrent networks of today, than the seemingly limitless world that has been created in the cyberspace. The expansion came through technology becoming cheaper and people getting connected more. Thus, companies realized the enormous potential and the explosive growth of the Internet became reality.

It can be said that one of the common denominators in the evolution process of the Internet has been the way in which average users have adopted some new purpose of use. In the very beginning it was email and specific domains, and in the Web 2.0 phase it was the ability to create your own content and share it with others. These in turn have created huge opportunities and markets for companies that were not there to begin with. Therefore, what FI-WARE is trying to accomplish may seem as something that might not work. However, it must be noted that FI-WARE is not initially intended for the average consumer directly but more for the companies that will create products and services to them.

In part 5.1 FI-WARE is compared with the GSM/UMTS project. One of the findings was that to ensure the success of FI-WARE, the project should have been started at the emergence of the Internet and evolved with it like the

GSM/UMTS project did with mobile phones. Thus, it could be that FI-WARE is entering the game too late. Nevertheless, the people interviewed for this study do not feel that FI-WARE will be unsuccessful, but some of them do feel that the whole project might have been more efficiently executed if it were structured differently. Either the technology base for FI-WARE should have been built before the Use Cases were assembled or the other way round, Use Cases established before FI-WARE. Both views have valid points of why the platform should have been built that way, but both also have clear problems.

If FI-WARE would have been established first, it would likely have been done so by a central committee. The assignment of this committee would have been to evaluate the existing Internet technologies and current trends, and from them depict a map of what the future Internet would be like. They would then decide which of the technologies would be made available to the Use Cases and try to find partners who could provide the project with technologies. This would have probably helped the establishment of FI-WARE itself and the communication channels could have been given more attention. The interviewees indicated the clear downside in this approach would be that the Use Cases would not have had any influence on what would have been in the actual platform.

If on the other hand the Use Cases would have been built before FI-WARE, this would have changed their role in to a more significant one. The Use Cases would have had time to define their purpose clearly and also to explore what the technologies could be that they would need to complete their projects. FI-WARE would then have been built on these requirements. Through the interviews it came clear that this would have probably been the more impractical approach as the Use Cases could have potentially had a lesser understanding on the technologies available for FI-WARE. Thus, the platform would have had trouble in providing these requests as they might not have been realistic. This is what is described in the platform literature as the chicken and egg problem (Baldwin and Woodard, 2009).

At the time of writing this thesis, the FI-WARE platform has been launched as a test bed version. This means that the services are available for the Use Case projects but not yet for third parties. However, this step should happen in the near future and it will be called the FI-WARE Open Innovation Lab. So far 29 Generic Enablers have been made available for the UC's (at the time of writing these could be viewed at the website http://catalogue.fi-ware.eu/enablers). 7 in the Applications/Services chapter, 3 in the Cloud Hosting chapter, 9 in the Data/Context Management chapter, 1 in the I2ND chapter, 4 in the IoT chapter, and 5 in the Security chapter.

7 Conclusions

This section concludes the study. In the first section the study is summarized and the key contributions are presented. The second section will identify the limitations to the study. Finally, suggestions for further research are made.

7.1 Research summary and Contributions

This study is a case study on one project that spreads across the whole European Union. It is the first European attempt to build a new version of the Internet for the use of businesses. Already from the single case, clear conclusions could be made regarding how the Internet architecture should be approached.

The purpose of this study was to analyze how the construction of a large Internet based architecture should be assessed. A Europe wide project called FI-WARE, which was launched two years earlier, was selected as a target case and several project managers were interviewed to obtain a sufficient knowledge base on the project and the theoretical models that can be applied to a large scale ICT project such as this. Currently the FI-WARE project is still missing an overall framework of what it consists of. This study has tried to conduct and present a framework according to existing literature in relevant research fields and interviews with experts.

From the study a conclusion can be made that when regarding an ICT project that has as many partners and use case scenarios as FI-WARE, a single ICT model is insufficient in describing the operational, architectural, or managerial characteristics. The premise was that FI-WARE could be analyzed using platform theories and models, but it was found that it is necessary to broaden the scope to include system-of-systems theories and models as well. With this broader analysis, it is easier to understand the project and to communicate it to members. New models of how FI-WARE operates and is established from both platform and SoS sides was constructed. The communication of objectives has been insufficient between the Use Cases and the Core Platform project. This is clearly visible from the differing opinions that the experts interviewed for the purpose of this study have provided regarding the project.

It was found that instead of being a clear research project, FI-WARE should be considered to be more of a technology transition within Europe. Currently there is little technological research being done and no new technologies are developed within the project. The best way to describe FI-WARE is that it is a system of many individual technology systems brought together in a shared platform. This platform is intended to take the European ICT industry one step forward ensuring the competitiveness when compared to the rest of the world. A model was constructed to depict this situation.

