Deliverable D 500.3

Specification on network elements and functions of Core Platform

WP 500

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FUTURE INTERNET PPP

SEVENTH FRAMEWORK PROGRAMME

Smart Agri-Food

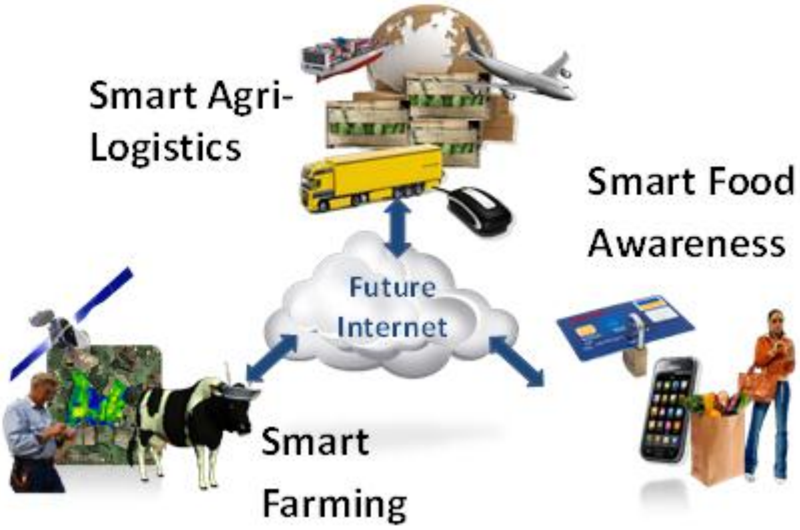
The SmartAgriFood Project

The SmartAgriFood project is funded in the scope of the Future Internet Public Private Partnership Programme (FI-PPP), as part of the 7th Framework Programme of the European Commission. The key objective is to elaborate requirements that shall be fulfilled by a "Future Internet" to drastically improve the production and delivery of safe & healthy food.

Project Summary

SmartAgriFood aims to boost application & use of Future Internet ICTs in agri-food sector by:

- Identifying and describing technical, functional and non-functional Future Internet specifications for experimentation in smart agri-food production as a whole system and in particular for smart farming, smart agri-logistics & smart food awareness,
- Identifying and developing smart agri-food-specific capabilities and conceptual prototypes, demonstrating critical technological solutions including the feasibility to further develop them in large scale experimentation and validation,
- Identifying and describing existing experimentation structures and start user community building, resulting in an implementation plan for the next phase in the framework of the FI PPP programme.



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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Document Summary

In this deliverable, the architectural specification of the information and communication (ICT) infrastructure for the SmartAgriFood use case is developed. It describes how the corresponding network elements and functionalities relate to the FI-WARE core platform. To facilitate the development of an integrated ICT architecture spanning the entire food supply chain, a super-scenario is sketched, where access to all kinds of information related to an agri-food product's lifecycle is given to any type of involved actor at any stage within the supply chain. The super-scenario thus links the three SAF sub-use cases and considers the interaction between these. Based on this scenario, the requirements for the architectural specification are derived, and a detailed description of the main components of the architectural specification and their functionality is given.

Abbreviations

API	Application Programming Interface
B2B	Business to Business
B2C	Business to Customer
BAM	Business Activity Monitoring
BPEL	Business Process Execution Language
BPMN	Business Process Model and Notation
CAP	Context Awareness Platform
CDI	Connected Devices Interfacing
CDMI	Cloud Data Management Interface
CEP	Complex Event Processing
CP	Core Platform
CPU	Central Processing Unit
CRM	Customer Relationship Management
CRUD	Create Read Update Delete
CT	Communication Technology
DB	Data base
DC	Distribution Center
DCRM	Data Center Resource Management
DIY	Do It Yourself
DNS	Domain Name System
DSE	Domain Specific Enabler
DSL	Domain Specific Language
EC	European Commission
EFSA	European Food Safety Authority
EHEC	Enterohemorrhagic Escherichia Coli
EPC	Electronic Product Code
EPCIS	EPC Information Services
ERASSF	European Rapid Alert System for Food and Feed
ERP	Enterprise Resource Planning
FCAPS	Fault Configuration Accounting Performance Security
FFV	Fresh Fruits and Vegetables
FI	Future Internet
FQDN	Fully Qualified Domain Name
GRAI	Global Returnable Asset Identifier
GTIN	Global Trade Item Number
GUI	Graphical User Interface
HTML	HyperText Markup Language
IaaS	Infrastructure as a Service
ICT	Information and Communication Technology
IEC	International Electrotechnical Commision
I/O	Input/Output
IoT	Internet of Things
IP	Internet Protocol
iRASFF	Integrated Rapid Alert System for Food and Feed
ISO	International Organization for Standardization
IT	Information Technology
EHEC	Layer 2
EPC	Local Area Network
EPCIS	Location Based Services
L2	Lightweight Directory Access Protocol
LAN	Linked Open Data
LBS	Long Term Evolution
LDAP	Machine-to-Machine
LOD	Moving Picture Experts Group
LTE	MPEG Query Format
M2M	Network Information and Control
MPEG	Near Field Communication
MPQF	Object Name Service
NetIC	Open Services Gateway Initiative
NFC	Peer to Peer
ONS	Platform as a Service
OSGI	Personal Area Network
P2P	Personal Computer
PaaS	Plants and Flowers
PAN	PrimeLife Policy Language
PC	Public Private Partnership
PF	Layer 2
PPL	Local Area Network
PPP	Location Based Services
QM	Quality Management

QoS	Quality-of-Service
QR	Quick Response
Q-VMI	Quality Based Vendor Managed Inventory
RASFF	Rapid Alert System for Food and Feed
RDF	Resource Description Framework
REST	REpresentational State Transfer
RFID	Radio Frequency Identification
RSS	Revenue Settlement and Sharing
S3C	Service, Capability, Connectivity, and Control
SaaS	Software as a Service
SAF	SmartAgriFood
SCEM	Supply Chain Event Management
SLA	Service Level Agreement
SLO	Service Level Objective
SME	Small and Medium Enterprises
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SQL	Structured Query Language
SSCC	Serial Shipping Container Code
TTL	Time to Live
UMTS	Universal Mobile Telecommunica-tions System
USDL	Unified Service Description Language
VDC	Virtual Data Center
VM	Virtual Machine
WAN	Wide Area Network
WiFi	Wireless Fidelity
WP	Work Package
WSN	Wireless Sensor Network
XML	Extensible Markup Language

Short Names of Organizations in Smart AgriFood

Organisation	Short name	Country
Stichting Dienst Landbouwkundig Onderzoek	DLO	Netherlands
Institut für Angewandte Systemtechnik Bremen GmbH	ATB	Germany
Nederlandse organisatie voor toegepast-natuurwetenschappelijk onderzoek	TNO	Netherlands
CentMa GmbH	CENTMA	Germany
Atos ORIGIN SOCIEDAD ANONIMA ESPANOLA	ATOS	Spain
Ariadna Servicios Informáticos S.L.	ASI	Spain
Huawei Technologies Düsseldorf GmbH	HWDU	Germany
Maa- ja elintarviketalouden tutkimuskeskus (MTT Agrifood Research)	MTT	Finland
Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V.	KTBL	Germany
National and Kapodistrian University of Athens	NKUA	Greece
Universidad Politécnica de Madrid	UPM	Spain
Campden BRI Magyarország Nonprofit Kft.	CBHU	Hungary
Aston University	AST	United Kingdom
VTT Technical Research Centre	VTT	Finland
Payment and Control Agency for Guidance and Guarantee Community Aids	OPEKEPE	Greece
Deere & Company	JD	Germany
Wageningen University	WU	Netherlands
EHI Retail Institute GmbH	EHI	Germany
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1 Introduction

1.1 Objectives of D500.3

This document presents the results generated in Task 530 of Work Package 500 within the SmartAgriFood project. The objective of Task 530 is to outline the network elements and their functionalities required to address the demands and needs of the food sector as a use case of the Future Internet. As its major result, a comprehensive description of functional enablers should be obtained, which are able to be realized within an instantiation of the FI-WARE core platform.

With this deliverable, we address the following WP500 objectives:

- O 5.1: Define requirements from SmartAgriFood towards core platform
- O 5.2: Harmonize core platform requirements with SmartAgriFood use cases

The main goal of this document is to develop the architectural specification of the information and communication (ICT) infrastructure for the SmartAgriFood (SAF) use case, which describes how the corresponding network elements and functionalities can be implemented on the FI-WARE core platform. On the way towards this goal, first the architectural requirements on the Generic Enablers (GEs) provided by the core platform as well as the SAF domain specific enablers (DSEs), which will be implemented on an instantiation of FI-Ware, but are are valid in the context of the SAF use case only, is specified. For this task, a comprehensive approach spanning the entire food supply chain is pursued; i.e. we seek for and identify the functional elements that are common for all three sub-use cases of the global SAF use case (Smart Farming, Smart Agri Logistics, Smart Food Awareness), which have been investigated in detail in WP200 - 400. Besides identifying these common functional elements, we develop suitable functional blocks according to FI-WARE concepts of GEs, FI-WARE platform product, FI-WARE instance and FI-WARE application, forming the fundamental components of the architectural specification. To enable support of legacy ICT systems that are available already today, we identify those seen the most relevant (like data bases, vocabularies and standards) for being considered when implementing the SAF use case as Future Internet application.

The document is structured as follows:

In chapter 2, we first present our vision of augmented experience in the food supply chain when information exchange over all stages of the supply chain is enabled by the introduction of novel ICT solutions and concepts. To facilitate the development of such an integrated ICT architecture spanning the entire food supply chain, we then sketch a super-scenario, where access to all kinds of information related to an agri-food product’s lifecycle is given to any type of involved actor at any stage within the supply chain. Hence, the super-scenario links the three SAF sub-use cases and considers the interaction between these; correspondingly it is defined in close alignment with WP100 – 500. Based on this super-scenario, we provide in the succeeding subsections of chapter 2 an analysis of business roles and stakeholders, elaborate on current practices and future needs and present a first analysis on the type of information to be shared between all kinds of stakeholders. In chapter 3, we then derive the requirements for the architectural specification from this super-scenario, and we describe the main components of the architectural specification and their functionality in detail, considering in particular the architectural integration of GEs and DSEs. We further analyze other FI use case projects to identify additional enablers that may be relevant for the SAF domain, and finally a summary of all functional enablers is given.

1.2 Deliverables and Dependencies

The work package 500 (WP500) is structured in six tasks whose goals are specified as follows in the FPP/DoW (Full Project Proposal/Description of Work):

- Task 510 - “Analysis and Handling of Core Platform Requests”
- Task 520 - “Compilation of Required Generic Enablers”
- Task 530 - “Architectural Requirements”
- Task 540 - “Generic Capabilities and Interface/Interoperability Coordination”
- Task 550 - “Domain Specific Capabilities and Prototype Development”
- Task 560 - “Feasibility Assessment”

The main objectives of the WP500 are as follows:

- Create a close communication with the Core Platform (FI-WARE)
- Analysis and definition of requirements.
- Development of the pilots related to smart farming, smart logistics and smart food awareness
- Analysis and test of the FI-WARE’s test-bed
- Definition of an end-to-end scenario connecting the different areas along the supply chain

The tasks 530 and 540 are related to the definition of the SmartAgriFood scenario, while the others are closer to the pilots and the Core Platform. These 2 tasks are involved in the definition of both the specification and the architecture needed in the end-to-end scenario.

The task 530 involves both the definition of the specification and the architecture needed in the end-to-end scenario. The task 540 defines the necessary communication between the different stakeholders/systems of the supply chain (interfaces, protocols, web services, workflows, etc.) and also defines the data management to be used.

This document is directly connected to several deliverables belonging to other work packages of the project:

- D200.2, D300.2, D400.2: these deliverables fully describe each one the pilots to be developed, so the D500.3 includes many references to the description of their architectures and their descriptions.
- D100.4: the overall technical architecture for end-to-end supply chain integration is in this deliverable described from a business and politics perspective, presenting economic and social opportunities offered to the agri-food sector by Future Internet.
- D700.4.2: (Exploitation Plan, Section 2): this deliverable describes the dissemination and exploitation plans of the concepts developed in the SmartAgriFood project, detailing the envisaged actions for FI-PPP Phase II.

1.3 Approach for Architectural Specification

Three sub-use cases constitute the SmartAgriFood use case: Smart Farming, Smart Agri-Logistics and Smart Food Awareness. Each sub-use case covers a different link in the supply chain, from primary production to consumption, or “from farm to fork”. For each sub-use case two pilots were selected in order to illustrate the future internet opportunities for the AgriFood sector and to evaluate the business case for those opportunities. The deliverables D200.1, D200.2, D300.1, D300.2, D400.1, and D400.2 define scenarios and architectures for the pilots, following the approach set out in deliverable D100.2.

The architectural specification in the present deliverable is focused on common elements of the different pilots. These can be realized either through generic enablers offered by the FI-WARE core platform and shared with other FI-PPP use cases, or through specific enablers shared by the SmartAgriFood pilots, which will be specified in the present deliverable. The main purpose of this deliverable is to specify architectural requirements on both the generic enablers and SmartAgriFood specific enablers that are common and can be applied over the whole supply chain. This shall serve as a starting point for the work on integration of supply chain information. Requirements that are specific to a single sub-use case are out of scope.

The agricultural products are the common entities of all sub-use cases. Smart Farming concerns the agricultural production process, resulting in the delivery of products at the farm gate. Smart Agri-logistics focuses on tracking and tracing the products from that point onward, and on quality management during transport and storage, taking the perishability of agricultural products into account. Smart Food Awareness is concerned with informing consumers both reactively and proactively, tailored to their individual information needs, about product properties such as environmental impact and animal welfare, health aspects and allergenic properties relevant to the consumer.

It is obvious that the sub-use cases require a great diversity of data, but what they have in common is the need for data about the agricultural products. There is not only a need downstream for data generated upstream in the supply chain, where consumers are informed about production, transportation, and storage conditions, but also for data to flow upstream. Data from all stages are valuable for all actors. Some examples:

- Both farmer’s revenue and food waste can be improved when farmers are better informed about point-of-sale data. Farmers can adjust their production process based on consumer appreciation or quality conditions of their products at point of sale. Further, using combinations of actual and historical sales data, they can anticipate fluctuations in consumer demand.
- During transport of agricultural products, the quality degradation risk can be increased by causes like extreme temperatures or rough handling. In such cases, traders can redirect transport to nearby outlets, or retailers can promote sales from stock. These actions can improve revenue and reduce food waste.
- Dynamic expiration dates, informed by production, transport, and storage conditions, can be applied to improve food safety and reduce the waste of perishable products at the consumer stage.

Since the sub-use cases cover single stages in the supply chain, a “super scenario” has been defined as the basis for an integrated architecture. This scenario concerns the life of a product from farm to fork. Products are the items forwarded through the supply chain. It is the only entity type to which data are attached at all supply chain stages. Like a product carries value throughout the supply chain, its virtual representation on the Future Internet is the vehicle that can hold data to be exchanged across all supply chain stages. Therefore, the virtual representation of a product is a central issue in the information architecture[1].

Product information is the core component of the architecture. It relies heavily on Internet of Things (IoT) technology and on the GS1 set of standards for product identification and product information[2]. An essential property of the supply chain is that several actors are involved in the process of forwarding the products from farm to fork. Reliable identification of the actors and their virtual representation in the cloud are the second component of the architecture, shared by all sub-use cases and pilots. The third component comprises business relations services, which form the fundamental basis of any supply chain. Such services are indispensable for the discovery of new business partners across supply stages and for supporting the supply chain operations. Millions of actors form dynamic supply networks in the agri-food system. Furthermore, in an environment where so many actors play a role and where products may affect public health day by day, certification is a sine qua non for building trust. Certification of actors and products is required in all of the three sub-use cases. Consequently, certification services will represent the fourth component of the architecture.

The main components of the architecture are depicted in Figure 1-1. Chapter 2 elaborates on the requirements derivable from the super scenario and Chapter 3 describes the architectural specification.

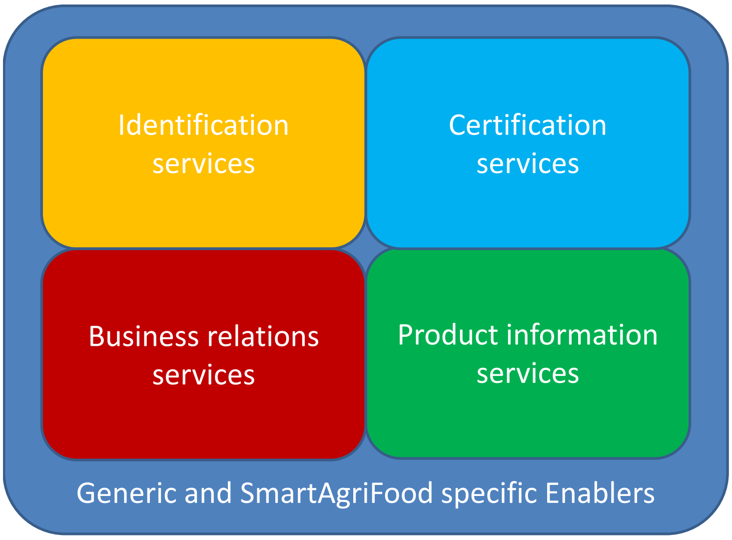

Figure 1-1: Components of the SmartAgriFood architecture

1 cf. the "Virtual Tomato" concept in "SmartAgriFood: Interoperability in the Agri-Food Supply Chain" presentation at the IoT Semantic Interoperability workshop http://www.probe-it.eu/?page_id=642

2 http://www.gs1.org/

2 Smart Agrifood Scenario and Requirements

2.1 Goals and Vision

The SmartAgriFood project aims at the realisation of a fundamental change in the agri-food sector by exploiting innovative technologies which form part of the Future Internet. This goes far beyond the adoption of single functionalities by certain actors, and aims to provide an entire set of enablers that will support agri-food chain actors as well as all of us, as everyone is a consumer. The agri-food chain wide dimension and specific goals can be summarised as follows:

- Increase the effectiveness of farming procedures and globally increase the availability of food for all,
- Enabling small farmers to access both the local and global market with equal ease and trade their products equally effectively in a global market place or in their local community,
- Dramatically reduce the waste in food logistics considering both the local as well as the global distribution of produce that continuously undergoes a quality change/decay over its life cycle, far shorter time periods when compared to other business domains,
- Make more effective the detection, prevention of distribution and recall (when needed) of unsafe food, which, for example, has been contaminated with bacteria, too high doses of pesticides, or other contaminants,
- Facilitate and support the trust of consumers in sustainable food production, by providing a detailed information of e.g. the origin, quality and method of cultivation or husbandry,
- Establish a new dimension of communication in the food chain; enhancing the collaboration from farm to fork and at the same time opening a new dimension of feedback from fork to farm, simultaneously enabling the realisation of new services and revenue models never thought of before,
- Finally enable the consumer to have direct impact on the food supply chain, thereby assuring both effective and demand driven food supplies and also allowing the food supply chain to adapt to the new demands of changes in life styles and family life. At the same time consumers shall be enabled to optimise personal buying decisions by receiving reliable product information that serves as decision baseline to buy and consume food that meets the personal needs.

Basically, the components of the SmartAgriFood architectures shall provide those key elements that represent the overall enablers for a fundamental change regarding the points mentioned above. Nevertheless, one should not forget the constraints provided by the current manner of usage and penetration levels of ICT, current business processes, supply chain structures and the specific types of business collaborations which exist in the daily practice.

2.1.1 ICT technology usage in the agri-food domain

Over the past thirty years ICT technologies have been introduced in the agriculture and food sectors, improving food production and its transportation to the end consumers. However, the uptake of these solutions has been slow due to a number of important yet unresolved issues. Some of the key challenges for ICT in the agri-food sector are related to cross-company information management, either within specific domains or across the whole supply chain from farm to fork. The challenges of information management are compounded by specific characteristics of the sector, including the very large number of actors along the supply-chain and the heterogeneity of those actors. The consequences of this number and heterogeneity of actors is the very poor information flow that exists along the supply chain, especially between agricultural production and retail groups. This is compounded with a very conservative “need-to-know” attitude such that essentially information flows only “one-up, one down”. For example, the farmer might communicate with the wholesaler or food processor but not directly with the retailer. The retailer communicates with the consumer and wholesaler but (typically) with few other actors. This is of course even more accentuated in more complex supply chains or networks where food is processed or packaged for longer term storage.

This lack of information flow has been “solved” so far by a combination of government or EC level regulation (food standards, health and safety) and third party certification (organic food certification bodies, GlobalGAP, etc.). Although there is a very large number of such bodies and regulations, the overall result has been a series of either/or categories i.e. either food is safe or not, either it is organic or not, either it is fair trade or not, with a corresponding lack of numerical values used for quantification. No quantitative information is available, like how much water was used to produce a pint of beer, and even in the ingredients on packaged goods, they are listed by their relative amount, but in most cases without details on their exact quantity. .

The lack of information has been recognised as a critical issue for a long time in the agri-food sector. This has been expressed partly in the need for greater transparency, but also in the importance given to tracking and tracing of foods in the context of health and safety, making it possible to both prevent and quickly respond to food emergencies (mad cows disease, E. Coli, etc.). Another major factor is a growing desire on behalf of the food consumers to know more about the food they eat, a desire for greater food awareness. However, the complexities in reaching transparency are due to complexities in products and processes, but also due to the dynamically changing open network organisation of the food sector. This is amplified by the multitude of SMEs, their cultural diversity, differences in expectations, and abilities to serve transparency needs. Another factor which inhibits this process is the lack of consistent appropriate institutional infrastructure that could support coordinated initiatives towards higher levels of transparency throughout the food value chain.

Another factor in the slow adoption of ICT technologies in the agriculture sector is that existing solutions (e.g., farm management information systems, logistics services, enterprise resource planning) have been developed as closed proprietary solutions, whose amount of capabilities is directly proportional to their cost. Thus, it is very difficult to achieve inter-operability among different systems and to easily upgrade functionalities while keeping the costs at an affordable level. Moreover, being able to react to changes in the agri-food chain on the short-term or in a quick response to the dynamically changing consumer demands remains a big challenge.

2.1.2 Overall structure of the agri-food domain to be handled

When analysing the agri-food sector, one can structure it into three main segments. There is the food production or farming sector, the logistics sector which conveys food products from farm to retail outlet, and finally the retail sector which provides healthy and fresh food to the consumers. Therefore, in the context of the SmartAgriFood project, we specifically address the challenge of exploiting existing solutions and apply innovative FI-based ICT potentials to the agriculture production and transportation sector while at the same time improving the food awareness for the end consumers. These three sectors are called within the SmartAgriFood project as:

- Smart farming,
- Smart agri-food logistics and
- Smart food awareness.

Smart farming addresses the techniques of agriculture that may be automated and ameliorated to assist farmers in their tasks. The present state-of-the-art in the application of ICT to farming is called “precision agriculture” or smart farming. A generic definition is [2] as follows:

[*Smart farming is*] *that kind of agriculture that increases the number of (correct) decisions per unit area of land per unit time with associated net benefit.*

The realisation of this concept involves computerised systems that assist farmers to collect, process, store and even publish data in order to automate the control of farm operations and improve their results. Although this concept has been around since the 1980's and has already proved its value, existing systems either provide limited functionality or they are complex and fairly expensive proprietary solutions with limited or no supported interoperability with other systems. There has been a particular lack of integration of farm systems with other systems further down stream in the supply chain with a corresponding loss of decision support and efficiency.

Smart agri-food logistics involves a large number of stakeholders dealing with logistics services, including auto-identification, conditioned transport using sensors and control systems, remote-controlled early warning systems. In [3] the following definition has been given:

Logistics is that part of the supply chain process that plans, implements and controls the efficient, effective flow and storage of goods, services and related information from the point-of-origin to the point-of-consumption in order to meet customer requirements and satisfies the requirements imposed by other stakeholders such as the government and the retail community.

However, the path of agri-food related products needs to be organised from the farm gate up to the point of sales. This path is neither a single point to point connection, nor a defined combination of known organisations in a well settled supply chain. In addition, it is not driven by the core logistics providers (i.e. transport providers), but by actors like traders or distribution centres. Altogether, it represents a global network of organisations with highly dynamic business relationships that are varying over short time periods without prior notice, especially because of the perishable nature of food with its varying availability over the seasons and its continuous deterioration due to ambient factors. Logistics systems are typically designed to track and ship containers and do not capture information about the content of those containers, the quality of the food, the origin and the processes it undergoes. Typically the information captured concerns only such items of information as product ID, batch number, and weight. As a consequence, transportation problems have a significant effect on the overall food waste. Current ICT systems are not capable of providing the means for a complex information exchange enabling the selective forwarding of product related data (e.g. unexpected changes of produce characteristics during transport; notifying an exception due to laboratory findings) via several nodes in a network.

As a consequence, transportation problems have a significant effect on the overall food waste. Means for a complex information exchange enabling the selective forwarding of product related data (e.g. unexpected changes of produce characteristics during transport; notifying an exception due to laboratory findings) via several nodes in a network are beyond the current capabilities of ICT systems.

Smart food awareness involves the retail stores and the end consumers that want to have access to information related to health and safety issues, availability, environmental impact, animal welfare etc. Although much information is available at the sales points and in distributors' and producers systems, this information is not easily accessible for those that are interested. Currently there are only some simple applications where the bar code of a product can be read by a smartphone and some information about the type of product is accessible over the Internet. There exist certain websites where some subsets of relevant information are available (nutritional information, or environmental information, or country of origin) with varying level of details in different countries. However, there are hardly any examples of personalised provision of product related information to consumers and no products at all that can provide information about all processing stages of the product (i.e. from seed to shelf), and not to mention an integration of multiple data sources.

From the above it is clear that the agri-food supply chain is very complex and consists of heterogeneous processes and systems. The ICT systems available today in all three areas are largely proprietary monolithic solutions that were built as isolated solutions and function as information silos. They provide useful functionalities, but this usefulness is usually directly linked to their cost. Although they are able to provide a significant amount of data to perform specifically designed tasks, this data cannot be linked across silos for new functionalities or to address new social, business or policy objectives. These characteristics obviously limit the capabilities and hinder their wider adoption by all stakeholders.

2.1.3 Overall Vision

To tackle the above mentioned issues, we need to design ways that will allow users to make their data easily accessible to other stakeholders if they wish. Also, we need to provide an automated way to integrate information generated by different systems and to enable an easy integration of these systems. In this manner, we would be able to provide far more advanced services in a simpler and cheaper way. For example, stakeholders in the food chain should be able to discover, subscribe to and combine data from services offered by different parties. In such an environment a farmer could easily discover a meteorological or state's policies notification service to combine it with an advisory service (e.g., an electronic agriculturist) or to facilitate the trading of the produce on the world market. This automatic service discovery and service composition along with data correlation is expected to enhance the functionalities offered to the end users.

Moreover, an actor in the agri-food supply chain should be able to discover other stakeholders all over the world and form with them business relationships in a simple way. In other words, future technological solutions (i.e. the FI) should allow for the dynamic formation of new business links among stakeholders and among services and stakeholders [4]. These links will support the flow of information among the different systems in the agri-food supply chain using standardised means for interoperability, security and authorisation schemes (i.e., different stakeholders will have different access permission privileges when accessing data) on the one hand, and on the other using easily adaptable tools for dynamically composing services for the stakeholder's own usage or as service for its customers. This dynamic formation of links in this business environment also requires enabling "trust" among the involved entities. By "trust" we mean that

1) the stakeholders should be confident that the services they are going to use to automate their work will deliver what they promise (also taking into account means for assuring non-repudiation) and
2) the users can be confident that the stakeholders with whom they form a new business relationship for the first time are reliable.

To turn this into reality in the context of a dynamic business ecosystem that already consists of a vast number of real players, FI technology needs to provide a number of advanced yet generic services along the whole food supply chain. For example, the FI is expected to enable the connectivity and access of end devices (e.g., sensors, tracking devices) and machinery (e.g., tractors). Additionally, the FI is expected to allow cloud implementation of services that will facilitate the effective accessing, processing, and analysing of massive streams of data from these end systems. It will also provide the means for service developers to build sophisticated services that will use libraries of software modules dealing with opinion mining techniques, real time recommendations to end users, location based services, etc. It will also provide the means to use expert systems that will improve the "intelligence" of control processes possibly using distributed schemes. Finally, it is expected that generic interfaces among the services located in the cloud, the underlying network infrastructure and the end devices will improve considerably the quality of experience of end users. In order to realise a highly innovative and at the same time practicable solution, the Generic Enablers that are provided by the FI-WARE project are considered the key enablers for solution development as well as for assuring dynamic adaptability and reuse.

The following Figure 2-1 presents the overall vision, which is one of a fully integrated and virtualised agri-food marketplace where stakeholders and services from all over the world can interoperate. With the advent of the FI we will witness a number of service providers along the food chain (e.g. Farm Management System Providers, Logistics services providers, Food information providers) that will provide end users with advanced services. They will also be able to integrate a number of services offered by external parties as well. These providers will operate fully inside the cloud or they can use proxies to cater for network traffic optimisation or for handling unstable or low bandwidth Internet links. These proxies can also have additional functions like aggregating at a first level all data collected by local Internet of Things (IoT) environments consisting of sensors, tracking devices, farming machinery, lorries, sales points, etc. To discover and select among a vast number of services or even stakeholders, an end user may consult his associated service provider (e.g., a farmer will use his farm management system provider) or he will be able to contact directly a Public Registry (or broker) that will play the role of a yellow pages service.

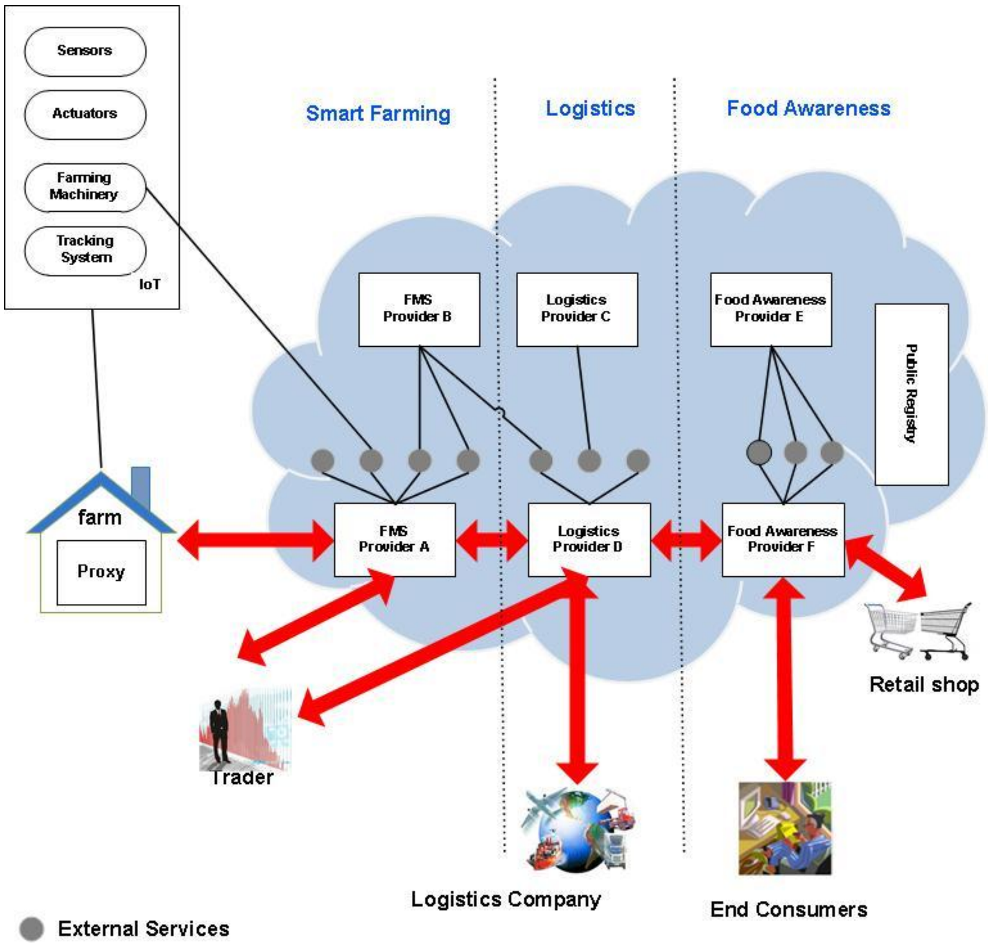

Figure 2-1: The vision of an integrated agri-food network from farm to fork and vice versa.

The result of this vision is that we can form a direct link among all the stakeholders in the food chain and have potentially access to any information we may need to perform a specific task (e.g., plan an optimum itinerary for a logistics company) or simply have full transparency on food products information (e.g., for handling food health disasters).

The following sections will further outline the requirements as well as the link to FI-WARE.

2.1.4 A Vision comes true – Envisaged usage of FI-WARE Generic Enablers

As pointed out before, information and management systems along the food chain need to ensure a seamless integration and mash-up of different supporting services. They also need to enable an easy exchange of information for business activities among stakeholders. It is expected that distributed sources of information will be processed and a scalable platform with standardised interfaces will be provided. As today's solutions are proprietary and do not offer appropriate interfaces due to a lack of standards, they implement specific stovepipe solutions only at a national scale. Hence, they will not be able to evolve to the vision of future EU-wide or globally harmonised and enhanced systems featuring the characteristics we have described above. Thus, a future-proof framework is required, on top of which application developers, service providers as well as so-called prosumers will be able to build their particular solutions.

This platform should be part of the "Future Internet", which is more than just a bit pipe of IP packets: it shall provide solutions for today's shortcomings of the Internet (e.g. address features like service provision for the dynamic interaction of business partners, built-in security, performance assuring QoS, service integration and scalability). The analysis in the three domains of SmartAgriFood identified the need for diverse Generic Enablers which are related to all different GE groups that were defined by the FI-WARE project:

- ***Cloud Hosting*** – the fundamental layer that provides the computation, storage and network resources, upon which services are provisioned and managed.
- ***Data/Context Management Services*** – the facilities for the effective access, processing, and analysis of massive streams of data, and semantically classifying data into valuable knowledge.
- ***Service Delivery Framework*** – the infrastructure to create, publish, manage and consume FI services across their life cycle, covering all technical and business aspects.
- ***IoT Services Enablement*** – the bridge used for FI services to interface and leverage the ubiquity of heterogeneous, resource-constrained devices in the context of the Internet of Things.
- ***Interface to the Network and Devices*** –open interfaces to networks and devices, providing the connectivity to services that are delivered across the platform.
- ***Security*** – the mechanisms that ensure that the delivery and usage of services is trustworthy and meets security and privacy requirements.

However, apart from the "generic enablers" in the context of the SmartAgriFood project, we define a set of "domain- specific enablers". These are software modules that are applicable in the agricultural sector. These enablers may be totally independent from the generic enablers (e.g., coordinating the execution of external services) or their operation may be based on the functionality offered by the generic enablers. For example, it is expected that the generic enablers will provide the tools to perform statistical analysis. These tools can actually provide a library of generic functions (e.g., average value, deviation, etc.). A domain-specific enabler for statistical analysis for the "Smart Agri-food" sector will use these generic functions to provide the required functionality for agricultural tasks. Thus, both the domain-specific as well as the generic enablers will be a main part of the agricultural supporting sub-systems. Figure 2-2 presents this concept. The lower layer consists of the generic enablers as these are provided by FI-WARE. These generic enablers could be considered as a kind of framework of generic functions or general purpose software modules. The intermediate layer contains software modules that make use of the generic enablers (e.g., Farm statistical analysis, Farm data acquisition and Farm Execution module), which is indicated by the dotted lines in the figure. Other software modules may even be totally independent of them (e.g. Service Coordination module). All external services will have access to (or they will provide) data to end users by communicating through the domain-specific enablers. The lines among services and domain specific enablers indicate logical interfaces among software modules. In some cases, the external services may even have access to the generic enablers to simplify their development. However, the communication should in this case be carried out through a domain specific enabler that will record any such usage for security and accounting purposes.

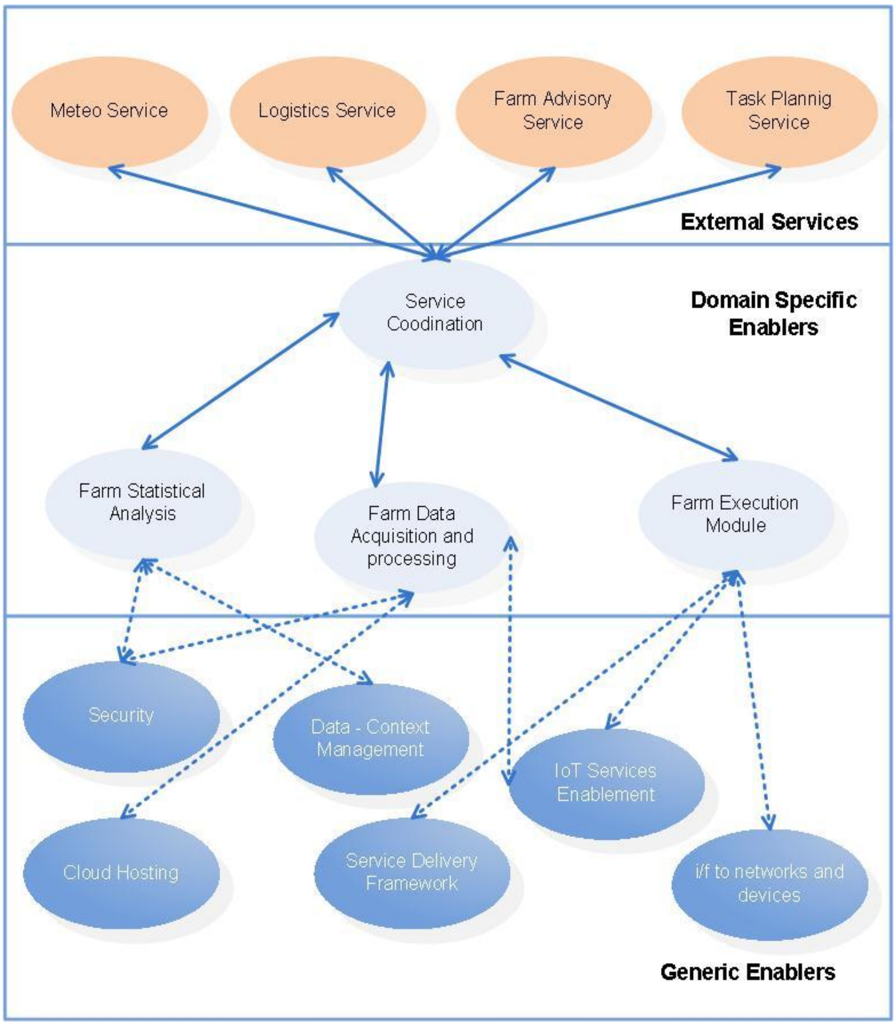

Figure 2-2: New dimension of services by composing domain-specific and the generic enablers for realising agricultural supporting sub-systems.

Looking at today's existing IT and communication solutions, a large variety of products and technologies could be applied for composing enablers. However, besides assembling technological components, one of the main challenges in realising the fully integrated agri-food chain is the definition of an open, standardised infrastructure that supports the integration of vendor-independent solutions and services. Chapter 3 will further detail the SmartAgriFood requirements on the envisioned architecture towards the realisation of this vision.

2.2 Narrative: A tomato's life

In this section we provide a narrative account of the impact of the technologies defined and described in this document in order to show the kind of impact that the technologies will have in terms of everyday capabilities. For dramatic effect, we tell the story from the perspective of the Tomato.

The FI Tomato: I am looking forward to the Future and especially the Future Internet. There is so much that I will be able to tell people about where I was born, what happened to me as I grew up and matured, how I travelled, and how good I will be in tonight's salad. I know, I know, you will say, we always knew all this stuff or at least someone knew it. Well not really. And also someone knowing it is not the same as anyone, anywhere, knowing anything they need about me. Now the world is going to be different.

[FARM] I grew up in a greenhouse in Greece and from the moment I was born systems of sensors kept track of me - how well I grew, how fast, how much water I used or needed, when and how much fertiliser was given to me, what the temperature around me was, oh and so much else! This information was stored both on the farm and some of it in the Future Internet cloud. When it came time for me to leave home, I was placed in a large box and off I went carrying with me (well mostly telling the cloud) all the important stuff about me - the date I was picked, how "good" I was, whether I was organic or not, my environmental footprint up to then, and much more.

[LOGISTICS] Every step of the way, the cloud knew where I was so I could not be lost. If someone needed to find out where I was, what temperature there was around me, when I would arrive, this was easy to do. In the old days, Joe would ask Fred and Fred would ask Tom and Tom probably didn't know or perhaps might guess. Now we just ask the cloud. And if the cloud does not have the very latest information, it can ask the sensors that accompany me on my journey. Also sometimes, I am supposed to go to one place (let‘s say a supermarket in Bonn) but suddenly things change so I may end up in a supermarket in Birmingham. The consignment I am travelling just changes destination and all the information about is available to anyone who needs it and is allowed access.

[AWARENESS] The really exciting bit is when I arrive in the retailer. Here I can tell the retailer how good I am and how long to keep me on the shelf - of course this depends a bit on how well I have been treated all along my journey but I can ask the cloud to remind the retailer if there is any doubt. Then when shoppers come to buy their fruit and vegetables, if they have added to their electronic lists "tomatoes", I will have already been identified as useful to them. I can even ask the cloud to recommend what dish or salad recipe to recommend for me - after all I am a special tomato. Sometimes the shopper needs to know whether I am healthy to eat (you ask!) or how many calories I contain, all of which I can tell on demand. I heard from a cousin of mine (we tomatoes have a dedicated IM to gossip) that he got caught up in a food scare - E.Coli I believe - and it took ages in those days to work out if he had been in contact with anything that had the bug (manure, etc.). Nowadays of course this is easy. I can tell you exactly the places I have been from the moment I was born and if you ask the cloud you could even find out exactly what has been around me at every moment. As a result if there is a bug around these days, and it has come with me then I and all my fellow tomatoes, who have come on the same journey or the same set of boxes, can be taken out of the retailers or wherever we are and we are then sent to the Great Tomato Soup in the Sky.

The FI Cloud: The Tomato thinks I know everything but actually I do not. It works like this: The farmer (or rather the farmer's farm management system) collects a lot of information about the tomato all the time. A lot of the time, all I do is answer questions ("What is the weather going to be like today or this week?" - and I just put the FMS in touch with the meteorological service). Sometimes the FMS sends me data to keep or process - like when they want me to contact the market modelling service to ask whether more tomatoes or cucumbers should be planted or they want to know where the products dispatched two weeks ago are located now because of a serious health problem..

[LOGISTICS] The big day comes when the tomato leaves the farm, and then I get a lot of data sent to me to keep for a while. I have already been told by the retailer that they need tomatoes, and as a result I sent a message to the transport company to go and get the tomatoes. As the tomato or its consignment leaves the farm, my logistics tracking service (a SaaS) allows me to know where the tomato is, what temperature is in the truck (I check with the sensors regularly) and thus update my model of shelf-life and quality.

[AWARENESS] Another big day is when the tomato reaches the retailer. The retail management system asks me what I know about this tomato, and of course I tell all - in fact at that moment I check back with the FMS and the tracking service and hand over the data to the retailer. At that point, after doing some calculations, the retailer may access the Consumer Food Awareness service which I can deliver to smartphones and provide the relevant subset of information for shoppers to access. So basically I am not omnipotent, it just looks like that to an average tomato...

2.3 Scope

Within this project, we have identified three sub-use cases (Smart Farming, Smart Agri-logistics, Smart Food Awareness) and within these sub-uses a number of pilots have been developed covering spraying of crops, greenhouse vegetable production, fresh fruit and vegetable logistics, flower supply chains, tailored information for consumers, and the meat supply chain (cf. Deliverables D200.1, D300.1, D400.1). For the purposes of this deliverable, we will look exclusively at the architectural requirements of the “super-scenario” which is defined as an over-arching pilot covering the whole supply chain. Because this scenario is longer in reach - attempting to stretch from farm to fork - we are restricting its scope to focus on fresh vegetables, specifically the tomato or cucumber.

The motivation for this restriction is that the food and farming supply chains are very complex as has been noted above. A fresh vegetable provides a coherent set of challenges with regard to integration with FI Generic Enablers and the development of Domain Specific Enablers to act as a proof of concept. The “super-scenario” includes the whole journey of fresh vegetables from farm to the consumers, which covers the farming, the agri-logistics and the food awareness areas. We are intentionally excluding the flower chain, the meat chain and all processed foods. These supply chains involve considerably greater complexity, although obviously our intention in future projects would be to extend the architecture we describe here to these other food supply chains. The current scope, however, allows a coherent foundation to be laid for the future extension of the architecture.

With respect to functionalities, the major focus will be on designing the architectural integration of FI Generic Enablers together with Domain Specific Enablers so as to make possible:

a) the collection and sharing of data about food including quality, origin, treatment, growing methods, while collecting data from each step of the supply chain;

b) provision of access to the data collected in a variety of environments and across a range of devices;

c) the appropriate level of data privacy, data integrity, appropriate access control dependant on business role and the purpose of access;

d) provision of traceability data so as to track back any given item to every step along the supply chain;

e) provision of mechanisms to enable trusted relationships between stakeholders to be built and maintained whether on the fly or over the long term;

f) the application of EU or government directives, the collation of data for the purposes of certification and food quality labels.

2.4 Business Roles and Stakeholders

The agri-food sector is composed of different actors at different stages in the supply chain that are linked by continuously changing business relationships. The agricultural production is characterised by a decreasing number of farmers that work an increasing area as well as take care of all aspects of farming from planting to harvest and conditioning processes. Agribusiness trade organisations bundle and sell agricultural commodities from multiple farmers (local and global) to food industry companies or in case of fresh unprocessed products directly to retail groups. The food industry companies process different raw materials from multiple suppliers to final food products. Retail groups procure food stuffs from multiple food industry and traders and are the interface between the supply network and the final consumer. These actors are supported by service providers that organise the distribution, transports, packaging, quality control as well as the certification of companies.

In this section, we characterise these different actors or stakeholders in the agri-food sector and then describe the variety of business roles involved. “Actors” are stakeholders, which get directly in touch with the goods (food) in the E2E (end to end) food chain.

Main actors[3]:

Agricultural production

As described before, the farm stage consists of different farmer types that are specialised in their skills and processes. Farmers can be separated into:

- Growers (Horticulture) that produce plants, fruits, vegetables, and other agricultural commodities such as e.g. grains.
- Livestock farmers that breed and facilitate livestock to produce products from animal origin such as e.g. milk, eggs and meat.

(For reasons given above, this section concentrates on Fresh Foods and vegetables only.)

[3] In case of extending the super scenario to meat case: The main actors would be complemented with animal breeders, meat products producers, slaughter and cutting houses. The needs and requirements of the stakeholders are the same as below.

Agricultural trade organisations / Auctions

Agricultural trade organisations are procuring and bundling and trading agricultural commodities and livestock from farmers in order to sell it or auction it to food industry or retail organisations. For these trade activities different auction types or organisation forms are possible. Agricultural traders can be separated into:

- **Agricultural Marketing Organisations / Agricultural Cooperative Societies** have a special role in the agribusiness. These organisations are member-controlled business organisations whereas the members of these organisations are a large number of small-scale farmers. The intention of these organisations is to bundle and market the agricultural production of the members. These organisations are also supplying wholesalers and exporters.
- **Exporters / Importers** that import or export agricultural commodities on international scale. Often these companies are concentrating on horticultural products
- **Wholesalers** that operate with a larger portfolio of agricultural products and commodities. The customer group of these wholesalers are merchants, gastronomy and small-scale retail and speciality stores.

These trade organisations often operate online auctions as well as traditional auctions at fixed places.

Retail groups

- Retail groups are representing the interface between the production and trade stages and consumers. However, retail groups are considered as the second trade stage in the food sector. Due to their special role, retail organisations are taking the responsibility for providing safe food products at a high quality level at affordable prices as well as product information to consumers. Retail groups commonly have up to 700 different suppliers for a portfolio of over 10.000 food products. In order to assure replenishment of their associated supermarkets these groups operate a tremendous logistic infrastructure with a high number of distribution centres at strategically important places. Most retail groups are organised in the following way:
- **Operational Headquarters**, which cover all business functions, such as e.g. procurement, marketing, quality management, finance and customer services.
- **Distribution Centres**, which organise and centralise the distribution of food from previous stages towards supermarkets.
- **Supermarkets**, which sell the product portfolio to consumers.

Service providers

As described before, service providers play an important role in organising the product flow from farm to retail. The most important service providers are:

- Transport companies and storage/transhipment firms, which organise the transport of commodities, raw materials and final food products between the different previously characterised actors.
- Suppliers of Logistic Assets (containers, crates, etc.), which offer physical packaging and wrapping for food products (e.g. returnable crates for fresh fruits and vegetables, meat or trolleys for flowers) as well as return logistic services and waste disposal.

Consumer (in Super Market and at home)

Consumers are characterised as the final customer in the food supply chain with a highly individualised demand. Consumers demand safe food products with a high variety, convenience level and quality at affordable prices all over the year and challenge with their demand all actors in the food sector. Consumer expectations are the most important driver for change in the food sector. In the past the consumer behaviour changed due to several crisis and changes in lifestyle, which leads to an increasing demand for product- and production-related information.

Other stakeholder, having an active or directive role in the food supply chain

Due to the importance of the food sector for the health and well-being of the population of the European Union, national and EU legislation bodies have an important role for the food sector by developing the rules for production, processing and trade of food in the premises of the European Union and its member states. The efforts of legislation in the past lead to a complex system of legal requirements that have to be met in order to market food products. This 'food law' covers the so called public requirements, which are based on societal needs and is based on the regulation no. 178/2002.

The second pillar is based on stage-specific organisations and associations (e.g. farmer associations, retail organisation (e.g. the EHI)) which define standards for their members. These standards are highly specific and play an important role for the different stages, but are not of relevance for the food sector as such.

Due to several severe crises in the past, a third party emerged to importance for the food sector. This party consist of a large number of certification bodies formulating private standards based on legal requirements and additional private requirements from groups within the food sector. This leads to a tremendous increase of certification schemes, which cover aspects in focus of the society. The importance of this party is based on the fact, that the food sector is based on a high division of labour and actors at the end of the supply network are not able to control the previous stages, but have to assure, that the companies as such and their products have to fulfil at least all legal requirements.

General Standardization bodies[4] (examples)

- International Organization for Standardization (ISO) (http://www.iso.org/) defining standards relevant for the agri-food sector such as e.g. the ISO 22000 (food standard), ISO 9001 (quality management) or ISO 14000 (environmental issues).
- Codex Alimentarius Group, which is a WHO/FAO group for developing harmonised, non-binding views and definitions for the food legislation (http://www.codexalimentarius.org/)
- GS1: Standardisation of Identification Keys, Electronic Data Interchange, EPCIS, Logistic Processes and Catalogues (http://www.gs1.org) which are highly relevant and de facto standards in logistic sector including food logistics.

European Standards Organisations

- the European Committee for Standardization (CEN) (http://www.cen.eu/), which harmonised standards between the member states and the ISO. In this functionality the CEN has also strong relevance for the relevant standards and their approval within the European union.

[4] Source: European standards Standardisation - Key players, http://ec.europa.eu/enterprise/policies/european-standards/key-players/index_en.htm

- Small and Medium-sized Enterprises for Standardisation (NORMAPME) (http://www.normapme.eu/)

National Standards Bodies (NSBs) of the EU Member States

- Deutsches Institut für Normen (DIN) (Germany) defining standards with a broad scope, but also with relevance for the agri-food sector such as e.g. for food hygiene and quality management.

Food related Standardisation bodies (commercial or NGO)

- GlobalGAP, which is providing the internationally accepted standard for Good Agricultural Practice (http://www.globalgp.org).
- Q+S (Quality and Safety), which is an example for a German NGO standardisation body targeting at chain-wide quality and safety of food products by central data management.
- FairTrade International, which is a good example for social standards in the agricultural production, especially concentrating on developing countries (http://www.fairtrade.net/).

Examples for certification schemes and standards

- International Food Standard (IFS), which is the most considered private standard for the food production and retail sector.
- British retail consortium standards (BRC) which defines extended requirements and rules for all retail suppliers (initially in GB, but with increasing importance in central Europe)
- ISO9001, which is the basic norm for quality management and the source for many standards.
- ISO22000, which sets the norm for safe food production and Hazard Analysis and Critical Control Points (HACCP) in the food production based on legal requirements.
- GlobalGap Standard (see above)

Besides these examples of fundamental standards, there are over 200 active standards with relevance to food sector targeting on diverse issues in order to meet diverse consumer expectations.

Agrifood technology solutions or application providers, building specific solutions for the food chain actors.

In this group we present some selected examples for system providers, whereas the most common system providers are considered as well as highly specialised system providers for agriculture.

The most common system providers of medium- and large scale enterprises are:

- SAP, providing a comprehensive ERP system and related enterprise solutions in general.
- Microsoft, providing a comprehensive ERP system (Dynamics NAV) and a wide portfolio of enterprise software for different purposes (Windows, Office, Server software).
- IBM, providing different software solutions as well.

Specialised software solutions for farmers are often individual solutions that are provided by a high number of small- and medium sized software companies. These companies provide solutions for:

- Farm Management Systems (local or cloud based often provided by suppliers such as e.g. BASF)
- Disease Forecast Service provider

- Weather Service provider
- State and Policy Information Service provider (e.g. consulting organisations, European (EF-SA) or national boards (e.g. BfR))
- E-agriculturist Service provider
- Farm advisory service provider
  - Agronomist
  - Research Institutes

New roles in FI-WARE to be considered

Due to the potential of developing software solutions based on FI-WARE components we consider:

- FI-WARE application provider,
- FI-WARE instance provider,
- FI-WARE platform product provider, and
- FI-WARE generic enabler provider,

as new roles that are related to system providers.

The particular needs and requirements regarding the facilitation of Future Internet technology for each stakeholder involved in the super-scenario have further been analysed. A detailed description of these can be found in the Appendix 1.1.

2.5 Current practices and future needs

2.5.1 State of the art in agri-food

Data processing in food production starts on the field. Current technologies enable the sensing of data on the operational level and the control of equipment for farm operations like spraying, irrigation, greenhouse climate control etc. Advanced IT systems for these functions are available. On the **farm level**, management applications for production planning, recording of transactions, and information exchange with supply chain partners, certification authorities, and governmental services are in place (see Figure 2-3).

However, the existing applications have limited interoperability and farmers usually have to enter the same data, such us their land use plans, into several systems using different syntax. Furthermore, current applications offer functionalities that are limited by the current state of technology, such as insufficient coverage of broadband networks in rural areas, insufficient reach of local wireless networks, and insufficient precision of geographical location. These technological barriers will be levelled in the nearby future and the challenge for the Future Internet is to offer software functionalities that help the agri-food sector to significantly improve product safety and quality, consumer service, economic results, and social responsibilities such as ecological sustainability, reducing waste, and animal welfare.

Limited interoperability between field level systems, farm management systems, and systems for data exchange with supply chain partners and authorities does not only result in inefficiencies at farm level. It seriously hampers the downstream information availability and is a source of data inconsistencies. This may conflict with the fact that supply chain partners, consumers, certification agencies and governmental services are demanding an ever increasing amount of information about the products and the way these are produced, such as ecological footprint, water footprint, improved product safety guarantees, social issues in employment contracts, nutritional responsibility, animal welfare, economic responsibility and local market presence.