Although the FI-WARE platform consists of multiple Generic Enablers and there are several Use Cases involved, the platform currently fails to describe the business model environment it is trying to build. There are very little concrete examples of how companies could benefit from it.

At the moment the FI-WARE project is at its very beginning stages and thus it is somewhat unclear what its implications will be. Now it is seen as a solution to almost any ICT industry problem that European companies have. However, there is a chance of FI-WARE failing to be established due to lack of communication between Use Cases and the FI-WARE team. Therefore, there is a need for a communication body within the project that would operate at a more involved level than has so far happened. The findings of this study indicate that issues in communication are the biggest threat facing the project. It should be attended to as soon as possible.

The study found that the amount, scope, and type of partners currently involved in the FI-WARE project might present a possible problem regarding the success of the Core platform. There should be more partners and especially the involvement of more SME sized partners should be considered already at this time, although they would join at latest in phase 3. With the amount of current partners, it seems impossible to achieve the future Internet platform that would rival with the existing Internet. At the moment the project is too small to have enough leverage.

As FI-WARE is meant to be the basis of the future ICT environment of the EU through which European companies can build their products and services. It may be that the approach the project has taken does not fully support this purpose as the initial users of the actual platform are research projects. Therefore, it could be a threat that FI-WARE ends up being optimized for such research projects. Thus, more SME partners and test users could enhance the business opportunities provided by FI-WARE.

As such the project operates as a test bed for business models in the future Internet for European based companies. The partnering companies have managed to establish communication between each other and with new SME's. This has been a side product of the project itself and is not necessarily providing value to the FI-WARE project itself. On the other hand, this provides much value to the larger FI-PPP project as a whole through motivation to partners and increased communication and cooperation between European companies. Therefore, it can also be said that FI-WARE has already been a success as it has had an impact on the European ICT industry.

7.2 Limitations to the Study

The study has limitations that were noticed while interpreting the results. It should be noted that this study is based on the qualitative research methodology and used in a single case study approach. Thus the scope of the study is somewhat narrow and due to the nature of the study, generalizations derived from it are not necessarily reliable even in the case study itself. As the project that was the focus of the research is relatively unknown, it can be said that the interviewees were one sided or biased in their views. The assumption can be made that a broader perspective in the interviewee selection could have provided a wider knowledge and analysis of the research problem.

The information that was acquired through the interviews was not at a level that was hoped for. In general, the interviewees supplied partially unspecific or shallow information, which made the studying of the research problem difficult. Furthermore, it must be noted that the interviewees themselves agreed that they were somewhat uncertain about the implications of the FI-WARE project, as communication has been challenging and there has never been a similar project. However, this was a result of the project itself more than the research design.

7.3 Suggestions for further research

The FI-WARE project is still in its very beginning phases. The scope of information on the platform is still very vague and scattered. Thus, there is need for a broader research on what the project actually is, what knowledge is critical, what is unnecessary, and how everything affects FI-WARE. Future studies should focus on the more concrete aspects. As this study revealed, there are still areas of FI-WARE that should be understood better in order to make it successful.

There is a need for a study that focuses on the concrete future aspects of how FI-WARE can affect businesses, especially SME's. This study only vaguely assessed the business opportunities presented by FI-WARE as the interviewees did not have much common ground in this matter. Nevertheless, it is clear that this kind of platform presents businesses with new models and opportunities and a clear analysis of these is missing.

FI-WARE is likely to have economic effects throughout Europe. What these will be and how the ICT industry in this region will benefit from them is not clear. At the moment it is more taken as a given that the changes will happen and they will be only positive, but this is a too narrow view.

There should be an ongoing research that continuously assesses various aspects of the project and provides the FI-WARE project leaders with feedback. This could be done using the Action Design Research presented by Sein *et al.* (2011). This approach would ensure the highest possible learning from the project and ensure a better success rate for future pan-European ICT projects.

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APPENDIX A: Interview Template

Theme 1: FI-WARE Project

- Definition of the project
- Essential characteristics

Theme 2: General Level Implications

- Implications to business environment
- Implications to partners

Theme 3: Project structures

- Clear infrastructure
- Key success factors
- Business model opportunities
- Partners and Use Cases

Theme 4: Competitors

- How does FI-WARE compare to the Internet
- Big commercial players

Theme 5: Challenges

- Identifying the factors that may become issues
- Suggestions to managerial implications

APPENDIX B: Interviewees

The list of interviewees in the case study

Interviewee A	FI-WARE Project Leader
Interviewee B	Technical Manager for Use Case Project ENVIROFI
Interviewee C	Former Deputy Chief Architect Project FI-WARE
Interviewee D	FI-WARE Marketplace Lead
Interviewee E	FI-WARE Project external Reviewer
Interviewee F	Project Senior Member FI-WARE, Apps and Services Chapter, Standards, Cloud Chapter
Interviewee G	Senior Developer FI-WARE Testbed, Standards