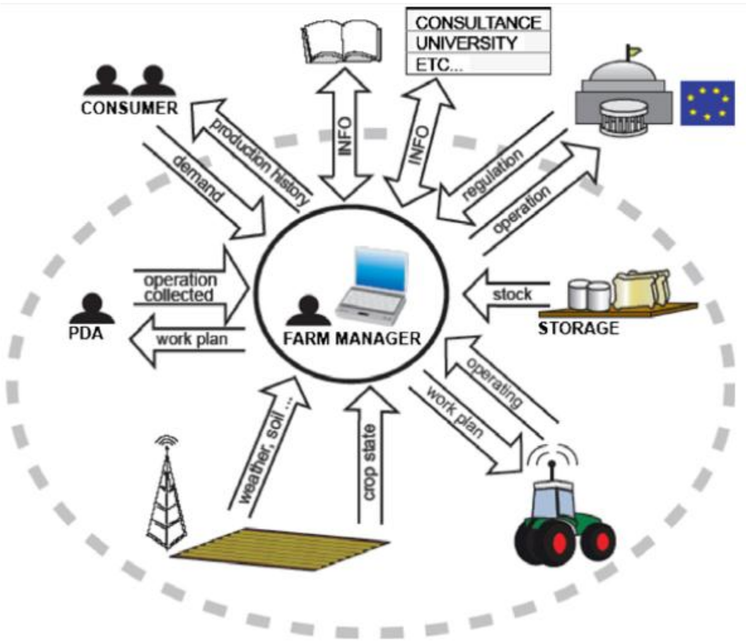

Figure 2-3: Information flows on the farm

'Precision agriculture' is a decisive concept for the future in farm data collection. It utilizes GPS and sensor technology to facilitate farm activities like spraying or fertilizing, but at the same time allows automatic data collection on process activities. For the information flow towards supply chain partners and certification agencies, precision agriculture technology does not provide principally new opportunities, but facilitates data collection and provision. It avoids manual data collection and allows farms to keep track on their processes in digital format. This in turn could improve the capability of farms to more easily comply with information requirements of its customers and the chain. However, interoperability with farm management information systems and interoperability with downstream supply chain partners remain challenges. The Internet of Things (IoT) provides great perspectives for improving information exchange. Virtual products, accessible through standard protocols, can carry the information of their real-world counterparts from supply chain stage to supply chain stage, using sensors in their environments to collect data about production, storage, transport, and ripening/perishing conditions. The information from sensors and internet sources can be combined by intelligent applications for precise planning of activities and precise steering of equipment. New features arising from European initiatives on space-based location and navigation systems Galileo and EGNOS can be applied to advance the precision of production and distribution processes.

Much as it is on the farm level, the current state of the art of ICT in **agri-food logistics** is characterized by large amounts of available data, but there is a poor level of integration, and the support for intelligent use of these data is insufficient. The complexity of current solutions is too high and jeopardizes the development and operation of affordable solutions. As a result, the adoption of the Internet for basic information services is high, but the use for more advanced functionalities is limited. Key challenges concerning ICT for Agri-food logistics include:

- Timely and flexible availability of product and quality information to a variable network of downstream and upstream partners; many current Tracking and Tracing systems are paper based and forward information efficiently only downstream; real-time upstream and downstream information could greatly improve network flexibility, quality, sustainability, and response to consumers' demands;
- Seamless interoperability of enterprise and supply chain systems, allowing for hybrid cloud and decentralised approaches and a two-way approach of on the one hand the long run pursuit of homogeneous standards and, on the other hand, short term technologies to deal with the current heterogeneity of standards concerning identification, frequencies, data interchange, etc.;
- Dynamic logistic planning and scheduling systems enabling last minutes changes and re-allocations based on early warnings and (quality) simulation capabilities; these solutions would enable features like context-based re-planning to prevent food waste, recall of products with surgical precision in case of food safety incidents, rapid response to changing consumer demands, weather conditions, and traffic jams.
- Information security (privacy, authentication, integrity) and data quality; farmers and other SMEs fear the greater market power of downstream supply chain partners; downstream partners are reluctant to open their data to competitors; tailored information security is a sine qua non for all supply chain actors to gain sufficient trust to provide their data;
- Affordable solutions which can be utilised by SMEs that lack significant financial resources and specialised competences; service-based, pay-per-use, architecture of farm and logistics information systems could make advanced technologies available to SMEs.

Consumers' trust in food, food production, the origin of food, and the actors involved is a core requirement for the functioning of European food markets and the competitiveness of industry involved. With the experience of the BSE crises and subsequent food scandals in mind, consumers increasingly expect transparency on which trust can be built. There is an increasing demand by the members of the food-chain for providing more and more information to the consumers about the product related information to help the consumers in the decision making. The consumers are overloaded by vasty of information; thus they can feel confusing. Therefore it is necessary to prioritise the information which is communicated to the users and to exploit the opportunities in aggregating, integrating the relevant pieces of important information into signals, on which clear, easily understandable messages can be based, which can assist the users in evaluating the credibility of different claims.

Transparency is not meant to know everything, but to create awareness on the issues consumers are interested in.

Several EU Regulations specify a minimum amount of food information that must be provided. In addition, more or better transparency will be based on awareness of actors and stakeholders in food supply chains as to what information and which issues consumers are interested in. In particular, this is information on the safety and quality of products and processes, and increasingly on issues around environmental, social, and ethical aspects.

Given that transparency implies provision of information on activities of all actors in the value chain, the design of appropriate transparency systems requires cooperation within the agri-food sector and a suitable IT infrastructure that enables collection and processing of data and provision of information in retail and to the consumer. Such an infrastructure should at least enable and support traceability[5]. Much information is available at the point of sales and in the systems of distributors and producers. Using this information for consumer services via mobile devices is perceived to be futuristic, although some experimental cases are known.

Current solutions for data interchange on Internet are mostly based on mark-up languages, but there is a lack of end-to-end interworking solutions. Standard languages are a mandatory requirement, but this is not sufficient for ensuring interworking. The efficient management of huge amounts of information and their forwarding to the suitable points require identification of information elements, definition of such information in standard languages (data from sensors, actuators, RFID, etc), and automatic management based on M2M (Machine-to-Machine) Architectures. The complexity of the current solutions is too high and hampers the development and operation of affordable solutions. In this context only big companies that are able to pay for specific solutions and to deal with their complexity, can benefit from those solutions.

2.5.2 Business needs beyond the state of the art

Information technology in the agri-food industry has to deal with the following specific characteristics, in comparison to many other industrial sectors:

- heterogeneous and dynamic natural conditions (e.g. soil, weather, pests and diseases)
- seasonal growing of crops: some processes (and decisions) occur only once a year;
- natural products grow, decay and usually have a high variation in quality which means that decisions have to be changed in time because the product has changed or there are different markets (for different qualities) to be taken into account;
- dynamic, open chains: depending on the state of the product and the market demand, the product at one moment has to be shipped to customer x and another moment to customer y, with different information requirements;
- daily need for food and high demands (food quality and safety)
- high volume distribution causing a high impact on (global) transportation;
- large number of small and medium sized enterprises;

[5] EU Reg 178/2002 defines ‘traceability’ as "the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution;"

- long and complex structure of the supply chain networks, where small enterprises (farms and some of the processing industry) trade with large multinationals in the input and retail sector.

Due to these characteristics application of ICT is not always as obvious and straightforward as it might be in other industries. For example, in addition to the high need for interoperability, there is a need for flexibility to deal with the high dynamics in agri-food supply chain networks. Furthermore, the need for sector-specific ICT solutions is high, but the SMEs in the agri-food sector cannot afford large investments. This hurdle may be taken by making ICT solutions available on a pay-per-use basis.

According to the surveys reported in D700.2, it is expected that cloud hosting services will benefit especially small enterprises, which need no investment in installation and maintenance of IT infrastructures. However, the cloud hosting on the other hand is seen as a potential risk for data security and privacy.

From the farming perspective, an intelligent advisory system had been identified as an especially important application for supporting lots of daily decisions to be made on how to treat plants, prevent diseases or include relevant information such as weather services. Many of these applications or systems are already available in farms, but are not wide-spread, because of their costs.

For the logistics sector of transportation and distribution of food, Future Internet applications that have an appeal include the ability to share online monitoring of information from trucks during the transport of cargo, a flexible solution for on-demand dock reservation and an integrated freight and fleet management. Today there are limitations, as data needs to be joined and connected through different applications and systems. The lack of standardized interfaces and processes needs to be solved in parallel to the provision of Future Internet functionality.

In the food awareness area, the food tracing capability is seen to be the most important topic, providing knowledge about the origin, production and treatment of products. The customer expects to get the information with an easy and configurable interface, extended with an advisory functionality based on individual customer preferences. Just like it is in logistics, the scope of today's solutions is limited by missing standards on data interfaces and processes, and the cost of the RFID tags or QR codes[6] is still too high to enable widespread use. Furthermore, It should become easier for all actors and stakeholders in food supply chains to become well informed about the knowledge, attitudes, opinions and demands of consumers. Future Internet applications should offer consumers the opportunity to give feedback and consumers should be enabled to decide on whom to allow access to which feedback.

To satisfy the main user requirements, data from different systems and different locations have to be linked and joined, while at the same time guaranteeing data access policies. Existing solutions are specific and proprietary, mostly having their own specifications about the functionality they provide and the means to interwork with other services. Furthermore, there is not yet a pan-European solution for e-government services, providing secure authentication and authorization functions to users, which are essential for trading, payment, privacy, liability, service subscriptions and a user-friendly "single-sign-on" feature. There are some common **demands and expectations** identified in D700.1, which need to be realized in the future to eliminate the limitations and problems faced by the users.

Basic demands for the cost:

[6] Quick Response code: a matrix bar code which can contain a large amount of data

- Currently the price of the technologies required (RFIDs and satellite based technologies for traceability or monitoring, automated systems) is too high particularly for smaller businesses.

Basic demands for the accessibility and privacy:

- Ensuring the accessibility to the data, while restricting access in a secure way.

Basic demands for the data exchange:

- **compatibility** of the different applied devices, programs and systems or **integrated systems** instead of different connected applications;
- filtering and **systematic organization** of the received, stored, sent or browsed data, even on demand, by a predetermined profile;
- **automatic transfer** of the recorded and received data to the right system or persons - measured and recorded information and data should be available and the forwarding controlled in accordance to events, rules and process/ambient context. Disburdening the ICT system users from administrative tasks, only asking for an interaction with ICT when the human operator is required for making a decision, the ICT cannot do or it is not authorised to do.

2.5.3 Standards for agri-food information representation and exchange

The present communication landscape is dominated by enterprise focused applications and solutions with limited communication across enterprise borders that reach beyond the exchange of basic business documents as, e.g., bills or product documents. As a consequence, the agreement on, and the utilization of, communication standards has not yet received the attention required for the establishment of comprehensive food chain coordination and communication schemes. To make it clear, there is not a deficiency in standards but a deficiency in agreements on standards ('which one to use') and the development of standards for broad application ('working all along the supply chain and in all circumstances').

The discussions on syntax specifications for unique identification of products in the supply chain are being dominated by the GS1 standards dealing with data exchange between industry and retail and the agro-XML standard dealing with data exchange between farms, as well as between farms and their trading partners. They are complemented by some more specific standards that focus on specific data exchange requirements as e.g. the standards ISOBUS and ISOagriNet.

The standards have been developing over quite some time and build, especially the standards GS1 and agro-XML, on an extensive base of documentation, experiences, projects, and implementations. For industry, GS1 (e.g. www.gs1-germany.de) is offering the Global Product Classification (GPC) which has specifications for various lines of activity. Data exchange protocols involve EDI and are standards for the exchange of data on product movement. The standard EPCIS (Electronic Product Code Information Service) is meant to be complementary to EDI. It deals with questions such as what (product identified by manufacturing data e.g. EPC number), where (location of enterprise, position in supply chain), when (time of event) and why (status, process step).

The open and non-proprietary ISOBUS (ISO 11783) protocol is considered to be the communication standard for automated tools implemented on tractors. It is based on CAN-technology[7] and has the same shortcomings. ISOBUS enables the integration of fundamental implement con-

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[7] CAN standard for microcontroller communication in vehicles: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=33422

trol features and the display of implement conditions and parameters on the tractor. The ISOBUS sub-standard Class 3 is not yet ready and hardly implemented. Its purpose is to enable implements, such as pesticide sprayers, to control the tractor by safely setting parameters like speed and RPM (“automatic driving”). ISOBUS Class 3 is realized only for a few specific applications mainly for control of hydraulic selective control valves (SCV) on the tractor. Further, realisation of Class 3 is limited due to safety issues since the tractor may never allow an unknown implement to command safety relevant tractor functions.

ISOagriNET is a standard for data exchange mainly between process computer and between process and management computers in livestock farming. It supports networking in stables between feeding computers, climate control and regulation machinery etc., but it is also used in dairy production and cattle breeding to transport milk recording data between farmer and dairies or breeding associations. As such, it provides an on-farm bus system as well as an inter-enterprise communication channel. ISOagriNET conformant bus systems are now available on the market and a number of research initiatives exist, that leverage and process data from a variety of farm management systems and process control systems in novel ways.

Any communication requires not only a suitable technological base, but agreements on ontology, i.e. on vocabulary. The difficulty is that there are various ontologies in place, but no agreement on standardization. The AGROVOC thesaurus by the Food and Agricultural Organization of the United Nations (FAO) is nowadays the most comprehensive multilingual thesaurus and vocabulary for agriculture. Originally, it was devised for indexing of literature, but it is increasingly used also for facilitating knowledge sharing and exchange through electronic media and machine-readable data formats. As such, AGROVOC can enable semantic interoperability, also between systems in different languages.

Future Internet should not aim to develop new standards, but should build on these widely accepted standards, and should enhance these standards to support interoperability from farm to fork.

2.6 Information processed, exchanged and shared

As noted above in Sections 2.4 and 2.5, one of the key challenges in achieving the level of data integration envisaged for the SmartAgriFood Super-scenario lies in the exchange of data. The ability to exchange data easily, seamlessly, between different IT systems, whether they are on farm, in the logistics process, within retailer systems and then to interact with the consumer's IT systems is one of the most important objectives of the work undertaken in SmartAgriFood on the Super-scenario. The interoperability and exchange of data is not an end in itself but rather makes possible the functionalities expressed as a narrative in Section 2.2 and further elaborated in Section 2.3 (cf. also D100.2 Part I). At a simple level, the ability to query for data for a given product, or in reverse the ability to query for specific attributes and identify a set of products will create a large number of business opportunities and resolve key issues in tracking and tracing.

In this section, we address three questions:

1. For each actor, what data do they generate about a product? Thus for a product such as a tomato, what data is generated on a farm, what data is generated during transportation, what data is generated at the retail stage of the supply chain?
2. For each data item, how will this be represented in an interoperable manner? This means we need to identify the relevant knowledge representation standards in order to represent the data.
3. For each data item, who has access to that data? Some data is only relevant to some actors, while other data some actors consciously do not wish to divulge. Yet further data is demanded either for certification purposes or due to consumer pressure.

We present a Version 1.0 of our analysis in Appendix 1[8] in which we have provided a catalogue (in the form of a spreadsheet/table) which answers these questions. The table is organised to list actors (e.g. farmer), the relevant information concept (e.g. farm product), the sub-concept (e.g. species or cultivar) and the data format (e.g. string, numerical, binary). Further columns list the availability of that data point to actors along the supply chain. In other words, this would determine access control at a default level. Obviously certification bodies have different requirements from transporters etc. Finally the table specified which knowledge representation standard (i.e. ontology or GS1 standard) is appropriate for representing this piece of information.

There are a number of points to make:

1. The actors considered at this juncture are the ones relevant for the fresh vegetable supply chain. As noted above (Section 2.3), we can extend this model for more complex supply chains such as the meat supply chain.
2. The list of actors and relevant information concepts is open ended. This is because currently insufficient primary research has been done on the actual data points needed, and because we expect the relevant data points to change in view of changes in policy, law and consumer expectations.
3. The availability of a specific data point to other actors must be treated with caution at this stage. Access to data may be different in different countries, for different types of actors and may also change.
4. The knowledge representation formats suggested are to be treated as indicative, as yet no research has been undertaken to evaluate the suitability of specific vocabularies for the

[8] Appendix 1 provides PDF version of the spreadsheet. An Excel version is available at http://csi.aston.ac.uk/projects/saf/docs/D500_Sect3_6_table_revised.xls

purposes described in this document. For example, the concept of a “tomato” exists in AGROVOC, GS1’s GPC and other taxonomies. Currently, we have no criteria to determine that the use of one vocabulary is superior to another.

5. Although it is true that there is a deficiency in agreement on which standard to use (as noted in the preceding Section), there are also gaps for the representation of knowledge for certain domains. One example of this is the absence of a coherent vocabulary to represent the various components of the carbon footprint of food (i.e. footprint from various stages in the supply chain, and the overall result).

In conclusion, the key outcome from the data collected in the table in Appendix 1 must be that the overall architecture is designed so as to be able to use the standards/vocabularies and their formal syntax for data exchange, for data import/export as well as for data exchange between different Generic Enablers and Domain Specific Enablers.

3 Architectural Specification

3.1 Functional Modules / Concept

In this section a description of the global system architecture concept for Future Internet applications supporting the SmartAgriFood domain is given. Figure 3-1 depicts the functional modules being part of this architecture and illustrates their corresponding interconnection. Applications are provided to the users by the *Specific SAF Application Provider*, which is represented by the pink box on the right hand side. This provider may host applications for all three sub-use cases Farming, Logistics and Awareness, as they have been defined and described in work package 200, 300 and 400 of the SAF project. Besides supplying an appropriate interface for all kinds of user-driven accesses and requests, the provider also facilitates the integration of legacy systems that exist already today for the distinct use cases (e.g. Weather Service Providers for FMIS, ERP systems, database systems, enterprise software). Making these legacy systems compliant with FI-WARE technology would require the service provider to migrate; however, since this may come at high effort for the provider, such a migration cannot be guaranteed. Hence, integration on the application level by linking those legacy systems via external interfaces can be considered a viable solution to facilitate the desired downwards compatibility. The interfaces will most likely be proprietary solutions, though. The definition and description of interfaces to the legacy systems will be subject of deliverable D500.4.

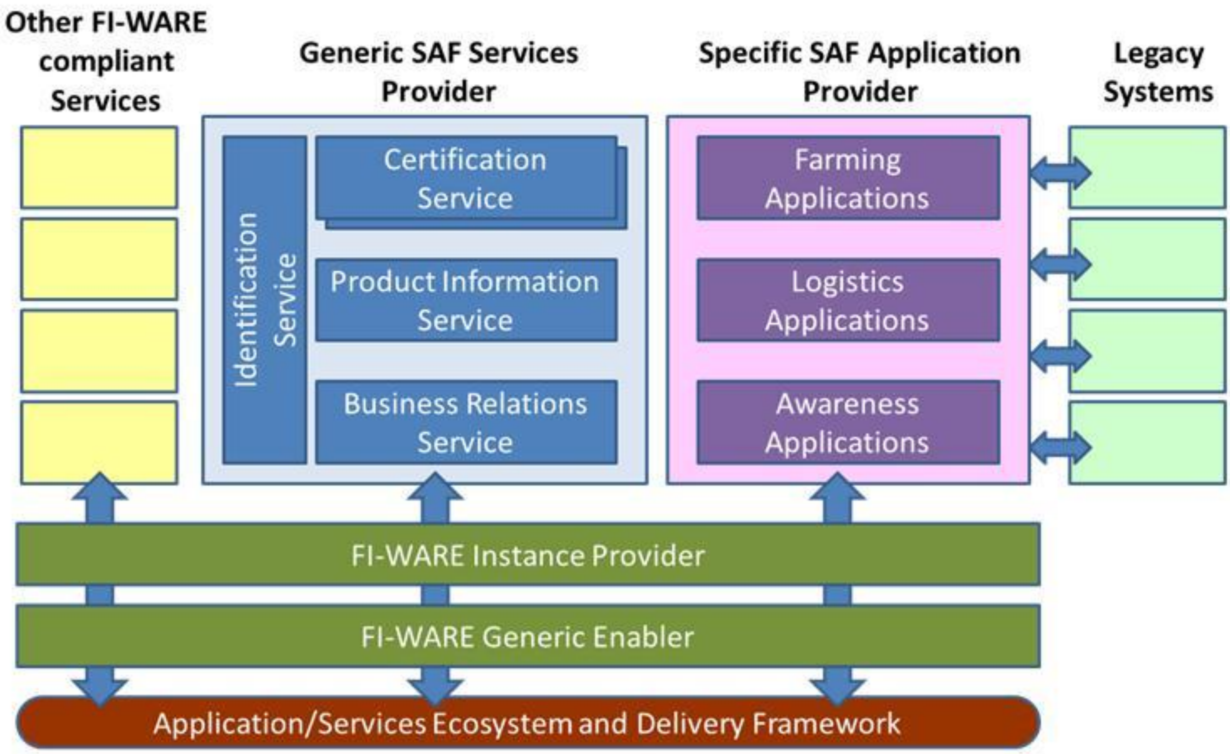

Figure 3-1: System architecture for Future Internet applications supporting the SmartAgriFood domain

Each of the SAF applications may use particular services, which are realized based on the functionalities offered by the FI-WARE platform. These services are hosted by a dedicated *Service Provider*, which is connected to the Application Provider through the *Services Ecosystem and Delivery Framework*. With this framework, which is one of the Generic Enablers specified in FI-WARE, the communication between the applications and any kind of FI related service is facilitated. Applications and FI related services may make direct use of other *FI-WARE Generic Ena-*

blers, which are made accessible through an appropriately configured *FI-WARE instance*. Both items, FI-WARE GEs and FI-WARE instance, thus form the basis for all FI related services and applications as well as for the communication between these. A detailed description of the *Service Ecosystem and Delivery Framework* including a sketch of the communication principles to be followed by the different involved actors is presented for each of the three sub-use cases in section 3.2of this chapter.

For the architecture presented here, we distinguish between

- *Generic SAF Services*, representing those services that have been specially designed for the SmartAgriFood usage area and are available in this context only. They are based on selected Generic Enablers and are common for all sub-use cases within the SAF domain.
- *Other FI-WARE compliant services*, representing those services of more universal use, i.e. they may be used in the context of several other usage areas as well (e.g. access to social networks, search engines, data bases for weather forecast etc.).

As Generic SAF services providing the main functionality for all SAF applications that span all three sub-use cases, four services have been identified as the fundamental components of the system architecture (cf. section 3.3). As seen in the light blue box on the left hand side in the Figure, these are

- *Certification Service*
  enabling to answer queries about certificates of partners and products[9]
- *Product Information Service*
  enabling to answer queries on status and history of specific products
- *Business Relations Service*
  enabling to establish & find new business relations and new market places
- *Identification Service*
  providing secure personal identifications and authorized access to (private) data

A detailed description of each of these services, including the involved communication processes and the FI-WARE Generic Enablers used, can be found in section 3.3. Other FI-WARE compliant services that are relevant for the SAF usage area are elaborated on and summarized in section 3.4. The focus here is on services coming from other FI-PPP usage area projects, which allow for a more universal use and thus may beneficially be used also in the SAF context.

Finally, based on the detailed description of all functionalities within the SAF system architecture, we provide in section 3.5 a summary of all Generic Enablers that are used by all the subsystems described in this chapter.

[9] In fact, we will have one service provider for each certificate. The architecture is open for any certificate provider to integrate its certification processes in the workflow.

3.2 Services Ecosystem

The Future Internet, with the assistance of the FI-WARE Project, determines a set of generic principles for the prospective services and applications to follow. Issues that are related to creation, composition, delivery, monetisation, and usage of them are defined. Without dispute, these basic instructions have helped all the three subsystems – farming, logistics and food awareness – to identify, design or even enlarge the essential services more efficiently than ever before.

The “Services Ecosystem” defines the communication behaviour to be followed by the different actors involved in an ecosystem. Namely, it defines how a set of roles and rules these actors must accomplish, understanding these actors are the different systems and applications involved in the ecosystem.

The rules are defined to create a common understanding of the communications within an ecosystem, since communication between distinct actors can be quite different (from an old-fashion legacy system to a new mobile application). These rules will be related to the definition of interfaces, data exchange, message protocols and workflows.

The definition of the roles within the communications of an ecosystem is also important. It must be clear which involvement and task each system should have in the global communications. For example, a system implementing a service bus can be in charge of the data exchange with 3rd parties and external services; while another system is in charge of connecting the internal systems and managing their message exchange.

This global ecosystem communication scenario can be extrapolated to an internal system communications ecosystem. Therefore, the internal modules to be used would act as the systems in the global ecosystem scenario.

In the incoming subchapters the FI-WARE’s service ecosystem will be briefly explained, followed by the services ecosystem used by the three scenarios within the SmartAgriFood project. Finally, the reader will find the introduction to the end-to-end scenario service ecosystem, which will be explained in detail in the D500.4.

3.2.1 FI-WARE’s approach

FI-WARE defines several roles to be used within the communications of the Use Cases. Although these roles are deeply explained in the documentation provided by the FI-WARE project, here the most important ones for the Services ecosystem will be briefly commented, for the reader to understand them.

Figure 3-2 shows the ecosystem and its different roles defined by FI-WARE.

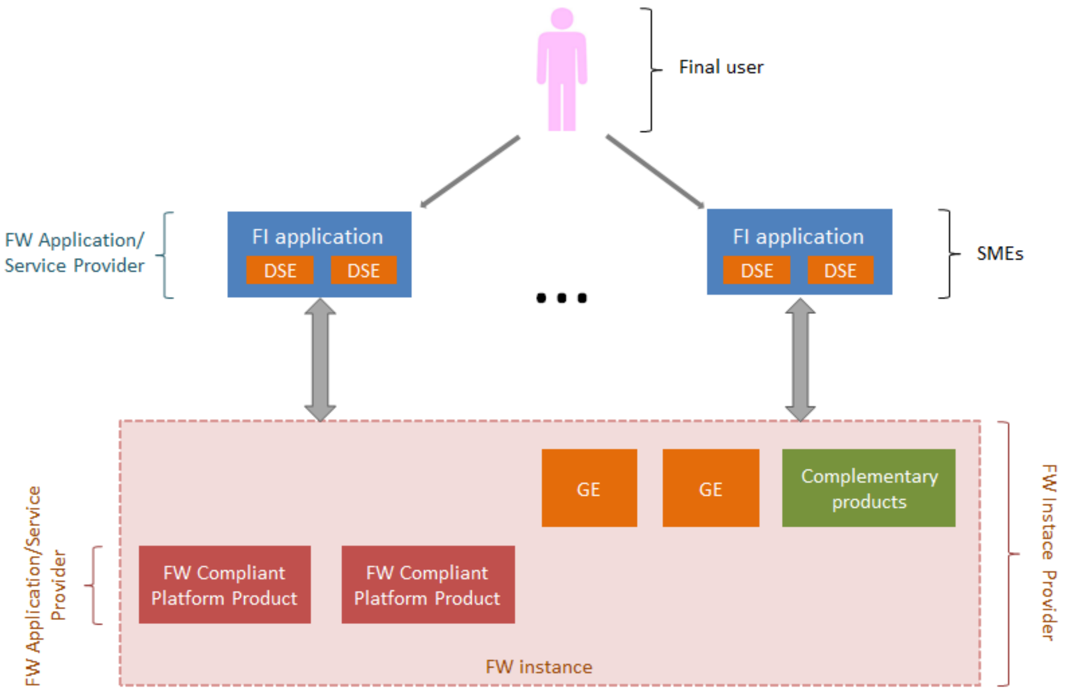

Figure 3-2: Ecosystem defined by FI-WARE

– FI-WARE instance: an instance of the Core Platform composed by a set of Generic Enablers defined by FI-WARE, and possibly extended by the Instance provider. This instance will expose, to the Future Internet/FI-WARE applications, the different GEs mainly using web services (with its correspondent APIs), but also as library files.
  Most of the GEs will be RESTful although others can use SOAP as message exchange protocol. The data will be exposed using JSON and XML.
  Although FI-WARE does not define a communications security roadmap, there are some GEs referring to this, so they could also be used in the dedicated FI-WARE instance.
– FI-WARE application: a Future Internet application will mainly consume the web services exposed by a FI-WARE instance to provide different functionalities to the final user. These applications will be developed by external companies (SMEs), but they should use both the ecosystem communication rules proposed by FI-WARE, i.e. using RESTful web services, JSON for data, etc., and the security rules proposed by FI-WARE.

3.2.2 Current service communication within each scenario

As it was mentioned in previous sections, each WP is expected to be used in a FI-WARE instantiation of the Core Platform providing its own domain specific enablers and interacting with the uploaded GEs of the test-bed. WPs 200, 300 and 400 have both identified the potential users of each area along the food chain and which type of applications a service provider is needed to provide.

The following sections explain the communication system used within the three different sub-use cases. The reader can find the full explanation of these sub-use cases in the deliverables provided by the Work Packages 200, 300 and 400, respectively.

3.2.2.1 Smart farming

The Smart Farming services ecosystem wraps up a FMIS (Farm Management Information System) in which multiple services/applications could be deployed or interact with it. Some of them that have been indentified and described within D200.1 and D200.2 documents are:

- E-agriculturist services: Software that can assist farmers in their daily tasks by providing them with suggestions for complex situations.
- Spraying services: This service can be used in order to enable farmers or tractor drivers to schedule their spraying tasks inside a farm.
- Meteorological services: The farmer needs to have access to meteorological data (current condition and forecasts).
- State's and policies services: These types of services would link efficiently the governmental authorities with the farmers.
- Other services: For more information, please refer to D200.1 and D200.2 documents.

FMIS Architecture

Figure 3-3 depicts the general view of the FMIS "layered" architecture. In this document, we will provide a summarized description of the FMIS architecture only, which focuses mainly on the communication channels within. The complete description of this architecture can be found in the deliverables of the WP200. The modules involved in the communications are:

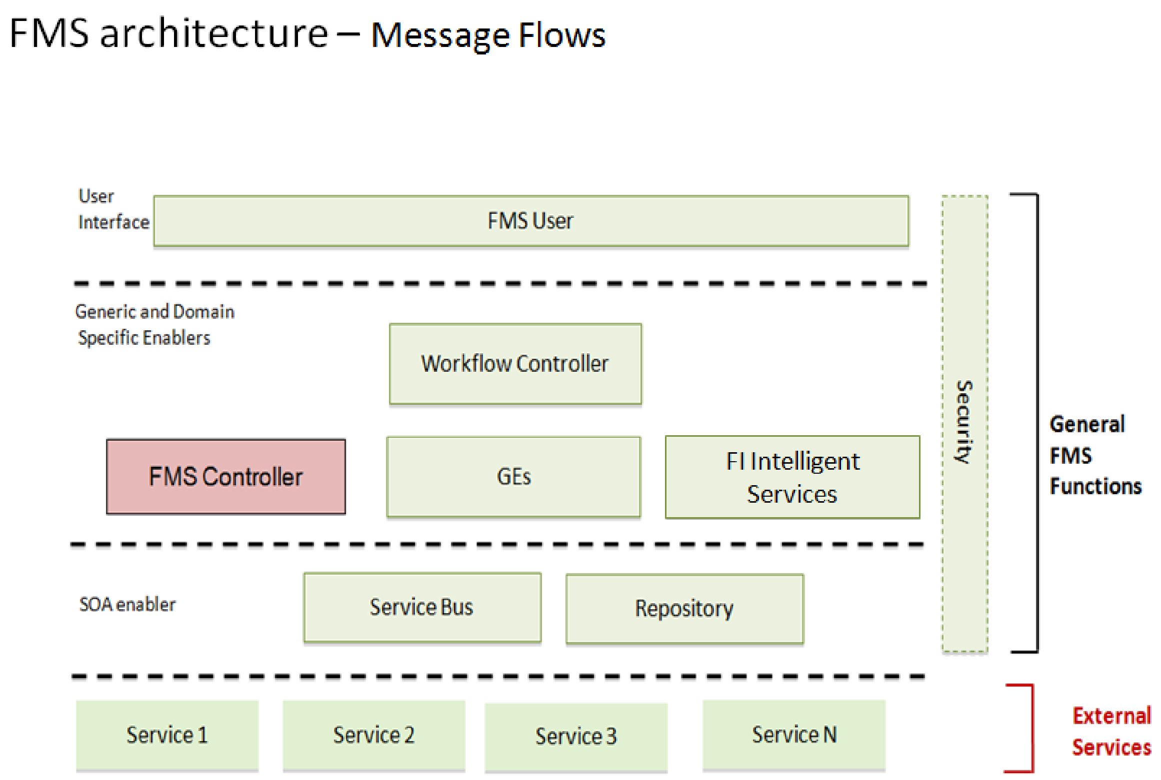

Figure 3-3: FMIS Architecture

- Workflow Controller
  It acts as a dispatcher for the Service Management and Application Layer. It will be used for listening to and forwarding incoming messages, which are formatted in XMLs and come from the end user's GUI.
- FMS Controller
  The FMS controller consists of a number of functional blocks that have been extracted from the 28 use cases described in the D200.1. They operate so as to satisfy the specific needs of the end users based on their interests and faculty, e.g., different data are kept for farmers or spaying contractors, etc. An internal module of it called *Notifier* is used in order to provide to end users notifications to different types of devices, such as mobile phones, iPads, PCs, etc.

Generic and Domain Specific Enablers Layer

The Generic and Domain Specific Enablers Layer comprises of modules whose implementation relies on FI-WARE project. A reader can notice that the modules that have been coloured with green[10] are the ones who act as GEs or interact with the GEs of the Core Platform, while the ones that are coloured with red act as Domain Specific Enablers (Figure 3-4).

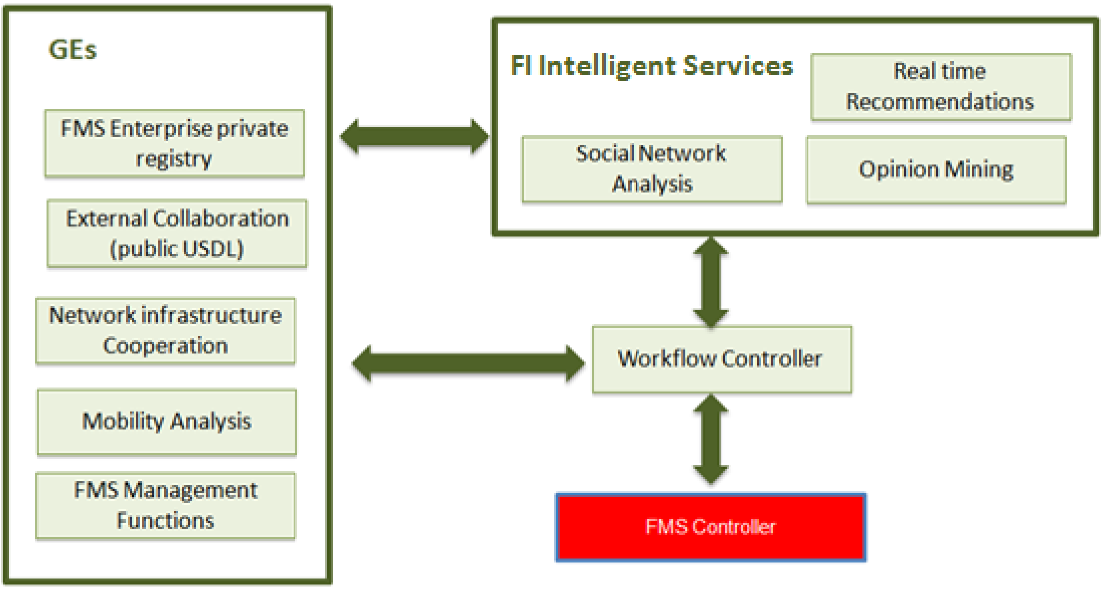

Figure 3-4: Generic and Domain Specific Enablers Layer

The Figure 3-5 shows the internal composition of the FMS controller; its functionality represents the Domain Specific Enablers of the Smart Farming Subsystem. Its main role is to process incoming data i.e., aggregate, classify, produce statistical analysis, etc, enable the communication with external services and notify the FMS User about significant events of his interest. The dis-

[10] All the other sub-modules that will not be released by FI-WARE, have been grouped in module called FI Intelligent Services. Its name was derived by the fact that within Product Vision these generic principles were classified as GEs for Implementing Intelligent Services. Since FI-WARE had not given us any information about the development of these GEs – whether they will be implemented or not – we have grouped them in a new module call FI Intelligent Services with the belief that its internal modules are necessary for developing high quality of services.

patcher of FMS Controller is the one which is coloured with red and it is called Configuration and Communication Module.

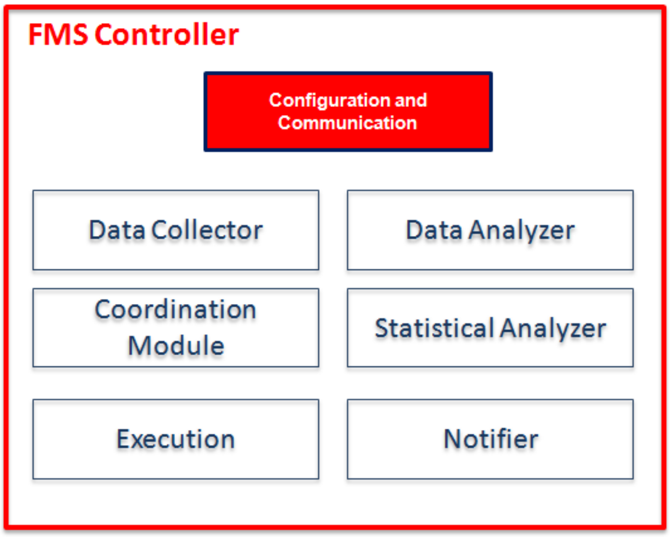

Figure 3-5: FMS Controller

The Configuration and Communication Module can act as the edge between the cloud and the local system as well as the point between the core FMS with the end user. It contains three sub-modules. The *Message Dispatcher sub-module* identifies and forwards the received messages to the appropriate module of the FMS Controller. This module sets the communication channels to collect raw data from the sensors and the farming equipment/machinery and also to communicate with services provided from other parties. The *Configurator* that is responsible for configuring all other modules of the system and the *Authentication and Authorization* that ensures that the involved stakeholders will have access to specific set of data.

A reader can easily understand that the functional blocks that have been envisaged for the FMIS architecture are aimed at cooperating harmoniously with all the external services. Within this document, generic SAF services that are needed along the food chain have been grasped and will be presented in the following chapters i.e. Certification Services, Product Information Service, Business Relation Service and Identification Service. An FMIS instance is capable of interacting with all of them since its implementation is based on the generic principles of FI.

Cloud Proxy and farming services

Except for the FMIS that is located in the cloud, the *local system* that a farmer uses for enabling his daily tasks, also known as Cloud proxy, plays a double role. First of all, it is attached to the local devices e.g. sensors, actuators, etc., and secondly it undertakes the overall control of the monitored farms when internet connection speed is unstable or down.

Apparently, when there is problem with the internet connectivity, the end user would not be able to interact with the cloud FMS and subsequently with any service that runs to the cloud. For this reason, basic functionalities that a farmer may need, e.g. fault identification of sensors, provision of simple advice, etc., will be provided with the assistance of the Coordination Module in the Cloud Proxy.

3.2.2.2 Smart logistics

As food chain logistic systems are distributed by nature, SOA-based technologies and the corresponding ESB solutions will be utilized for establishing communication among these services. In this subsection, we focus on the communication aspects specific within this domain.

It focuses on showing benefits of a centralized decision support system, in which process data and monitoring data are collected along the entire supply chain. The main outcome is a PF chain which has pro-active supply management based on constant monitoring instead of contemporary, passively demand-driven systems.

The entry point for matching demand and supply is the initial quality data base (special end-user interface will be developed for enabling the end-users entering the required large amount of data in a fast manner), containing the initial data about the plants at the grower's premises. Essentially, these data, along with the logistics events data, is being updated throughout the transport and storage of the plants in a communication with each stakeholder in the chain (either in real-time or coupled with specified logistics events).

Both event and initial quality DBs are stored in the cloud and used as an input for an expert system making plant quality and lifetime predictions, as well as the related business decisions (when and where to sell, order, etc.)

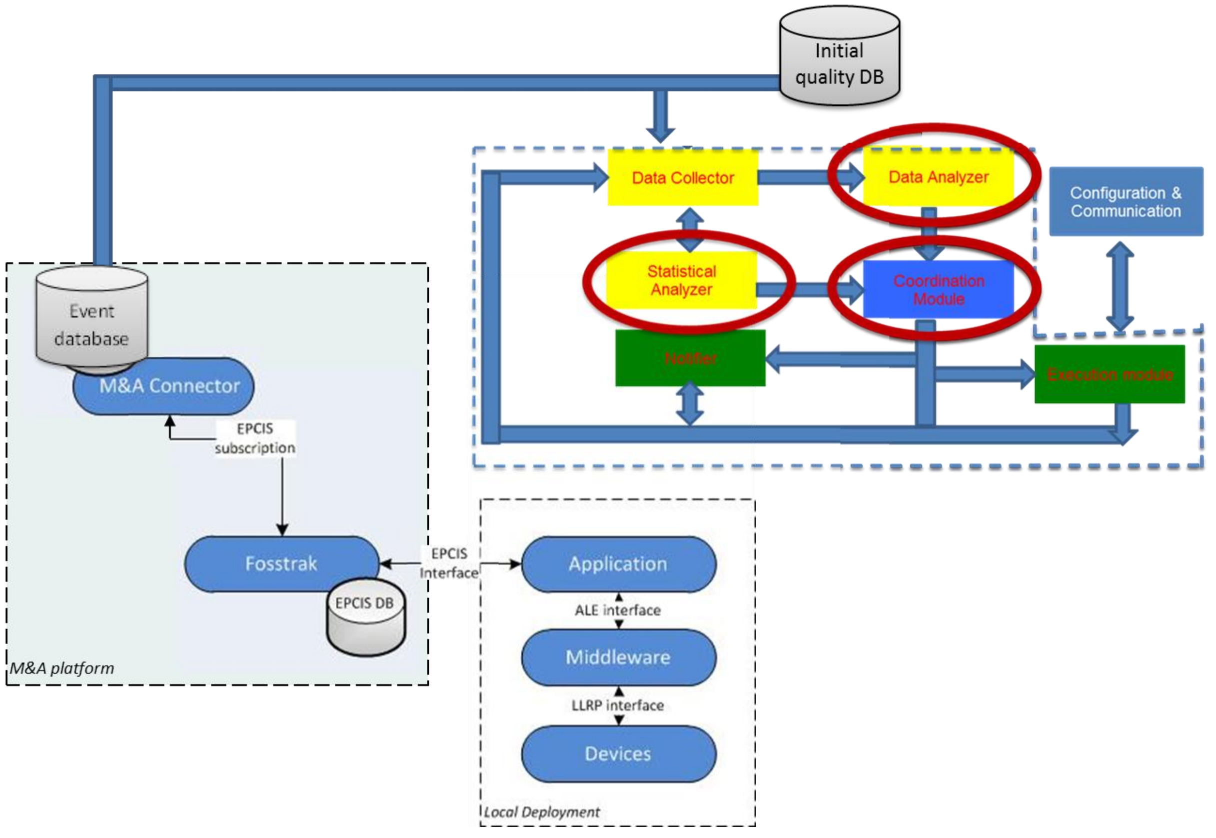

Figure 3-6: Communication between the M&A platform, the Initial Quality DB and the expert system in the PF pilot.

The expert system service being considered here is of a similar structure as the FMS Controller designed in the context of WP200 - Smart Farming [7], using, however, a different set of rules. Further work will include also the integration of the FI-WARE CEP engine where necessary.

In order to link the expert system and the M&A platform[11], an interface will be established between the M&A Connector and the Data Collector (cf. Figure 3-6). Additionally, an interface between the Initial Quality DB and the Data Collector has to be put into place.

11 Mieloo and Alexander (M&A) is and external partner supporting the work of the PF pilot.

Finally, a user interface will be built that can handle requests for updates of individual cultivars and that is able to present them to the end-user. Other specific services are modelled in Archimate in the context of WP300 [6].

The specific aspect of the FFV pilot is related to decentralised communication. The envisaged network is aligned with GS1 Standards (cf. [6]), and the stakeholders collect the information in local information systems (e.g., ERP systems). The infrastructure for information exchange is developed in accordance with the Electronic Product Code Information Services (EPCIS) standards as well as the standards for federated Object Naming Services (ONS) (cf. Figure 3-7) and, for more details, [6].

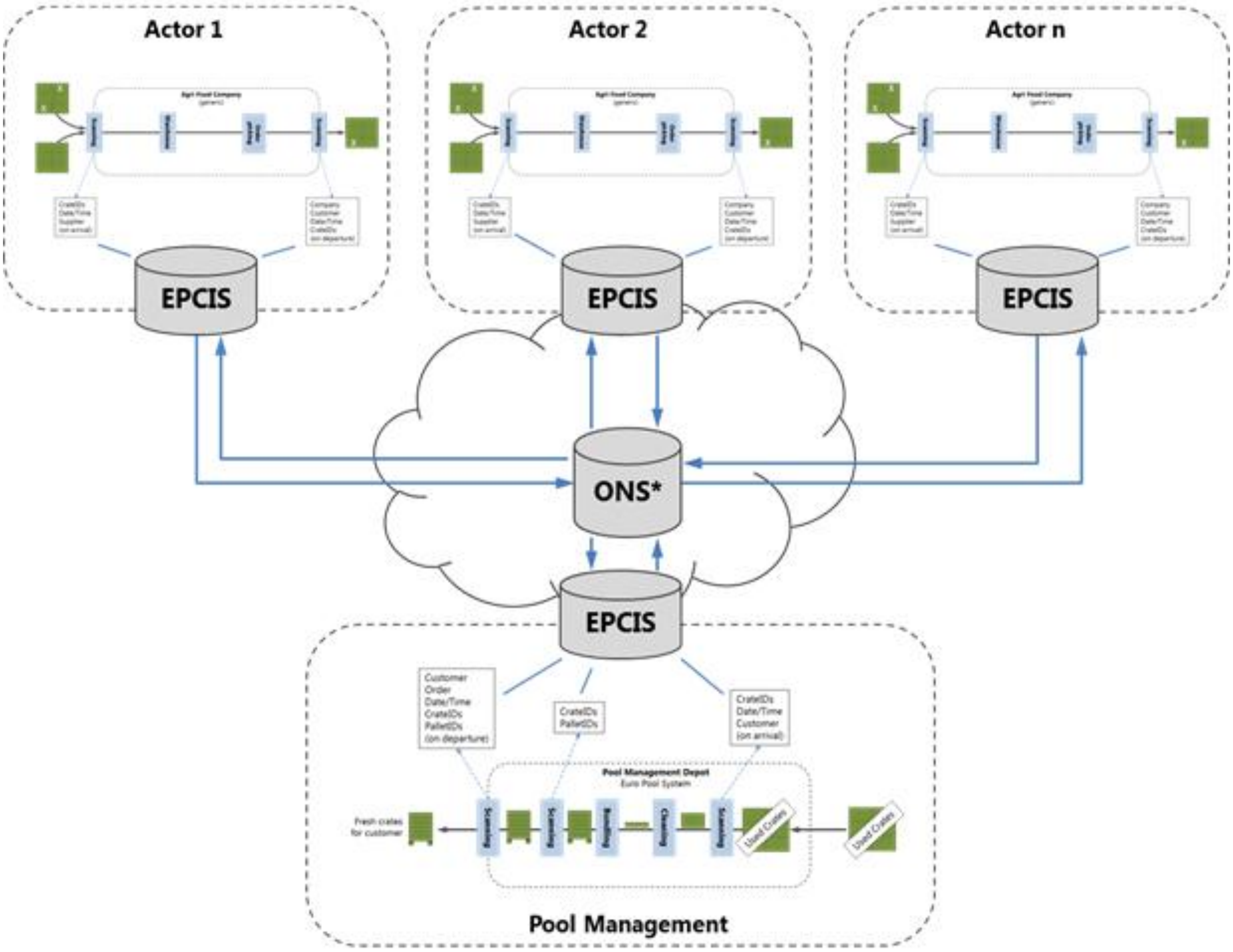

Figure 3-7: EPCIS based decentralised communication infrastructure as baseline.

The communication network in this case assumes loosely coupled business servers, as shown in Figure 3-8. In this figure the total number of business servers builds a decentralised cloud of product information. The central services in this network, unlike in the PF case, will be less pronounced following the stakeholders' requirements in the FFV chain.

A brief explanation of the behaviour of this cloud would be first, linking physical objects to internal data at the different stages of the supply chain, and then making information available using the SAF business server (local server) by different communication services (PInfS, Exception Reporting etc.) Further information can be found in the D300.2, FFV Pilot section.

The key technology for establishing this decentralized communication is P2P networking which is elaborated in Section 5.3.1.

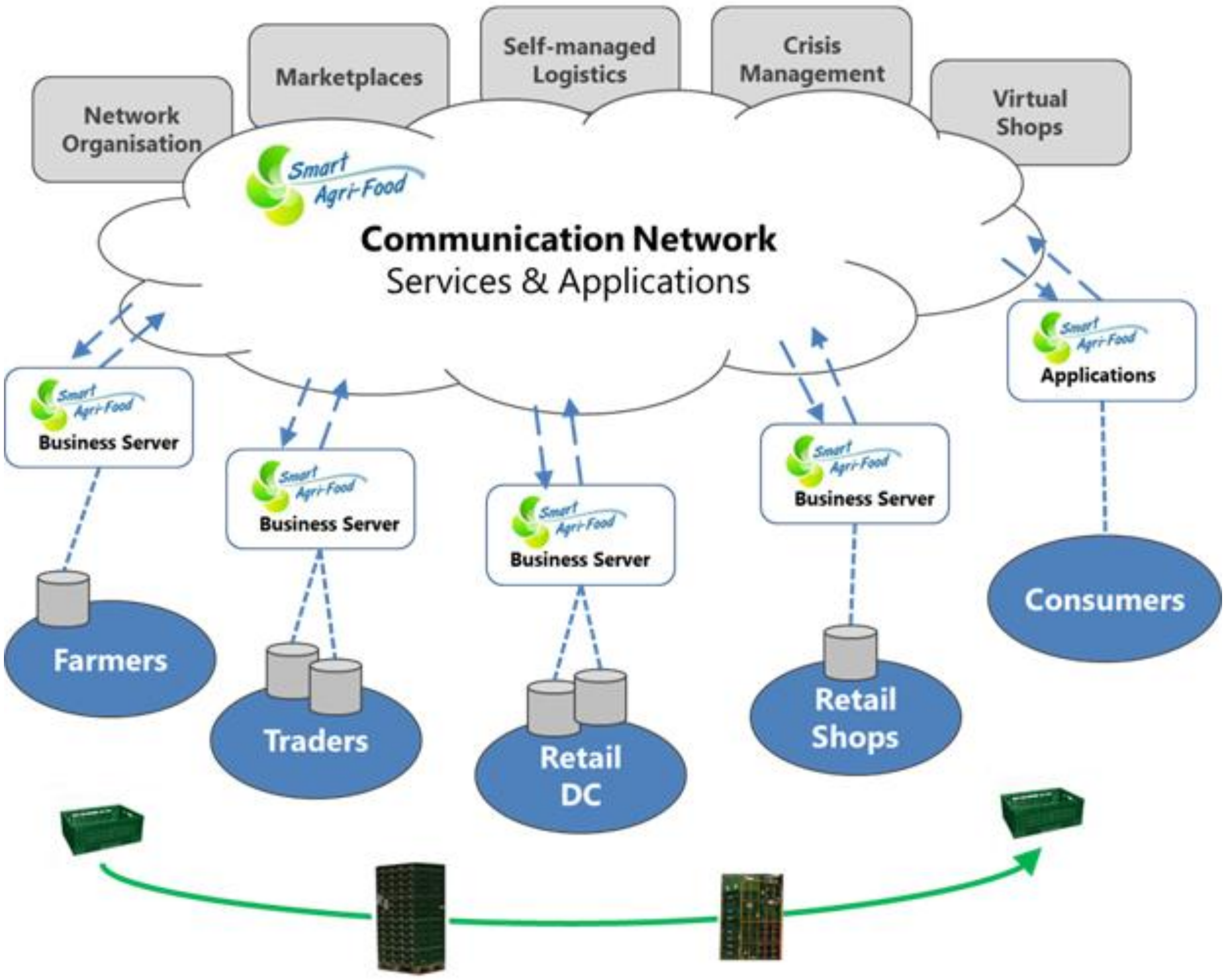

Figure 3-8: Smart-Agri Logistics communication network.

3.2.2.3 Smart food awareness

The main functionality of the TIC (Tailored Information for Consumer) pilot provides to the customer product information (logistic and other aspects) according to his preferences. The customer will experiment a new way of shopping just taking his smartphone with him. This is the last link of the supply chain. The smart agri-food awareness is the aim of the Tailored Information System.

According to the Figure 3-9 the Tailored Information System (TIS) interacts with the user smartphone to provide the tailored information to the costumer. The services ecosystem is developed over SOA architecture using Restful services (REST) due to their simplicity and lightness. To analyze the correct structure of the messages, there will be an ESB (Enterprise Service Bus) to guarantee their integrity, their authority and their authenticity.

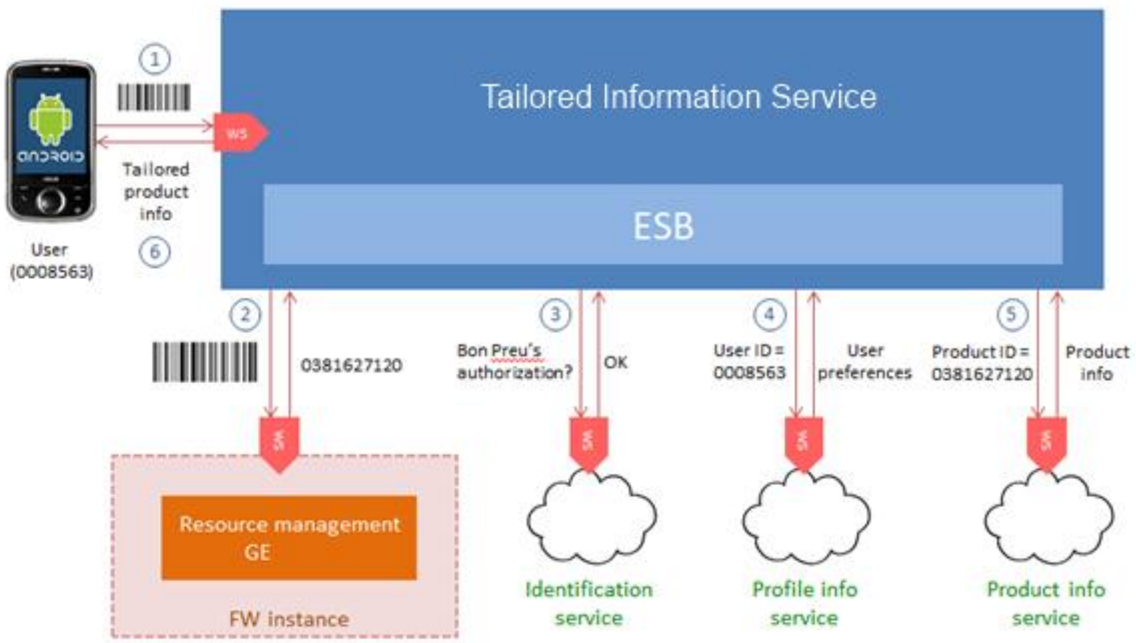

Figure 3-9: Organization of TIS architecture

3.2.2.3.1 Tailored Information System (TIS)

The TIS is the principal component of the TIC application. The Figure 3-10 briefly shows the architecture of the system, components and relations between them.

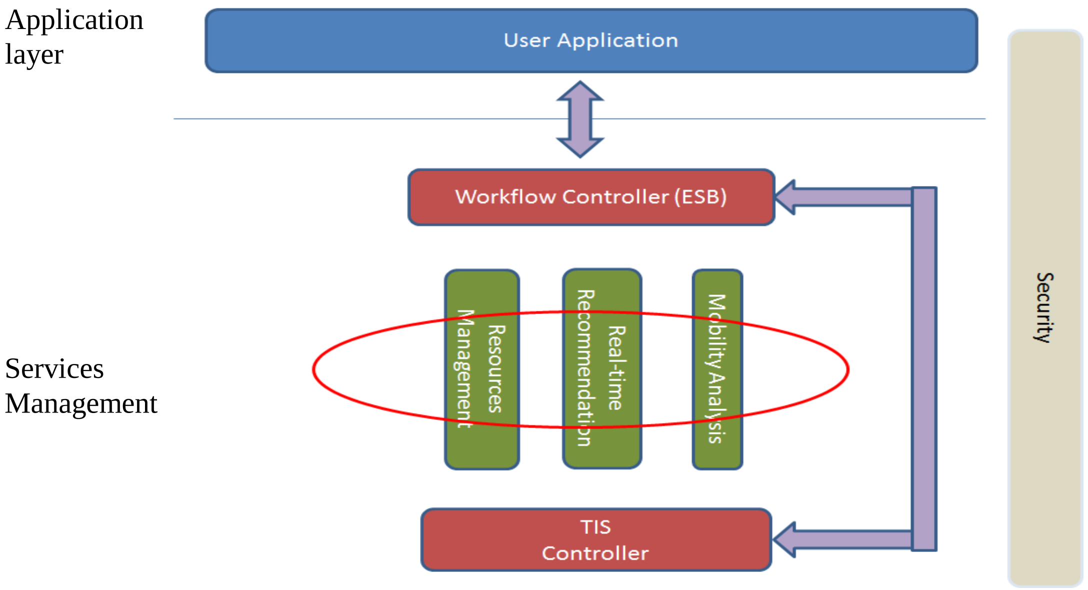

Figure 3-10: TIS architecture

This architecture is based on a layered architecture. The first layer is the Application Layer which is represented by the User Application. This layer is related to the Services Management Layer, which contains the rest of the modules necessary to control all the different functionalities of the application. Next step is to describe in a simple way, each of the modules of the architecture related to the communication ecosystem.

- User Application: several RESTful services are exposed to making possible consuming the functionalities of the TIS. Mainly the TIC app will make use of them.
- Workflow Controller: It acts as a dispatcher for the Services Management Layer. It will be used for listening to incoming XML messages that will be formatted, validated and forwarded.

3.2.3 Interactions in the end-to-end scenario

As previously mentioned in this document, the end-to-end scenario covers three different sectors of the supply chain, from the smart farming to the smart food awareness; i.e. from the farmer who grows a tomato to the final customer who buys it in the supermarket on his city, using different carriers to transport it.

But not only has the physical tomato to arrive to the supermarket. All the information associated to it (grower, cultivation dates, temperature within the trunks, etc.) has to be accessible to the stakeholders and customers involved in the final part of the supply chain.

This complex and long scenario has the necessity of a strong communications ecosystem between the stakeholders for a proper behaviour. Therefore, it is necessary for the several entities which provide different services, like certification services or data sharing services, to collaborate with each other. The next section 3.3 explains in more detail four of these services.

Figure 3-11 shows a first vision of the collaboration system to connect the two areas at the beginning and at the end supply chain, and to establish communication between their systems to allow for a data exchange between them. For example, a farmer can use a functionality of the FMIS to add the characteristics of a tomato, based on a Domain Specific Enabler, and the ESB of the FMIS can access one service to set that information. Days later, a customer in a supermarket uses a phone application, which interacts with the TIS, to get some information of the tomato. The ESB of the TIS gets the information from the same service used before by the FMIS.

Of course this is a simplified vision of the full product data exchange along the supply chain. Figure 3-12 shows the full vision of the product data exchange within the chain, including the stakeholders involved in the physical transportation of the products. This logistic product information must be also accessible to both the consumer in the supermarket and the stakeholders.

The complexity of this ecosystem communication is so that it will be deeply explained in the deliverable 500.4, fully dedicated to this issue.

3.2.4 Generic Enablers involved

The list of the Generic Enablers used in smart farming, smart logistics and smart food awareness is fully explained in the D200.2, D300.2 and 400.2 respectively.

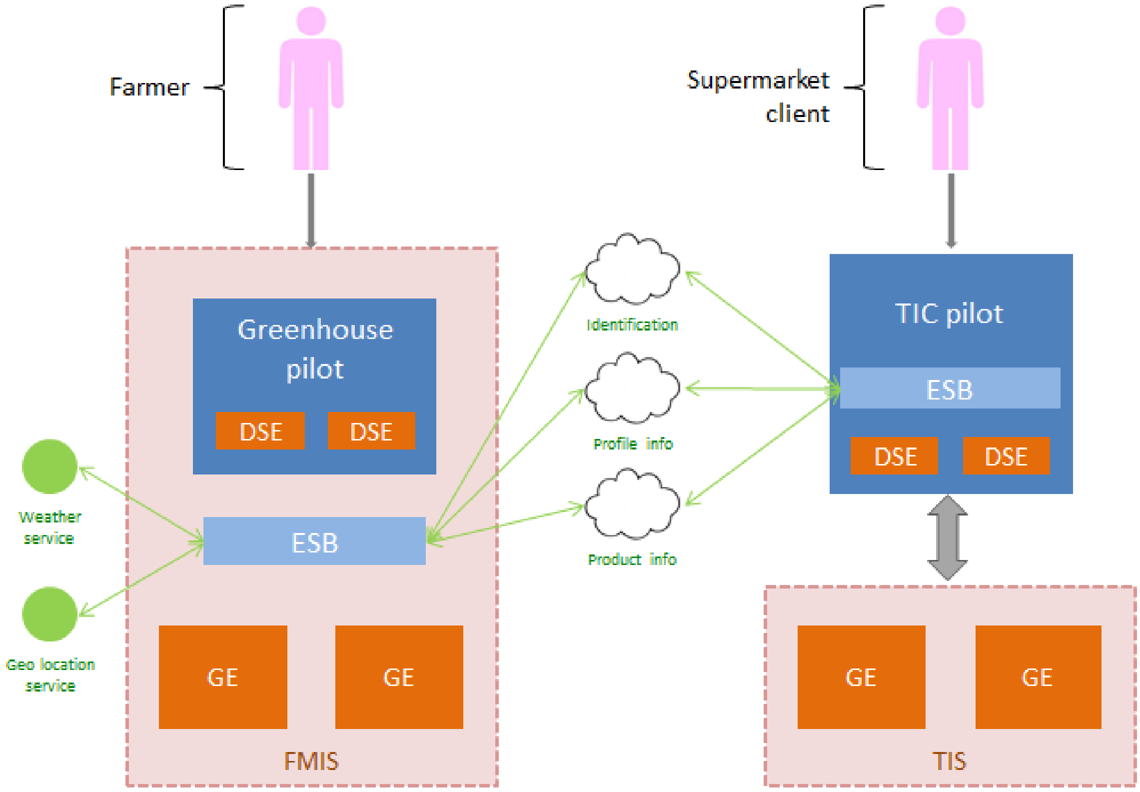

Figure 3-11: Simplified vision of the communication and data sharing along the supply chain

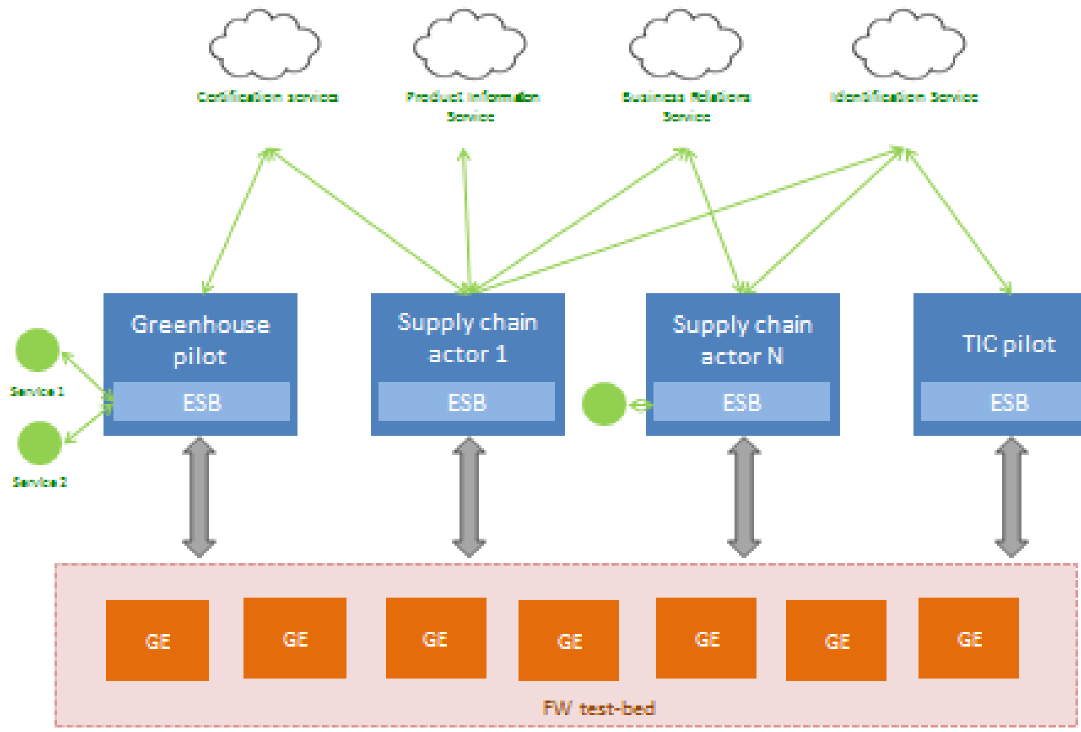

Figure 3-12: Full vision of the communication and data sharing along the supply chain

3.3 Generic SAF Services Provider

3.3.1 Certification Services

As the product information collected (product characteristics and labels/logo used), used and transmitted in the information systems all along the supply chain is the basis of the pilots, it has to be ensured that this information is reliable and can be trusted. In fact, that information is what will be communicated at the end to the consumers/end-users and one of the aspects to improve for the future internet is the trustworthiness of the supply chain information management for all the stakeholders, including end-users.

That is why at the very first stage of the pilots, when the information is collected, there is a need for some kinds of specifications/procedures, documents, records and responsibilities/training to ensure that the information is really reliable.

The control infrastructure is based on two pillars (see Figure 3-13):

- A certification validation service (CVS) that ensure the reliability of the certificates and its pertinence in relation to the product information reliability, and a logo validation service (LVS) that ensure a correct and reliable use of the logos.
- Specific elements (evidences like laboratory analysis, source of the information, product specifications, logo/label requirements...) that support trust in a specific information item and enable reproducibility and trustworthiness of the information that has been provided.

The final goal of this infrastructure is to provide a level of reliability for product information that will be transmitted to the end-user/consumer.

Reliability of information on the characteristics of a product

In order to proof the reliability of the information on product characteristics which are provided, some additional elements (information and documents) have to be provided:

- Type of information / product specification
- Responsible Person / Sender of the Message
- Last update of this information
- Sources for reproducibility and trustworthiness:
- Existing Laboratory results that proof the provided information are available
- Available existing documentation on the information collection and the methods used
- Any other evidences

The availability of these elements has a positive impact on the Reliability Level. The best situation (Level 3) would mean that a company can reproduce the information and has different elements that ensure the reliability and trustworthiness.

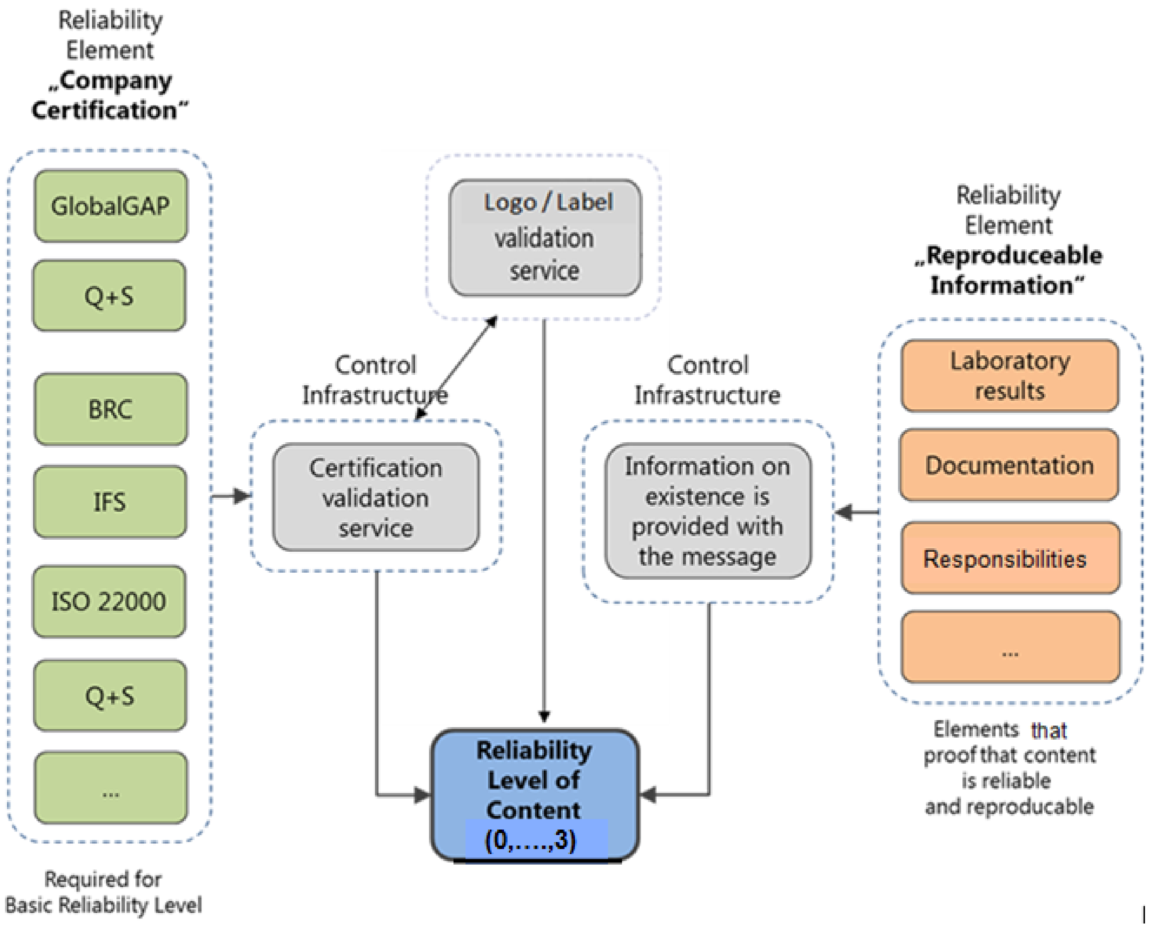

Figure 3-13: Control infrastructure for reliability of content

3.3.1.1 Certification Validation Service (CVS)

The idea of a certification validation service (see Figure 3-14) is to check if an Agri-Food company is owner of a valid certification, which might be required by business partners. On the other hand the certification process includes different steps, such as e.g. evaluation of the documentation that is required to fulfil a specific quality management scheme as well as the infrastructure that is in place to collect information for this documentation (EPCIS for GLN of the products under certification). In order to ensure this aspect, only the standards and certificates belonging to accredited standards and schemes will be considered. This would be the basic requirement to provide trustworthy product quality information and is therefore a critical element in elaborating the reliability level.

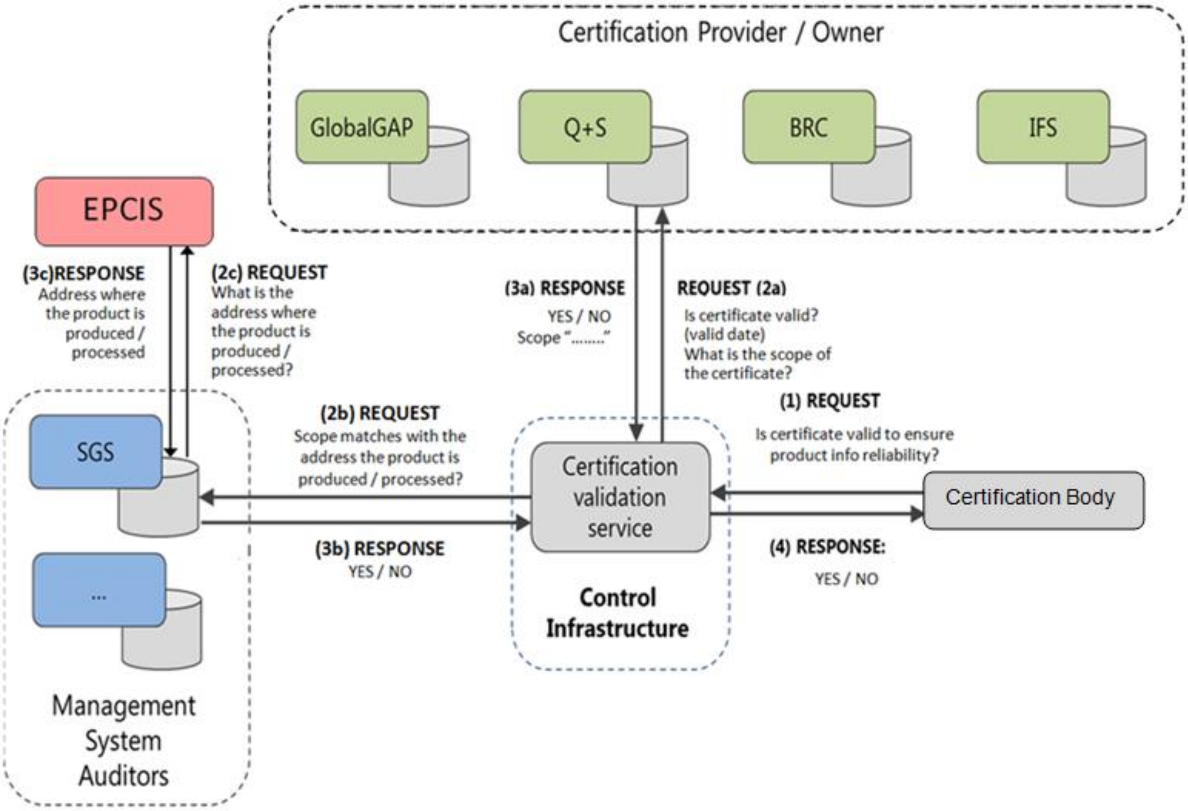

Figure 3-14: Certification validation service for end-users

The role of the certification body is not only to check the validity of the certificate but also checking if the scope of the certificate matches with the place/address where the product was processed in order to see if the certificate concerns the product which information is provided. And it is very important and necessary to know that the certificate can ensure a certain level of reliability of this information.

In this document the information is said to be 'trusted' if it can be proved its provenance is demonstrable scientifically.

For instance, in case of a product attribute like 'size' the information is said to be 'trusted' if there are checks made with calibrated measurement devices that prove the results are correct . In case of an analysis result e.g. carbohydrates content, the information is said to be 'trusted' if it comes directly from a laboratory that has performed such analyses.

In the other hand, the level of the "reliability" of the information given of a product will depend on its level of confidence, that would be directly related with the subject or entity that has made the analysis that endorses it. For instance, for a given information of a product, it is not the same if the analyses or checks have been made by an internal laboratory of the company, that if these analyses have been made by an external laboratory, that if they have been made by an accredited laboratory (what is called, in the quality certification world, an independent accredited third party).

Therefore, information could be trusted if it is according to real data but cannot be reliable, because the entity that is providing this information is not a recognized firm. For example, the quantity of sugars present in a product could be reliable if there are supporting analysis made proving this, but could not be trusted by the market if the analyses have not been carried out by an accredited laboratory or if the sampling taken of the product to make the analyses have not been made by an external independent party.

In this document what we propose is a control made by an external Certification Body to ensure that the consumer will get transparent information about the product, based on the information is trustful and as well on its level of reliability.

According to this, four levels of reliability of product information have been distinguished. These levels are defined below. The four different levels of reliability have been proposed according to the experience in certification audits issues performed to Food companies. The information about the level of reliability normally does not reach the final consumers, and however it could be in most cases a decision criteria in their purchases when they have to choose between different products with the same apparent quality level or even between cheaper (but less reliable) than more expensive (but more reliable) products.

In addition three levels of reliability of logo information are distinguished.

The proposed system will be fed from the information that each issuer will hang on the cloud (laboratory, certification body, producer company), with the required fields and frequencies.

Reliability level of product quality information

In order to prove the reliability of the information on product characteristics which are supplied, some additional elements (information and documents) have to be available:

- Type of information / product specification
- Responsible Person / Sender of the Message
- Last update of this information
- Sources for reproducibility and trustworthiness, such as:
  - Existing Laboratory results that prove the provided information are available
  - Available existing documentation on the information collection and the methods used

The availability of these elements has a positive impact on the Reliability Level. The best situation (Level 3) would mean that a company can reproduce the information and has all the necessary elements to ensure trustworthiness and an adequate reliability level. We propose to use different levels of reliability from 3 to 0, depending on the reliability of the information given.

Level 3

The maximum reliability level 3 is granted when the provider of the information can supply all the following information to support it:

- The updated product specifications (product characteristics) signed by a formal designed approver of the Company.
- A Global Food Safety Initiative accredited certificate whose scope includes the product and the place included of the certificate matches with the one where the product is manufactured.
- External Accredited Laboratory results that prove the information given is trustful made with a yearly frequency. The sampling of the product to carry out the analyses must have been done by the external laboratory.
- Internal Laboratory control plan whose scope includes the product and with an adequate frequency in order to ensure there are settled quality checks in order to ensure the product is liberated once its quality has been checked.

- Management procedures whose scope includes the product and with an adequate frequency in order to ensure the manufacturing of the product is made under control.

Level 2

The reliability level 2 is when the provider of the information does not provide with the same information than in level 3

- The updated product specifications (product characteristics) signed by a formal designed approver of the Company.
- External and internal Laboratory control plan whose scope includes the product and with an adequate frequency in order to ensure there are settled quality checks in order to ensure the product is liberated once its quality has been checked.
- Management procedures whose scope includes the product and with an adequate frequency in order to ensure the manufacturing of the product is made under control.

Level 1

The reliability level 1 is when the provider of the information can only supply with:

- The updated product specifications (product characteristics) signed by a formal designed approver of the Company.
- External/internal Laboratory control plan whose scope includes the product and with an adequate frequency in order to ensure there are settled quality checks in order to ensure the product is liberated once its quality has been checked.

Level 0

In any other case, the reliability level is 0 and means it is not possible to obtain evidences about the reliability of the information. This information will not be used or will be used with the additional information of "reliability level 0".

3.3.1.2 Logo Validation Service (LVS)

The idea of a logo validation service (see Figure 3-15) is to check if a company is authorized to use a logo, based on reliability criteria. This process includes different steps, such as e.g. evaluation of the compliance of the requirements that are needed to use a specific logo or label as well as the infrastructure that is in place to collect information (Logo Recognition Tool). This would be the basic requirement to allow a company to use a logo / label and is therefore a critical element in elaborating the reliability level.

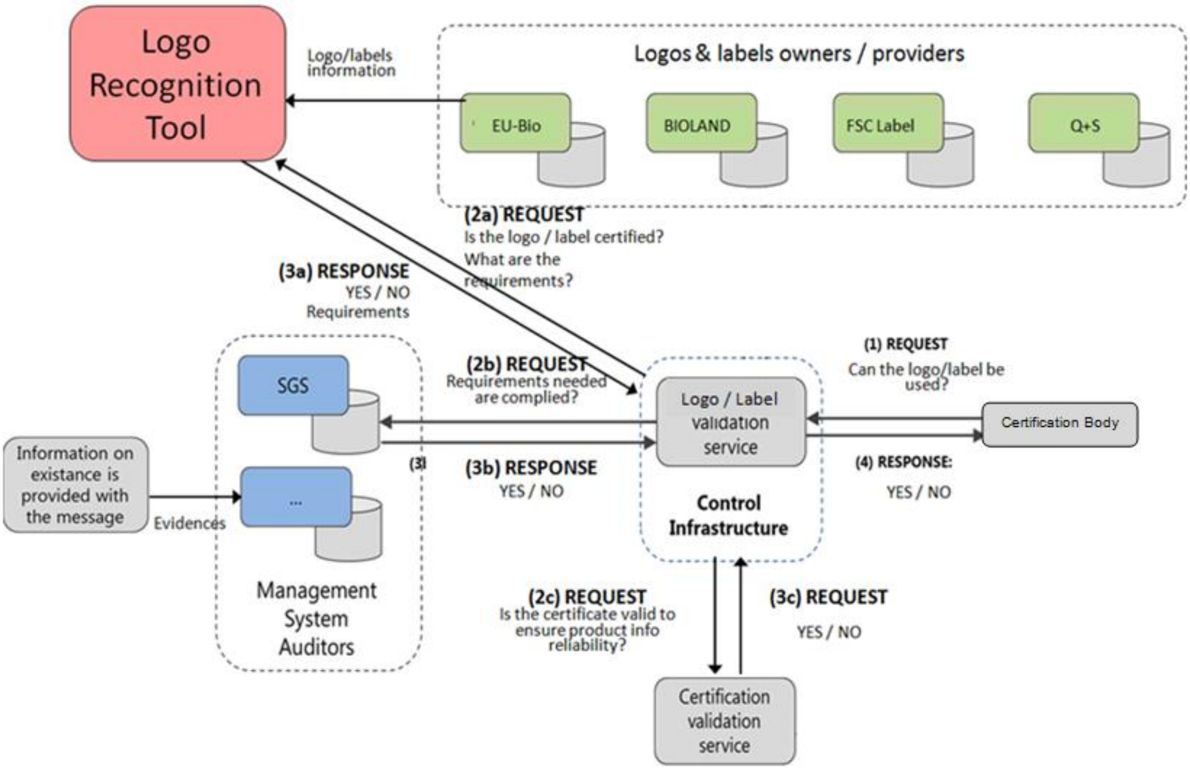

Figure 3-15: Logo validation service for end-users

The role of the certification body is to check the compliance of the requirements needed to use the logo (from Logo Recognition Tool ATB) and the validity of the logo certification (CVS) when applicable. And it is very important and necessary to know it to evaluate if the logo can ensure a certain level of reliability of information and can be used.

Reliability and use of the logos

The logos can be used when the provider of the logo / label can provide a certificate for this logo / label. If the logo / label is not certified, it also can be used when the provider of the logo / label can provide evidences on the compliance of the requirements needed for this logo / label.

In any other case, when it is not possible to obtain evidences about the reliability of the information of the logo / label, the logo / label have to be covered / hidden and will not appear in the product.

3.3.1.3 Relation to FI-WARE

Envisioned as an integrated part of the global SAF platform, the Certification Validation Service and the Logo Validation Service sit on the application level, its design and development based on the (already described) SAF's system components, architecture and infrastructure. Therefore, **their relation to the Core Platform is analogous to the one between SAF and the Core Platform**, in such a way that the low-level technical requirements and potentially usable GEs are the same for both "systems", as one (CSV, LVS) is part of the other (SAF) and both share the same architecture.

Finally, the reliability level established is used as a new extension in the EPCIS to be transmitted to the end-user/consumer (see Figure 3-16).

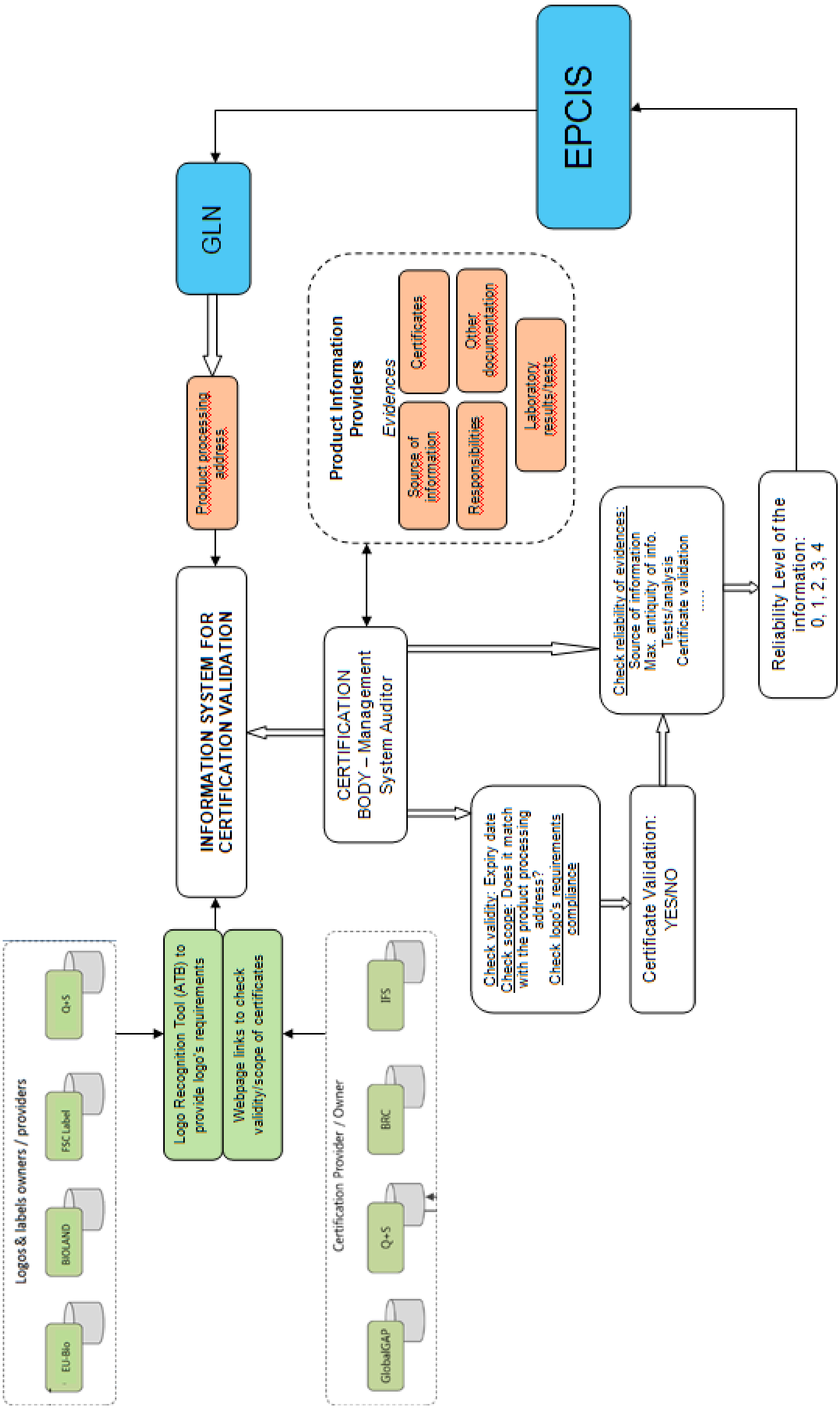

Figure 3-16: Information system for certification validation

3.3.2 Product Information Service

3.3.2.1 Product Information Service key objectives and purpose

The Product Information Service (PInfS, see Figure 3-17) shall present a generic service that would be developed, implemented and provided by ICT services providers. In SmartAgriFood, the ***main focus of such a PInfS*** is to:

- Enable a produce/ product related information exchange to facilitate the
  - control in complex supply networks and
  - drastically reduce reaction times with respect to quality issues,
- Disburden the single business actor from setting-up a
  - communication infrastructure related solution that fits a specific supply network,
  - basic technical environment that provides the generic functionalities,

Allow a participation of food chain actors with diverse ICT maturity levels,

- Enable a smooth food chain penetration allowing a successive solution realisation, while not all actors need to use the service from the very beginning,
- Bridge communication gaps in cases when single actors do neither use the PInfS, nor provide information electronically,
- Be compatible to diverse identification schemes as handled by the identification service,
- Guarantee the secure information exchange from a technical as well as business perspective, while the latter shall allow the usage of multiple layers and event driven access rights,
- Assure the scalability and adaptability of the PInfS,
- Allow to add, delete, replace or extent information objects (i.e. content) that shall be exchanged within the food chain/ network.

This main focus of the PInfS was elaborated based on the identified end-user requirements[12] (i.e. functional & non-functional), while the architectural specification needs to serve the different target audiences/ potential users that might come into play. The ***main user groups of the PInfS*** could be identified as follows:

- ***Farmers*** as initial sources of produce related information also providing the connection to their suppliers (e.g. supplier of fertilizer, seeds and pesticides).
- ***Traders/ groups of farmers*** that are collecting the produce and are selling batches of it on the b2b market,
- ***Processors of food products***[13] that are separating/combining batches or transforming the individual food object (e.g. cutting of meat),
- ***Transport providers*** that are acting as a kind of intermediary between the different actors in the network, handling the agri-food products as well as acquiring food related information especially with respect to the environmental conditions (e.g. temperature, humidity) and the location (i.e. geo-location & time).
- ***Logistics services providers*** that are offering unique identifiable packaging (e.g. crates of EPS, containers of CC).

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[12] The deliverables D200.2, D300.2, D400.2 are presenting the required generic enablers as well as the architectural requirements. Moreover, they are detailing the functional and non-functional requirements that need to be served for being able to realise a solution for the different sub-use cases.

[13] For the first phase of the FI-PPP programme, food manufacturers are not taken into account to reduce the complexity level with respect to batch traceability that need to be accomplished inside an organisation.

- ***Quality information service providers*** like laboratories that are analysing the agri-food products and are providing related information.
- ***Distribution centres*** generally owned by retailers that are collecting the food chain supplies in regional centres to prepare distribution to stores.
- ***Supermarkets*** as final link in the chain to the consumer.

As explained before, diverse stakeholders need to be supported and a collection of functionalities needs to be provided by the PInfS. Furthermore, the ICT providers would need to realise/ support ***basic business models*** that could enable the envisaged service provision. The following Table 1 is structuring and detailing the envisaged PInfS characteristics.

Table 1: Main PInfS characteristics with respect to the SAF sub-use cases.

<table>
<tr><th>Scope</th><th>Smart Farming</th><th>Smart Agri-Food Logistics</th><th>Smart Awareness</th></tr>
<tr><td>Product[14]</td><td>Fruits, vegetables, livestock, flowers, plants</td><td>Fruits, vegetables, flowers, plants</td><td>All kinds of agri-food products as well as processed products in transport units of diverse size & functionality</td></tr>
<tr><td>Information</td><td>Origin, product characteristics, harvest date, guidance on handling, details on packaging</td><td>Forwarding of data provided by farming, event data, location, time, product monitoring data, aggregation & disaggregation data</td><td>Forwarding of data provided by farming & logistics, information about certificates. Also forwarding product feedback information from consumers.</td></tr>
<tr><td>Service</td><td>Generating an initial record and identification of the product to be forwarded</td><td>Connecting supply network actors, requesting & forwarding information, exception reporting, event processing based on decay models</td><td>Subscribing to data provision, requesting & forwarding information, exception related event processing</td></tr>
<tr><td rowspan="2">Business Models</td><td>ICT provider or farmer association are hosting a platform or offering (downloadable) functionalities to acquire produce related data and interface with FMIS. Supporting mobile device usage for data acquisition in the work processes.</td><td>ICT or logistics services provider are hosting a platform or offer a kind of 'business server' for local installation. Based on BRS[15], partners exchange data, as configured in rules/ cases by the data owner. Offering specific predefined services for monitoring, exception reporting, event data reporting, rescheduling, exception handling, order virtualisation, quality documentation, etc.</td><td>ICT provider or retailer are hosting a platform or offer a kind of 'business server' for local installation. Connecting to logistics network, to enable the request of data and reception of exceptions. Supporting the realisation of social networks to provide and gather information to/from consumers. Supporting consumers in defining their profile to enable tailored information provision.</td></tr>
<tr><td colspan="3">From an ICT provider perspective and towards phase 2, it is envisaged to enable the PInfS users directly to extent the functionalities by themselves[16], creating and providing services over the core PInfS functionalities. This specifically requires a software development kit, an execution environment and a service delivery framework for software developer type of users. At the same time, even inexperienced users could be enabled to further customise the offered solutions by enabling mash-up of the user interface and orchestration of the underlying services.</td></tr>
</table>

[14] Products that are specifically addressed in the phase 1 of SmartAgriFood, while all kinds of agri-food products and aggregated products in transport units of diverse size & functionality shall be supported on the long-term.

[15] Business Relations Service

[16] Supporting so called 'Prosumers'.

As detailed in Table 1, main functionality of the PInfS is to facilitate the acquisition and provision of information. Therefore, the ***main principles for handling and storage of data*** are summarised in the following:

- The initial owner of the information shall be enabled to decide on the cases and rules on how to share the information. This might result in different access rights with respect to different data items of a group of data as well as different access rights for different direct/ indirect business partners.
- Storage of information shall be generally realised in the virtual realm of the data owner, while this can be a distributed storage as well as the used functionality of a service provider.
- There might be different access rights to the same information that vary due to specific kinds of occurred events (e.g. food exception with respect to pesticides that enables a public access to specific quality analysis results in relation to the produce concerned).
- Enabling the handling of different types of information:
  - Static information that is always the same for a specific type of fruit/vegetable (e.g. risk of allergies) that can be treated as a kind of master data,
  - Static information that does not change for a specific produce (e.g. origin),
  - Event related information that is generated due to the produce flow in the chain (e.g. last supplier, next customer),
  - Dynamic information that represents something in relation to the produce at a specific point of time in its life-cycle (e.g. envisaged shelf-life, temperature, location).

The following sections will further detail the envisaged functionalities of the PInfS as well as basic technical foundations. The envisaged structure and the different main elements will be detailed that need to be developed for realising the conceptual prototype. Finally, key enabling functionalities[17] are considered as major prerequisite for being able to realise the PInfS and are further detailed.

3.3.2.2 Main functional blocks of the PInfS

The sub-use cases in the WPs 200, 300 & 400 analysed the required functionalities and already identified key functions of the core platform that could be employed for the conceptual prototypes and in accordance to the specific pilots. However, this chapter shall summarise those results towards the identification of main functional blocks that could represent a generalised set of functionalities that will build the so-called Product Information Service.

The main idea of the PInfS is to use real world data and to provide a kind of process control for real world use cases that are represented in a virtual world. Therefore, the PInfS needs to forward the corresponding exceptions and requests to the appropriate recipients/objects in the virtual world. The corresponding infrastructure needs to be provided by the digital world that is represented by the local and/or cloud based ICT resources. The following Figure 3-17 is presenting these generic relations for realising a process control that shall serve as reference for structuring the discussion on

- Required functionalities to realise a PInfS,
- Most appropriate business models for commercially providing a PInfS and
- Available technological solution alternatives develop a PInfS.

[17] These can be Generic Enablers or Domain Specific Enablers. This needs to be further discussed and elaborated with the FI-WARE project.

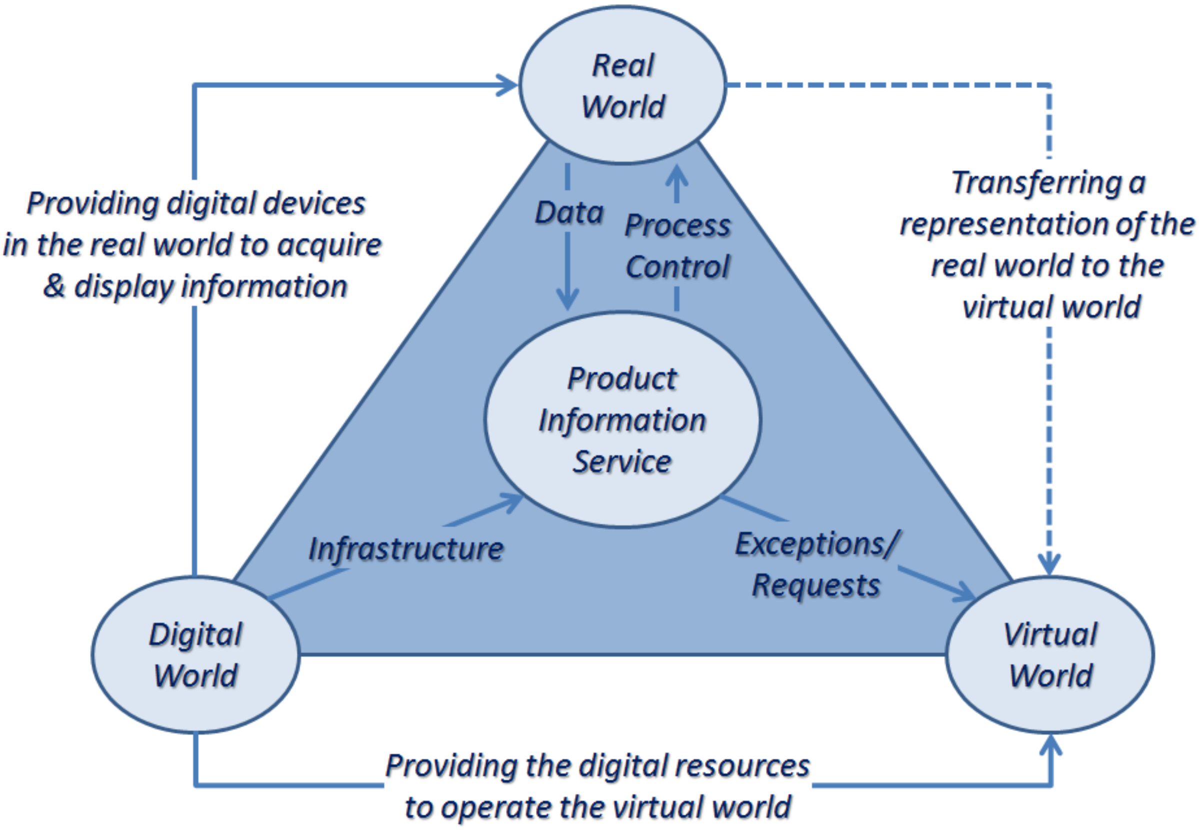

Figure 3-17: Generic relations of the PInfS for realising process control.

From a very generic view point, the main interest of an end-user in the real world could be possibly summarised as of being immediately informed as soon as he/she needs to make a decision with respect to the business process execution (e.g. re-planning of deliveries based on decay information) or needs to change previous decisions (e.g. stop forwarding of a produce in cases of a critical exception that does not correspond to quality requirements). Therefore, the very basic purpose of the PInfS is to generate control at whatever stage in the supply chain, due to the availability of data that was acquired at one or several stages of the supply chain.

Based on the main PInfS characteristics identified within the SAF sub-use cases (see Table 1), the main functional blocks were elaborated that shall group the required functionality. Main elements are the data acquisition and the process control, while the process control is further split with respect to the request of data by customers and the exception reporting to forward details about unexpected situations through the food chain. The main processing of data requests and reported exceptions shall be represented by a functional block as well as the forwarding of requests and additionally the exception forwarding. The following Figure 3-18 is presenting those main functional blocks in relation to another[18].

[18] The indicated "actors" that are providing or requesting information shall represent a source or recipient of information. This can be an individual end user as well as a corresponding ICT system that provides access to data or automatically processes an input for further consideration in the business process. Hence this model is not limited to a manual operation, but open to any automatic processing. The indicated figures can be replaced by e.g. data bases or legacy systems.

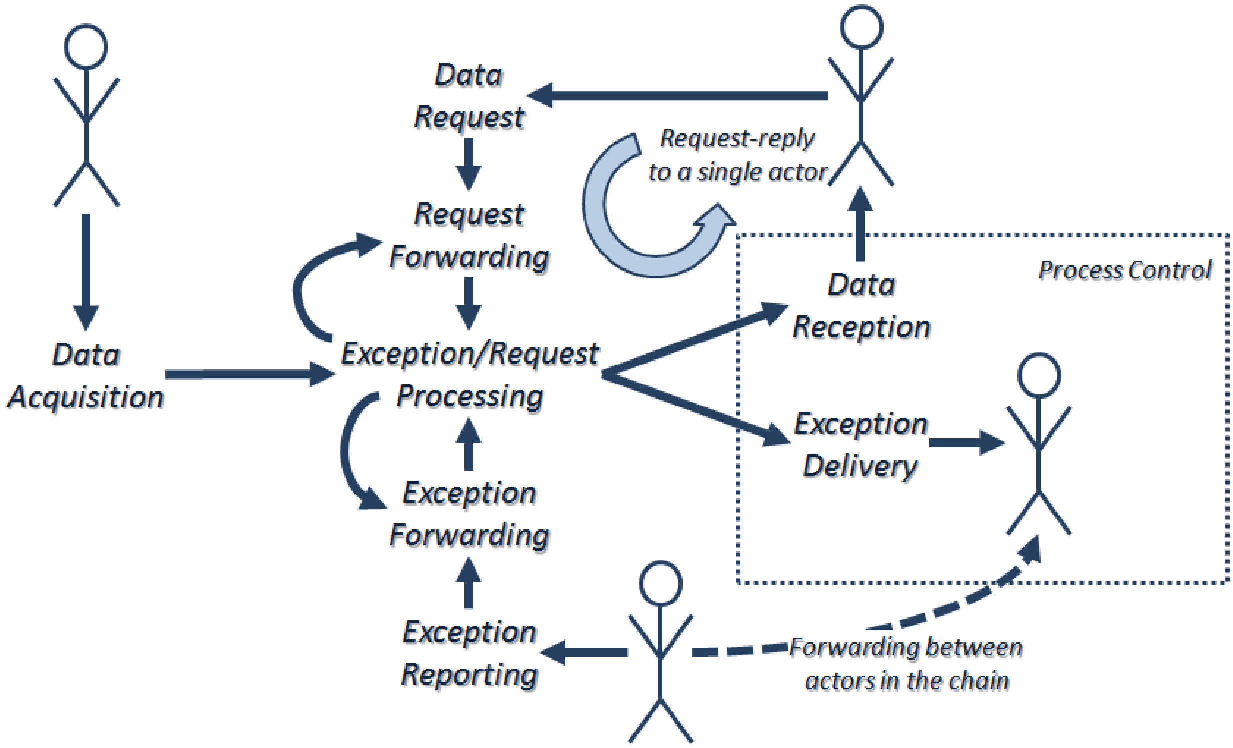

Figure 3-18: Main functional blocks of the PInfS.

Figure 3-18 is presenting a highly simplified model of the customer-supplier relationships. In the simplest case, the forwarding of requests and of exceptions can be realised in a direct supplier customer relationship. Nevertheless, it was specifically elaborated in WPs 300 & 400 that the PInfS needs also to support an exchange of product related information by spanning several supplier-customer relations (e.g. in cases when an end-user in a super market is asking for produce related information that is only available at the farmer or trader).

The key characteristics of the main functional blocks as presented in Figure 3-18 are listed in the following:

Data Acquisition

- Data needs to be acquired within the business processes to make it available to the PInfS for exception and request processing.
- The usage of specific ID schemes is very common in the agri-food domain to enable the mapping of digital information in the ICT system and physical objects in the real world.
- As soon as an ID is mapped with a physical object (i.e. single object or batch), it will be marked accordingly. Most common is the usage of barcodes in the agri-food chain, combined with additional human readable information. Also RFID technology is applied, while the costs for RFID tags are limiting their usage. Further details are also addressed with respect to the Identification Service in section 3.3.4.
- Data can be acquired with an end-user intervention in the workflow (e.g. by GUIs in mobile/ fixed scanning devices, picture recognition), as well as without an end-user intervention (e.g. by autonomous barcode/ RFID scanners) and corresponding interfaces from existing ICT systems.
- The owner of the data can define the access rights for the acquired data as well as access rights for aggregated data. This takes into account the organisation internal access and the access by authenticated external parties.

Data Request

- Requesting data that is available in previous steps of the supply chain, but was not forwarded in combination with the order/contract preparation or with the physical delivery of the produce. This is often due to the amount of information or the availability of data at the moment when the physical produce is leaving the supplier, like laboratory results of samples that were taken during the produce handling at the supplier.
- The data request could be initiated on a regular or irregular basis by the customer.
- The data request could be initiated manually as well as automatically by defining specific rules or cases that will trigger an automatic request.
- Supporting the request of different types of information like static, event related and dynamic (see also section 3.3.2.1).

Data Reception

- A supply chain actor receives the requested information. The business entity is considered as such an actor. It could be a human actor as well as an ICT system that processes the received information or mixed realisations.
- The received data can be used as-is or aggregated as defined by the requesting user.
- The data can be received as a 'complete package' that is forwarded through the chain. However, due to bandwidth and storage constraints it is also considered to only forward a link with the corresponding access credentials to the final recipient.
- The data reception shall assure that the correct/ appropriate human actor or ICT system will receive the data, taking into account a context sensitive priority.

Exception Reporting

- Any actor in the chain (i.e. in its role as supplier or customer) can report an exception to its customers and/or its suppliers concerning a specific delivery.
- The reporting can be done manually or automatically by an ICT system.
- The exception is classified according its criticality to identify the required reaction time by the current, previous or expected produce owners.
- An exception could identify a problem that would limit/restrict the usage/ consumption of the produce (e.g. contamination with bacteria or pesticides), identify a delay or describing a non-expected quality as well as a recently unexpected development of the decay/quality ratio. As some exceptions affects the service level agreement established with the supplier or customer, the exception reporting block has access to the SLA management functionality in service ecosystem (see section 3.3.4.4).

Exception Delivery

- A supply chain actor receives the exception related information. The business entity is considered as such an actor. It could be a human actor as well as an ICT system that processes the received information or mixed realisations.
- The data reception shall assure that the correct/ appropriate human actor or ICT system will receive the data, taking into account a context sensitive priority.
- An explicit reaction in the business process will be proposed to avoid any subsequent problems.

Request Forwarding

- The customer is sending a data request to its supplier. This request will be forwarded by the supplier to its supplier(s) accordingly.

- The forwarded request includes the reply address of the request originator as well as the details to identify the produce. The request might but shall not target at receiving answers that are repetitively forwarding the requested content, but enabling the access to the data that is stored decentralised (see also about 'data reception' above).
- In cases of available unique produce related information from farm to retail (e.g. GRAI of crates for transporting fruits and vegetables) the request could also be forwarded if there are missing links in the chain by central ONS type or decentralised peer to peer based mechanisms.

Exception Forwarding

- A business entity is forwarding an exception to its customer(s) and/or its supplier.
- If required, the customers/suppliers are forwarding the exception to their customers/ suppliers.
- The forwarded exception includes the reply address of the exception originator as well as the details to identify the related produce.
- In cases of available unique produce related information from farm to retail (e.g. GRAI of crates for transporting fruits and vegetables) the request could also be forwarded if there are missing links in the chain by central ONS type or decentralised peer to peer based mechanisms.

Exception/Request Processing

- It has access to all data that was acquired within the business entity and receives all data requests and exceptions.
- The processing is analysing the data requests and exception for being able to decide whether an action is required at the business entity and/ or it need to be forwarded further on.
- Different simple as well as complex rules (a kind of reaction patterns) can be defined and (re-)used to handle the data request and the received exceptions in an organisation. This shall support both exceptions/requests that need to be handled by the organisation itself as well as the required actions to forward the corresponding exception/request to other organisations in the chain.
- Data requests are handled in accordance to defined access rights in relation to the request originator.
- Exceptions are internally forwarded in accordance to their criticality and the produce concerned.

As identified before, there is a need for a unique identification of (aggregated) objects. Additional key functionality will be provided by the identification and the business relations service (see also sections 3.3.3 and 3.3.4). Nevertheless, main differences for the realisation of the PInfS are influenced by the state of practice in the agri-food business processes. The following basic alternatives need to be taken into account (i.e. as also be considered and coordinated with the identification and business relations service):

- Every produce is uniquely identified from farm to fork.
- The packaging is uniquely identified that carries a certain amount of produce (e.g. returnable crates for fruits and vegetables or containers for flowers and plants).
- A batch of produce is uniquely identified that represents e.g. a pallet or all produce that is transported with one lorry.
- The business entity in the chain uses its specific identification system, assuring identification when receiving the produce and mapping the unique produce identification to the related cus-

tomer for shipment. This can also cover aggregation and disaggregation of produce in the organisation itself.

The following sections are further detailing the main functional elements of the PInfS.

3.3.2.3 General PInfS model for conceptual prototype realisation

The following Archi Model in Figure 3-19 describes the particular parts of the Product Information Service and the involved/used entities. The blue rectangles represent the components of the service. Several FI-Ware services out of Data/Context Management, IoT Services Enablement and Security for example will be integrated. The different types of data bases represent the distributed information sources beside the local data bases. The yellow rectangles include users or consumers as well as other entities like devices or the products itself which access the Product Information Service over an interface to update or request information about specific products. Additional information sources like companies' own data bases are presented in green and are only accessible using information got from the ONS.

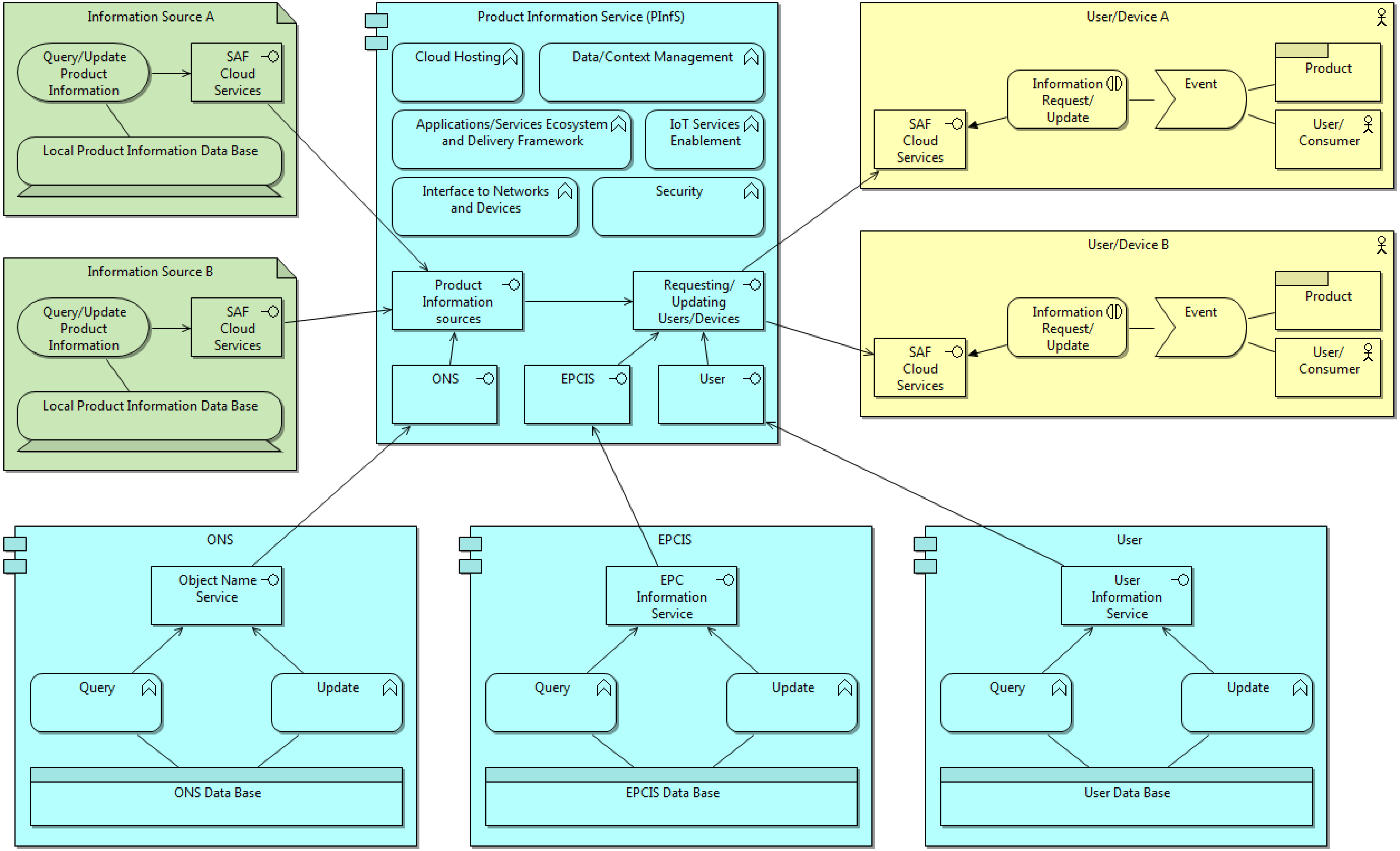

Figure 3-19: Relationship of the PInfS elements.

The second Archi Model in Figure 3-20 shows the different data and trigger flows between the components in a layer view consisting of three viewpoints:

1. The business layer shows the interaction between actors and the triggering of events and processes. It is connected to the application/service layer through an interface. In this case only the Product Information Service is considered to simplify matters.
2. The application layer gets orders from users or objects and run processes on the respective service. Several services here can interact with other services in addition to a data base interface to get or store information.
    a. The main components of this layer are the four generic SAF services. For the Product Information Service mainly the Identification and Business Relations Service can be used to enrich the provision of information returned.
    b. Consumer Services which could be also provided by this application layer. This component could be used by business partners especially retailers to provide additional services like logo recognition or product, receipt or diet proposal.
    c. Other Services for example restricted ones can be provided too, for instance for administrative matters.
3. The infrastructure layer finally contains the information requested by the Product Information Service. Here the different data bases are accessible which contain the information or the location to find it.

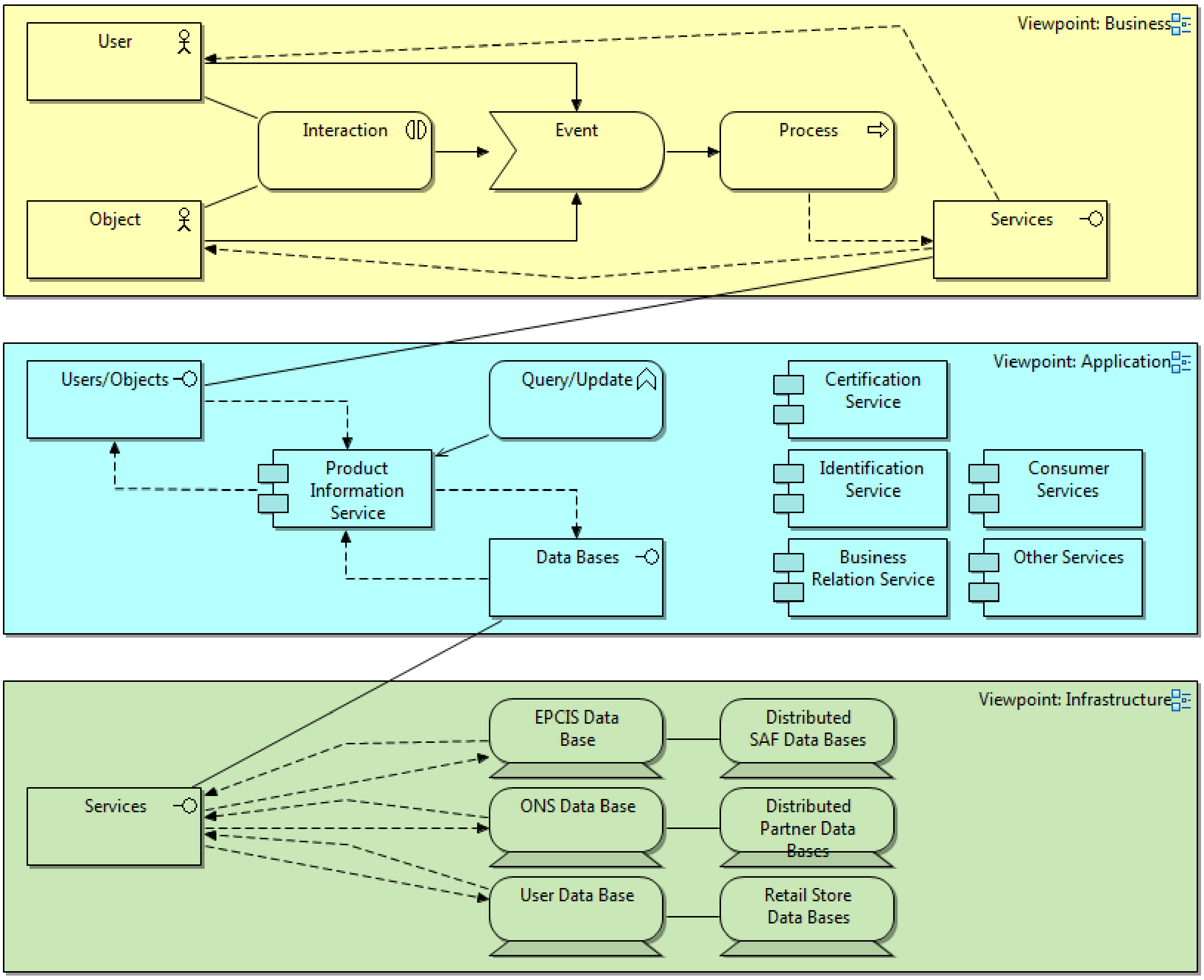

Figure 3-20: Trigger and information flow of the PInfS

3.3.2.4 Domain Specific Enabler

This chapter will describe these identified functionalities required by the PInfS, show existing solutions/standards and outline their advantages and disadvantages. The instantiation of the PInfS will use FI-WARE GEs as well as domain specific enablers which have to be developed to support some essential functionality. P2P connectivity and information lookup services were identified as domain specific enablers and are central parts of the PInfS. It shall support the communication between individuals/actors in the agri-food chain that does not need a centrally managed routing procedure. Moreover, with respect to information of a specific product, the DSE shall enable the actors in the agri-food chain to access the related information that is owned and independently managed by different actors/organisations in the chain.

The domain specific enablers will be based on a hybrid approach, which compiles the capabilities of individual technical solutions and allows a realisation of enablers that combine the advantages of individual approaches.

3.3.2.4.1 Peer-to-Peer Connectivity

In traditional server based application the infrastructure is quiet static and robust. The availability of servers is usually more than 99%. Also the IP-Addresses as well as the domain names don't change very often. This eases the server based and - most of the time - synchronous communication between different nodes. The IT-Infrastructure within the food supply chain forms a contrast to this, because some stakeholders (e.g. small Farmers) don't have a server infrastructure, but workstations or mobile devices that are connected via an end consumer connection (e.g. DSL, cable, etc.) to the internet. On top of that, most ISPs serving the end consumers provide a dynamic IP-Address to their customers which changes after a certain time. Furthermore most broadband users operate a routing device, which doesn't allow direct access to the devices behind.

This implicates the following typical characteristics for the network nodes of the related actors:

- No 100% uptime/availability
- No constant addressing. Neither via the IP-Address nor a domain name
- No redundancy regarding hardware, power, internet connection
- Not directly accessible over the internet

A general approach is to realise services on a central server instance to comply with these challenges. But this raises privacy issues with respect to the access to the transported messages, and a potential unintended disclosure of business relationships between agri-food chain organisations, data integrity etc. Because of that the PInfS is targeting at a decentralised architecture to put the information owner in full control of the data access. To support the creation and maintenance of a communication network that is required for the realisation of the PInfS, this DSE shall specifically provide services that allow:

- Asynchronous and synchronous messaging between nodes
- Constant addressing of each node
- Publishing and querying of services (Yellow Pages) and node characteristics (White Pages)
- Traversal of firewalls

A more detailed description of Peer-to-Peer connectivity and the related service advertisement and discovery can be found in the Appendix, see section 5.3.1.

3.3.2.4.2 Information Lookup Services

The focus of the Information Lookup Service is to allow actors within a network to propagate available information and allow others to discover these sources. This service also needs an authentication method as a basis for a controlled and secure flow of information. Furthermore, it should support the managed access to data in accordance to the privacy constraints imposed by the related data owner.

Current services (e.g. ONS, Barcoo, etc.), which provide product information lookup services are implemented in a centralised way, where one authority provides the ability to query for information by a given product identifier. Based on this mechanism an 1:n relation is established between the central provider of a lookup service and the consumers. This 1:n relation limits the capabilities in the sense that only one node (e.g. producer of the product) act in the role of an information provider and is the only one that can change product information related to the corresponding ID. In the agri-food chain all stakeholders can be a provider and consumer of information at the same time. To address this, the Information Lookup Service shall be realised upon the Peer-to-Peer Connectivity DSE to establish a decentralised approach, which overcomes the typical client-server paradigm.

To allow actors to easily provide and access product related data, the described network should be open available in the internet. This requires the need of an authentication and authorisation mechanism to control the access to data and decide about the trustworthiness of an information source from an ICT point of view. Furthermore it shall specifically provide services that allow the lookup mechanism needed for the realisation of the PInfS that are as follows:

- Centralised and decentralised propagation of information related to a product
- Asynchronous querying for information
- Authenticated communication (querying/propagation)
- Respect the privacy constraints of the actors

A detailed description of lookup service approaches outlining their advantages and disadvantages can be found in the Appendix, see section 5.3.2.

3.3.2.5 Generic Enablers involved

For the realisation of the conceptual prototype with respect to the PInfS, the Generic Enablers summarised in Table 2 will be used to materialise the functionality described in Section 3.3.2.2.

Table 2: Involved Generic Enablers

Functionality	Involved GE	GE Group
Identity	Identity management	FIWARE.ArchitectureDescription.Security
Data security	Data handling	FIWARE.ArchitectureDescription.Security
Query heterogeneous environment of data stores	Query Broker	FIWARE.ArchitectureDescription.Data
Exception Reporting/ Forwarding	PubSub	FIWARE.ArchitectureDescription.Data
Event/ Exception processing	Complex Event Processing	FIWARE.ArchitectureDescription.Data
Data Acquisition	Backend ThingsManagement Gateway.DataHandling	FIWARE.ArchitectureDescription.IoT
Reputation	Security, Trust and Reputation	FIWARE.Epic

3.3.3 Business Relations Service

3.3.3.1 Introduction

The Business Relations Service provides an interoperability infrastructure to maintain interactions of business partners, enabling connectivity and information exchange and facilitating the addressing and search of information in a Future Internet.

This service pursues two main objectives:

– Creating long term and quality relationships between partners playing different roles, supporting business-to-business, consumer-to-business and consumer-to-consumer relationships.
– Investigating how a customer responds to provided services, managing their feedback and distributing the information to the appropriate business entity.

The organizational model plays an important role for this service. We define organizational model as a social system composed by organizations and clients, defined by a set of properties.

Role defines the behavior of the organization along with it status and its position.

Offer/Demand establishes interaction requirements for the communication between organizations and organizations and customers.

Interaction model: Set of communication models, interaction paradigms and syntactic/semantic information that defining business-to-business, consumer-to-business and consumer-to-consumer relationships.

3.3.3.2 Service lifecycle

The organizational model, and particularly the interaction model, depends on the specific state of business relations with other entities. We consider an environment in which the relationships between entities are realized through the execution of cross-organizational services or business processes. The service logic defines the communication model that should be established between the business process participants, and therefore defines the communication requirements to be considered in the organizational model.

Services provided and consumed by organizations have a life cycle described in Figure 3-21.

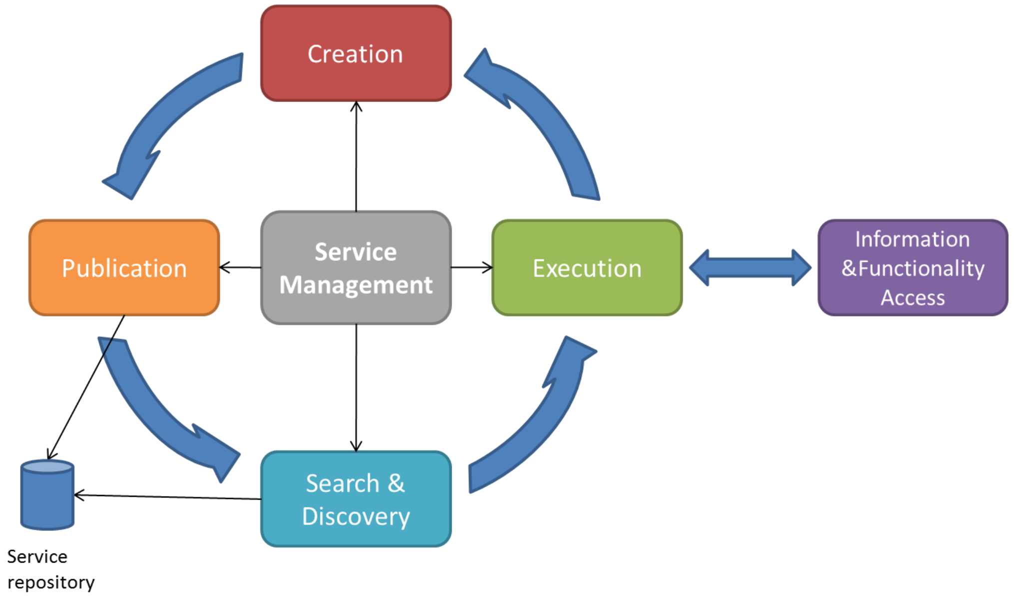

Figure 3-21: Service life cycle

The following describes each state of the service and its relationship to the interaction model:

Creation Process: The service begins to exist in the creation process. A business entity or a group of entities use some tools to create a service or a business process. At this stage, relationships with other organizations are defined, which parts of the service will be executed in other domains (cross interoperability of distributed services) or whether the implementation of the whole service is centralized. With the information introduced by the user, the service is ready for deployment.

Publication process: The main goal of the publication process is that the generated service will be available through the platform so that other partners can use it. A distributed repository is used to store service references, indexing them by categories (service repository). The publication process adds some execution requirements to the published service which are useful for the consumer execution environment to determine whether the service can be used or not.

Search & Discovery Process: Once the service is placed in a repository, involved organizational entities can play an active role and initiate a service search in the service repository. Regarding the discovery process, the Business Relations Service can actively communicate with involved entities to inform them that a service is available.

Execution process: This is the most critical stage from the point of view of the business relations service, as this service must build the interaction model between involved organizations to enable communication between different entities. In the next section (Business Coordination) the service execution process and the mechanisms implemented by the Business Relation Service are discussed.

Information and Functionality Access: The service execution process includes the information and functionality access process, which enables access to the functionality provided by other entities that are indirectly involved in the service execution (i.e. they do not execute any service logic but provide information or some functionality to the participating entities). An example for such an entity is a provider of Web services or functionalities located in the cloud, such as databases of product information.

FI-WARE provides tools for managing the service lifecycle. For example, the generic enablers *CompositionEditor* and *CompositionExecution* develop a service creation environment using the *Mashup* composition paradigm to interconnect the services offered by different service providers, in our case businesses and consumers. A service repository is also available for service deployment, by the Repository GE, and mechanisms for service search and discovery as well. All these mechanisms compose the Services Ecosystem, as described in Section 0. The BRS is closely related to the Services Ecosystem but, while the latter focuses on describing the generic principles related to creation, composition, delivery, monetization and usage of services, the BRS mainly focuses on service interoperability (Marketplace GE), SLA generation and service feedback.

3.3.3.3 Business Coordination

As described at the beginning of section 3.3.3 the objective of the Business Relation Service is to establish a fluent communication between participants. These relationships are critical for the implementation and execution of cross-organizational services and business processes. To enable a fluent communication between participants, the Business Relation Service performs the following operations prior to service execution stage:

- Generate a virtual representation of business entities taking into consideration their profiles, objectives and execution conditions.

- Associate business entities with service execution requirements and actively communicate with these entities to inform that a service is available.
- Provide access identifiers to enable communication between entities in order to allow other systems and services to provide security models, identity management and access control and reputation mechanisms.
- Provide mechanisms for service evaluation, service recommendation and feedback management. This operation requires that participating entities are associated.

These operations are provided in order to enable and facilitate three types of relationships: business-to-business, consumer-to-business and consumer-to-consumer relationships. For these relationships we establish two domain types (which are two particular scopes in which BRS execution is taking place):

- The *personal domain* refers to the set of devices, sensors and associated content that surrounds the customer. In a simple example, the personal domain can be a mobile phone of the user and the personal information that it contains.
- The *business domain* represents the set of devices and content located in a business entity, such as a supermarket or a logistic company.

3.3.3.3.1 Business-to-business relationship

B2B relationship defines the interaction model between companies that collaborate with each other through services. The most important mechanisms that are enabled from the Business Relations Service to facilitate interaction between these entities are:

- **Business Entity Matchmaking (BEM)**: Determines the suitability of an entity to relate to others through a given service. Figure 3-22 shows the architecture that described the detailed behavior of the function. The BEM loads the specification of a service that is planned to be executed in an entity, using the Service Specification loader module. The Service Capability Provider searches for capabilities provided by other entities and the Requirement Evaluation module evaluates if the requirements can be satisfied. If the requirement evaluation is successful, the Matchmaker module binds these two entities. The Service Capability Provider also search capabilities in entities that are not yet involved in a service execution and informs them on the availability of a new relationship with another company and the requirements for it. For example, this function is used for the supplier search process initiated by a supermarket. If the supermarket has an automatic ordering system that uses stock control it would like to choose a provider that is compatible with this ordering system. The same occurs with the labeling system used by the supermarket. These requirements are taken into account in the BEM process for choosing the best provider entity.

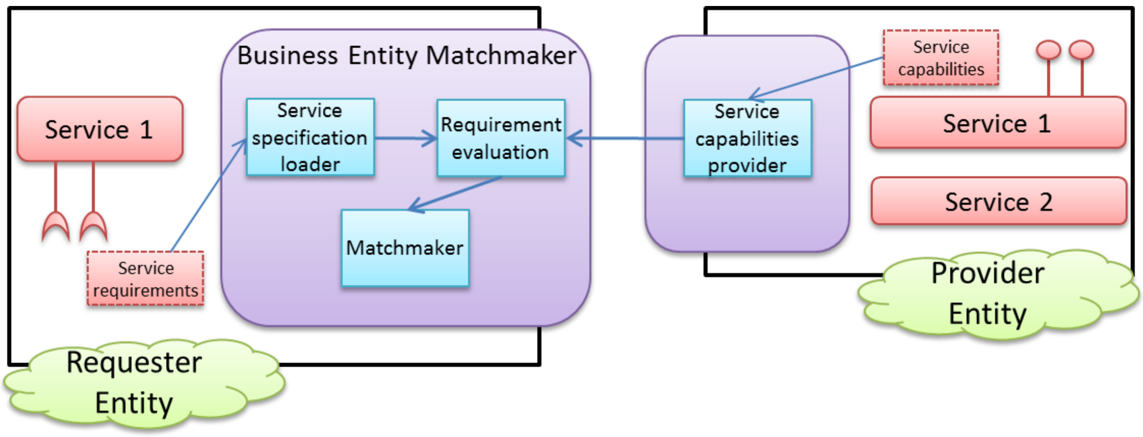

Figure 3-22: Business Entity Matchmaking architecture

- **Content Interoperability Assurance**: As the data interchange between interconnected entities may not be compatible in terms of protocols, data format or semantic information, the Content Interoperability Assurance function negotiates and defines the characteristics of the communication between entities at the level of service logic and data exchange, and establishes criteria to enable interoperability and coordination between entities. These criteria may be supported data format, communication protocols, semantic information, etc. For this, the Business Relation Service uses the functionalities of the Query Broker, SLA Support and Mediator generic enablers (see section 0 - Generic Enablers involved). Figure 3-23 describes the architecture of the Content Interoperability Assurance function. If the data interchange negotiation is successful, a SLA (Service Level Agreement) is generated between Entities 1 and 2. If not, the Business Entity Matchmaker module will continue searching for new relationships. This functionality provides a novel advance from the features that offers current professional networking websites, which try to put in contact business and consumers but doesn't support the establishment of new relationships and the creation of SLAs. Using the example in the previous paragraph, related to the relationship between supermarkets and suppliers, the Content Interoperability Assurance function determines whether the automatic ordering system can be connected with the ordering services of the selected provider. Also if the product labeling system used by the provider is compatible with the system used in the supermarket.

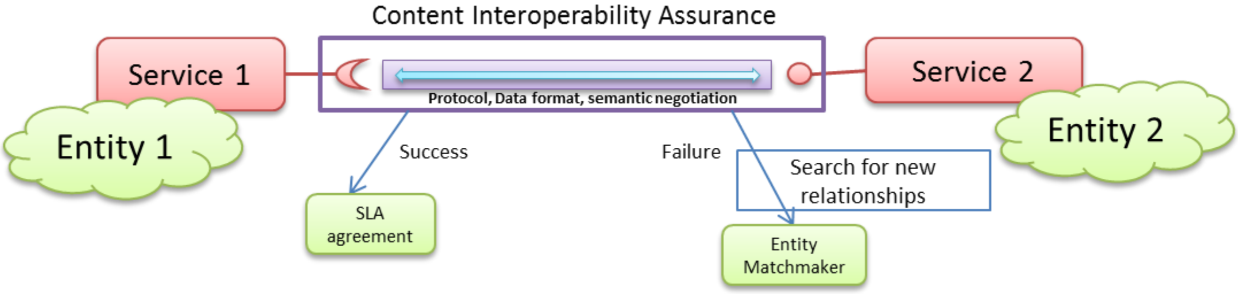

Figure 3-23: Content Interoperability Assurance architecture

3.3.3.3.2 Consumer-to-business relationship

C2B relationship defines the interaction model between companies that work together through services.

The mechanism provided for this type of relationship is the management of consumer feedback, from the point of view of consumer evaluation, service recommendation and QoS assurance.

Also, a content interoperability assurance takes place between the domain of the client (personal domain signal) and the business domain, to analyze the suitability of the service for the user's needs, as described in his profile (if it is available and if the user has given permission to access this information).

Figure 3-24 shows an example of the relationship established between a client, a store and a food distribution company (logistics). From the point of view of the business to business relationship the BEM and Content Interoperability Assurance functions operates at the Business Logic level (which describes how business objects interact with one another and the established relations) and at the Content level (which describes the data that is exchanged between entities) respectively.

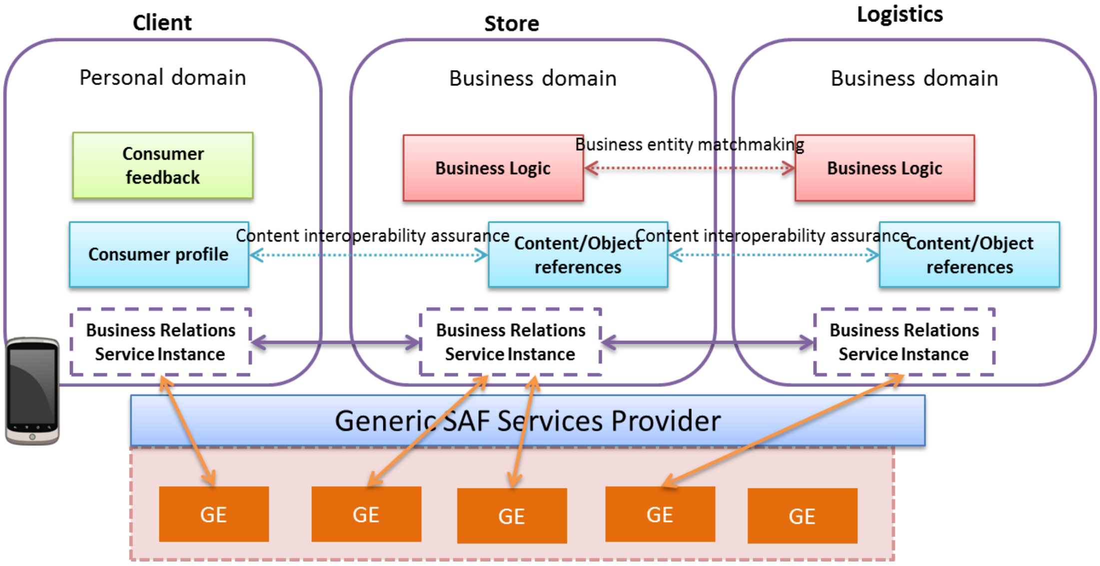

Figure 3-24: Business-to-business and consumer-to-business relationship example

As can be seen, coordination mechanisms between entities are carried out in a distributed manner through the instantiation of the Business Relations Service in each domain. The interaction between red and blue boxes, which represent the Business Logic and the Content level of the interaction between domains respectively, is represented by dashed arrows, meaning that the matchmaking and the interoperability assurance functions are performed only through BRS instances, while the data exchange once the communication has been established will be addressed directly between executing services.

Business relations Service instances access to functionalities provided by generic enablers, as stated in section 3.3.3.5 - Generic Enablers involved.

3.3.3.3.3 Consumer-to-consumer relationship

C2C relationship defines the interaction model between different consumers, which generally is indirect, i.e. there is no direct communication between the personal domains, but there is an exchange of information through the enabled services, which may be available in a centralized way in a business domain, or in a distributed way in the personal domains.

The main functions performed by the BRS in the Customer-to-customer relationship scenario are Service Evaluation and Assessment and Information Sharing, as illustrated in Figure 3-25.

- **Service Evaluation and Assessment**: This function handles the information generated in client domains related to the evaluation and assessment of services provided by companies. The Business Relations Service instance maintains an exchange of information between clients executing or planning the execution of the same service so that they have updated information about how clients have rated these services and whether clients recommend these services or not. For the management (generation, transmission, establishment of reputation criteria) of consumer feedback, the BRS uses the Identity Management and Security, Trust and Reputation generic enablers among others.
- **Information Sharing**: This function aims to achieve the exchange of information between consumers in order to provide better feedback to the company, related to the products offered or customer service. The use of the Information Sharing function between consumers, in addition to the provision of feedback between consumers and companies it also aims to involve all users in the recommendations and the level of consumer satisfaction in a company. The main difference with the Service Evaluation and Assessment function is that the latter deals with user feedback to other users and on a certain service, while in the case of Information

Sharing, consumer feedback is directed to the company and aims to improve consumer relationship with the company. This feature uses the capability offered by the Query Broker Generic Enabler.

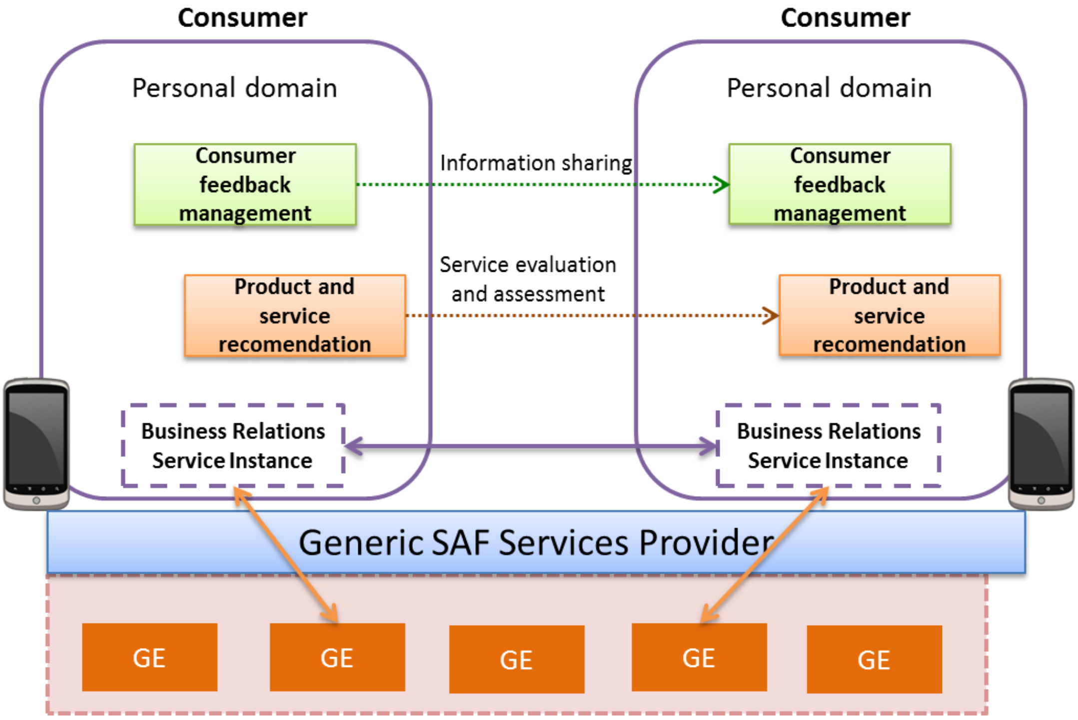

Figure 3-25: Consumer-to-consumer relationship example

As in the previous case, coordination mechanisms between entities are carried out in a distributed manner through the instantiation of the Business Relations Service in each personal domain. The interaction between green boxes, which represent the customer-generated information aimed to the company and orange boxes, which represent the customer-generated information aimed to other clients, is represented by dashed arrows, meaning that the Information sharing and the Service evaluation and assessment functions are performed through BRS instances.

3.3.3.4 Transversal Aspects related to Business Relation Service

- Security: Define, integrate and deploy security models to guarantee information sharing and business process coordination.
- Identity management and access control: Protects access to available data by a decentralized authentication of participants in service lifecycle.
- Reputation: Generates trustworthiness and accuracy in the stored content.

3.3.3.5 Generic Enablers involved

Throughout section 3.3.3 the functions carried out by the BRS have been detailed, related to the Service lifecycle and Business coordination. These functions are detailed and illustrated by figures and correspond to Service Lifecycle Support, Business Entity Matchmaking, Content Interoperability Assurance, Service Evaluation and Assessment and Information Sharing.

In this section we summarize the generic enablers to be used for each of these features, also considering transversal aspects such as Security, Identity management and Reputation.

Functionality	Involved GE	GE Group
Service Lifecycle support	Service Management	FIWARE.ArchitectureDescription.Cloud
Business entity matchmaking	SLA Support, Mediator (Apps)	FIWARE.ArchitectureDescription.Apps
Content interoperability assurance Information sharing	Query Broker	FIWARE.ArchitectureDescription.Data
Service evaluation and assessment	Marketplace	FIWARE.ArchitectureDescription.Apps
Security	Data handling	FIWARE.ArchitectureDescription.Security
Identity	Identity management	FIWARE.ArchitectureDescription.Security
Reputation	Security, Trust and Reputation	FIWARE.Epic

3.3.4 Identification Service

3.3.4.1 Introduction

Identification is the fundamental concept of uniquely recognizing an object (person, computer, etc.) within a context. That context might be local (within a department), corporate (within an enterprise), national (within the bounds of a country), global (all such object instances on the planet), and possibly universal (extensible to environments not yet known). Many identities exist for local, corporate, and national domains. Some globally unique identifiers exist for technical environments, often computer-generated. In this specification, the Identification Service (IdSv) (Figure 3-26) provides a generic service developed by ICT services providers. In SmartAgriFood project the Identification Service provides functions for:

- Registration of user, systems, and service provider accounts
- Login for registered users, systems, and providers by means e.g. of user name and password
- Service licensing and pricing agreements management
- Self-administration for users (e.g., password management, changes to user data, security management, access to recourses and trustees' management)

The following subsections describe the expected functionalities of the Identification Service of SmartAgriFood.

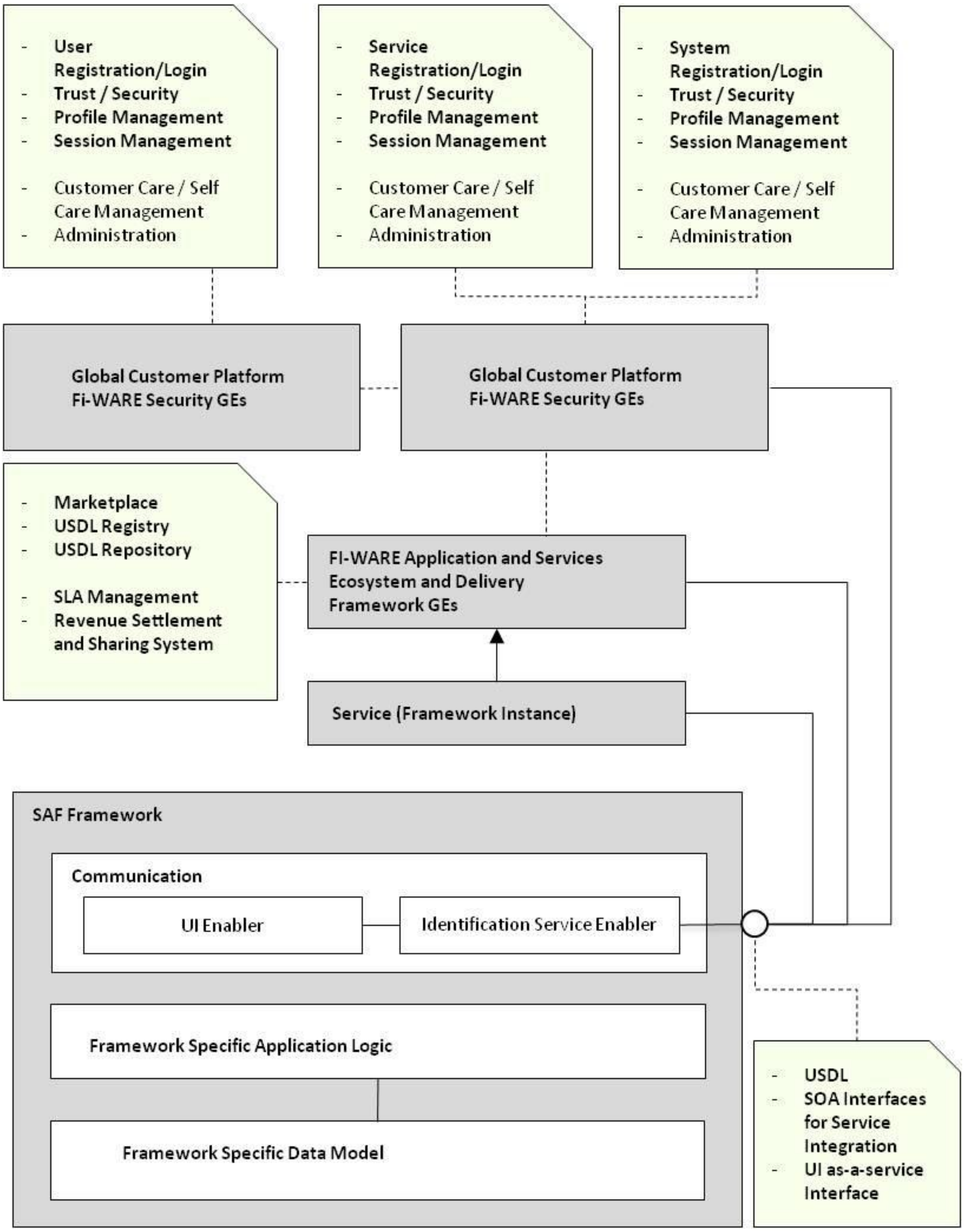

Figure 3-26: Identification Service in the SmartAgriFood Framework

3.3.4.2 Authentication: User Registration and Identification

Authentication is the process of establishing confidence in user identities electronically presented to an information system. Systems can use the authenticated identity to determine if that individual is authorized to perform an electronic transaction.

Authentication begins with registration. During registration, a user, service or device connects to the registration service enabler which then routes it to a Credential Service Provider. In the SmartAgrifood, the Global Customer Platform (GCP) specified by the FI-WARE provides these credentials. The GCP then issues the user with a secret, called a token, and a credential that binds the token to a name and possibly other attributes that can be identified. The token and credential may be used in subsequent authentication events to identify a user, service and device connected to a system. An example of registration of users, services and devices in is shown in Figure Figure 3-27.

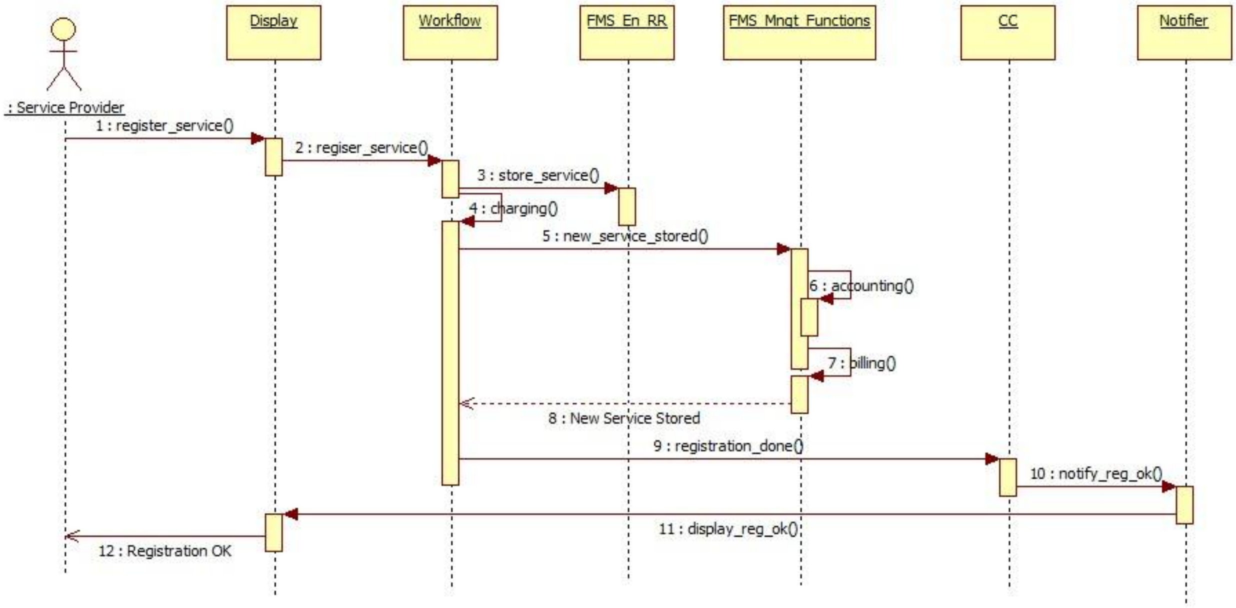

Figure 3-27: Registration of Service in the SmartAgriFood Framework

In this scope, the party to be authenticated is the FMS user, and the system for verifying that identity is the Identification Service. When a user successfully demonstrates possession and control of a token in an on-line authentication to an Identification Service through an authentication protocol, the Identification Service can verify that the user is the subscriber. The Identification Service passes on an assertion about the identity of the subscriber to the relying party. The architecture can also be arranged such that the Identification Service is a third trusted party.

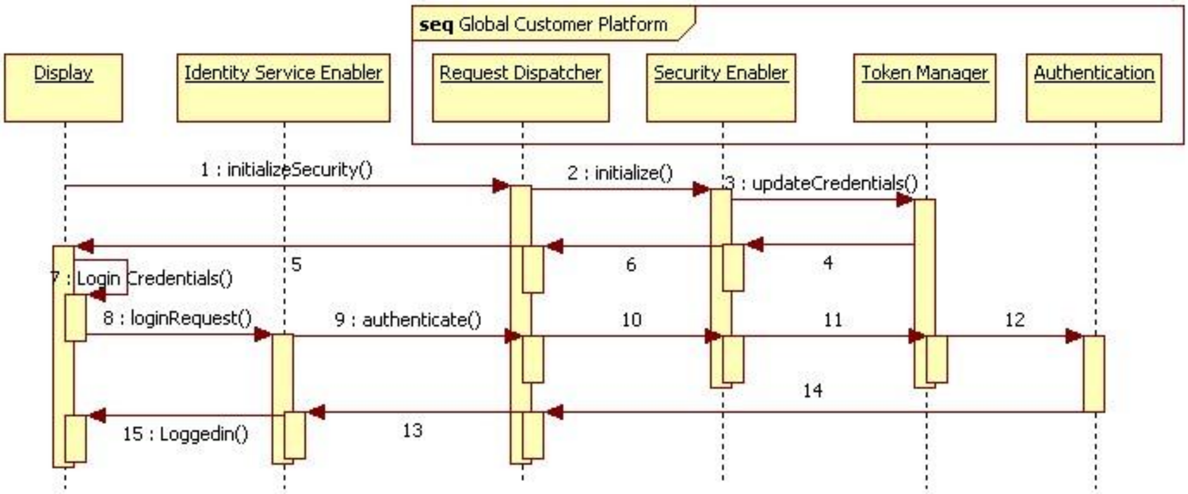

Figure 3-28: Authentication of User in the SmartAgriFood Framework using the FI-WARE Global Customer Platform

3.3.4.3 Identity Management

Identity Management (IdM) encompasses a number of aspects involved with users' access to networks, services and applications in under the SmartAgrifood (SAF) framework. It binds the user's credentials to service subscriptions. The task of identity management taken of by the Global Customer Platform of the FI-WARE includes secure and private authentication from users to devices, networks and services, Authorization & Trust management, User Profile management, Single Sign-On (SSO) to service domains. The Global Customer Platform communicates with the FI-WARE Application and Services Ecosystem and Delivery Framework GE to Identity Federation of users towards service applications.

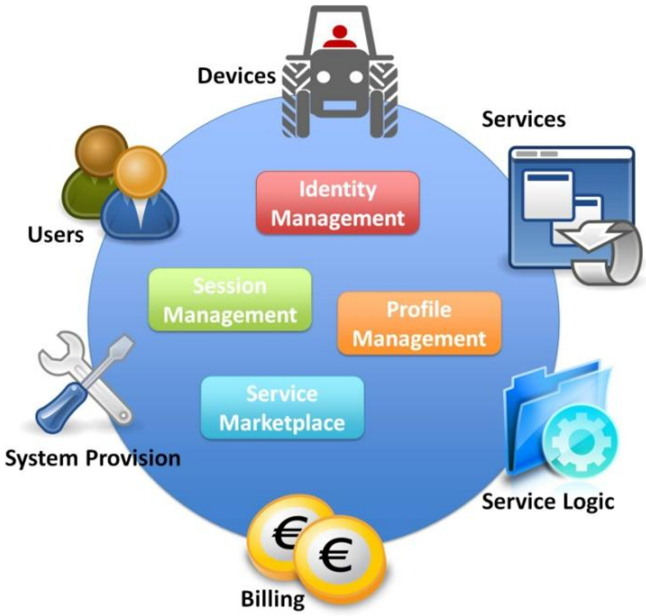

Figure 3-29: Identification Management in SmartAgriFood

An IdM system is intended to undertake the complex task of handling, communicating with and coordinating between the slew of today's diverse technologies. Provide user-friendly technologies, putting the end user and his needs squarely at centre of the architecture (user-centric approach) whilst protecting the users' privacy.

On the other hand the computing resources are being actively exploited by the Enterprises lately through the use of cloudification and virtualization technologies. Nevertheless, with regard to such an evolution on the Web, the SAF framework and should be able to deliver Identity Management to customers using these technologies. Thus, the GCP Identity Management Enabler delivers a multi-tenant user and profile management solution that allows different Agricultural Enterprises to manage consumers of their (Web based) services in the Cloud securely. As stated in the Authentication sub-chapter; instead of developing and operating the user and profile management within the SAF Framework itself, it can be hosted in the Cloud as a tenant instance and will be delivered on demand (Figure 3-26).

Identity Management encompasses a number of aspects involved with users' access to networks, services and applications, including secure and private authentication from users to devices, networks and services, Authorization & Trust management, User Profile management, Single Sign-On (SSO) to service domains and Identity Federation towards applications. The Identity Manager is the central component that provides a bridge between IdM systems at connectivity-level and application-level.

Identity Management in the GCP is used in multiple scenarios spanning from Operator oriented scenarios towards Internet Service Providers (ISP). End users benefit from having simplified and easy access to services (User Centric Identity Management) to register, create credentials, create their profile, and specify their billing and charging information.

3.3.4.4 Service contract orchestration and retrieval

Discussed earlier in the Business Relations Service section, service provision contracts exists between system user and service business orchestrator, business to business, business to service user, and service user to service user. The SAF Generic Enabler for service orchestration and retrieval will rely on the Universal Service Description Language (USDL) formulated by FI-WARE. As noted, the USDL itself is not a Generic Enabler, since it is a data format and vocabulary specification. The functionalities that will enable service contract orchestration, enforcement and retrieval will be as follows:

- A Store, which allows to offer services for agricultural stakeholders as well as developers of future internet service applications.
- A Marketplace, which allows finding and comparing services from different stakeholders and provides.
- A secure Revenue Sharing enabler, which allows the calculation and distribution of revenues according to the agreed business models.
- A set of Service Composition enablers, which allow composing existing services to value added composite services and applications, which can be monetized in the Business Framework.
- A set of Mediator enablers, which can be used to achieve interoperability between future internet services and applications and also allow interfacing to existing enterprise systems.
- And finally, service-level agreement (SLA) Support, which monitors and evaluates runtime data according to the agreements of service levels.

Management of Service Level Agreements; the service contract where the level of service is formally defined will be an essential aspect of service delivery in the future internet. In a competitive service market place, potential customers will not be looking for “a” service, but for “the best” service at the “best price”; also known as quality of services (QoS). A comprehensive and systematic approach to SLA management is required to ensure this complexity is handled effectively, in a cohesive fashion, throughout the SLA life-cycle. For the SAF framework contract management is implemented as described in the Applications and Services Ecosystem and Delivery Framework section shown in Figure 3-30.

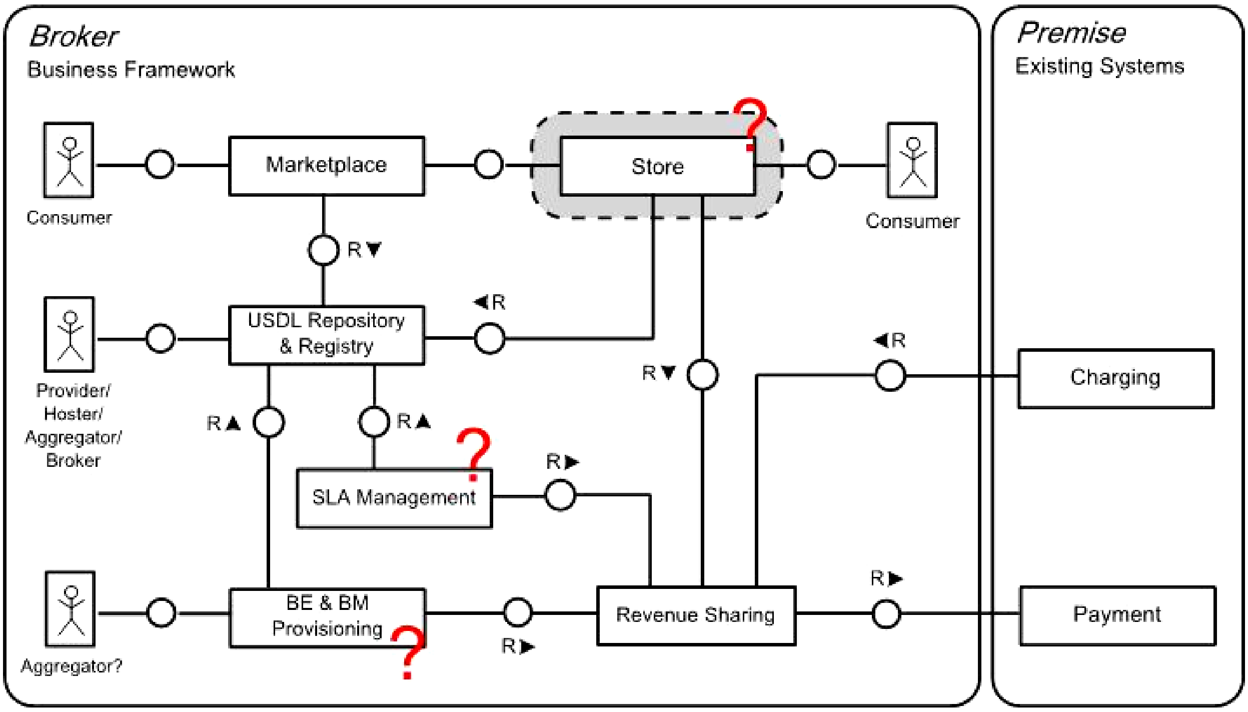

Figure 3-30: FI-WARE High-level architecture of the Business Service agreement, offering a revenue collection

Though for each service, the Service agreement, offering, a revenue collection is as described in Figure 3-30, the agreements are bound to the users' credentials which is implemented by the FI-WARE Global Customer Platform. As touched on briefly earlier, one of the main features of the GCP is User Life-Cycle Management. The GCP offers tools for tenant administrators to support the handling of user life-cycle functions. It reduces the effort for account creation and management on the tenant side, as it supports the enforcement of policies and procedures for user registration, user profile management and the modification of user accounts. Tenant administrators can quickly configure customized pages for the inclusion of different authentication providers, registration of tenant applications with access to user profile data and the handling of error notifications. 3rd Party Login - 3rd party login supports customers of the GCP to enhance the reach of their websites by means of attracting users without forcing them to register new user accounts on their sites manually. The GCP offers hosted user profile storage with tenant-specific user profile attributes. For this reason, developers do not have to run and manage their own persistent user data storages, but instead can use the GCP's user profile storage as a SaaS offering. A user profile consists of two different sets of user attributes: profile attributes managed by the user himself via a self-service Web interface, and profile attributes used internally by the tenant applications, this includes contract agreements with SLAs. For illustration, the Figure 3-31 shows how GCP arranges profile data support for multiple agricultural related service orchestrators.

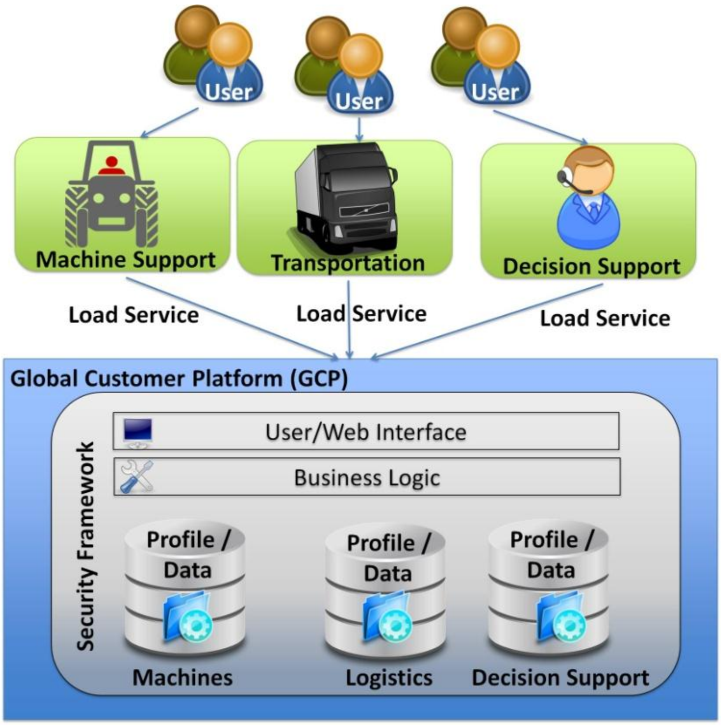

Figure 3-31: FI-WARE Global Customer Platform for multi-service management

The GCP serves as a Profile Management Service under the Identity Management Module (Figure 3-29). The main idea for the Identity Management Module is to use several Virtual Identities for different purposes which are belonging to one real person. This enables the avoidance of duplication stakeholder offering appearing on different stakeholder platforms. Multiple level SLA provision allows to formulate this virtual identity. The result is that a user can different profiles which are used in the farm office, on the farm field decision support, for shopping and ordering logistics services and so on. For example, all these profiles can have different SIP User Identities or special attributes which are useful to utilize special functionalities from a service.

A typical scenario to facilitate the use of IdM and GCP is illustrated in the FI-WARE specification is the request for a multimedia service (myService) from a FIWARE instance running an IP Multimedia Subsystem (IMS Core) with its User Database (HSS) as well as a user profile server Global Customer Platform (GCP).

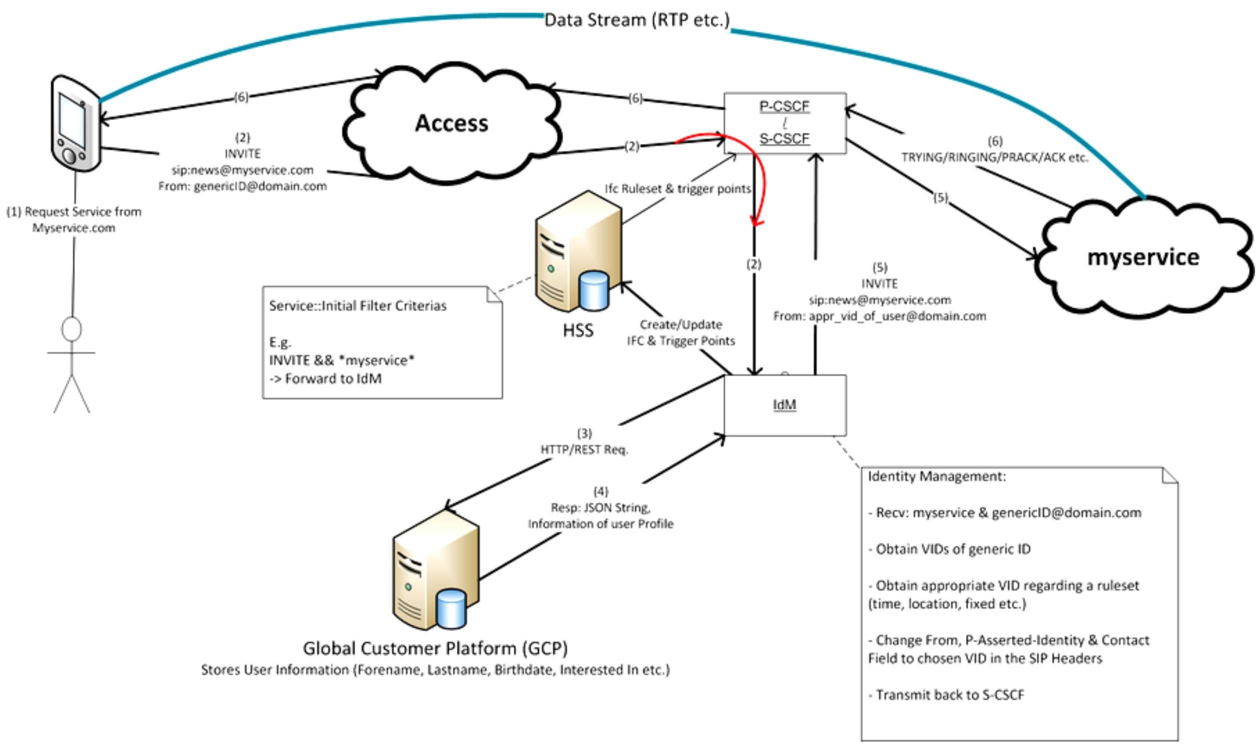

Figure 3-32: FI-WARE Global Customer Platform for multi-service management

Number (1) depicts that the user wants to use a service. In step (2) the INVITE request, which was created by the User Agent (UA) of the User Equipment (UE), will be forwarded through the access network as well as the core network towards the IMS P-CSCF/S-CSCF (Proxy/Call Session Control Function). In this request, the *From* and *Contact* as well as *P-Asserted-Identity* header field contain a generic identity which belongs to the user and his UE. The challenge in this scenario is to apply a rule set for the users which want to use the Identity Management Module for multiple use of a service in different types of identities. The idea is to create Initial Filter Criteria and trigger points to reroute the incoming request towards the IdM. However, this approach is still under discussion (red curve). After this packet flow, the Identity Management is involved in the whole initiation process.

In step (3), the IdM sends out a *Customer Profile Request* towards the Global Customer Platform. This platform stores user data which can be requested via a REST Interface. The database contains general user information like forename, last name, birth date and much more, but can also contain customized fields like special interests in a keyword manner or a timetable array for reachability. Other types are also possible.

The response in step (4) contains a JSON array with the relevant information regarding the request. The IdM looks up in this array for a feasible Virtual ID of its own database with the criterias of the user profile. After that, the incoming request will be rewritten. There will be changes regarding the identity in the *From*, *Contact* as well as in the *P-Asserted-Identity* Header fields of that request. Additionally, customized *P-Header* fields will be set for a better service experience. The fields for that are still under discussion. Some examples can be found at section *Interface towards a service*.

Packet flow (5) has now the updated INVITE request and will go back to S-CSCF. The function will finally deliver the INVITE to the originally requested service.

In flow (6) the regular SIP Handshake is processing. Once the session is established, the IdM will not be involved in the user data exchange. The data flows directly through the core and access networks to the UA/UE and vice versa. When the user or the service is closing the established session, the S-CSCF has to involve the IdM again for finding out the originating session properties and establish a correct closing of the session.

3.3.4.5 Relation to FI-WARE

The FI-WARE GE's employed in the SAF Identification Service are given in Figure 3-33.

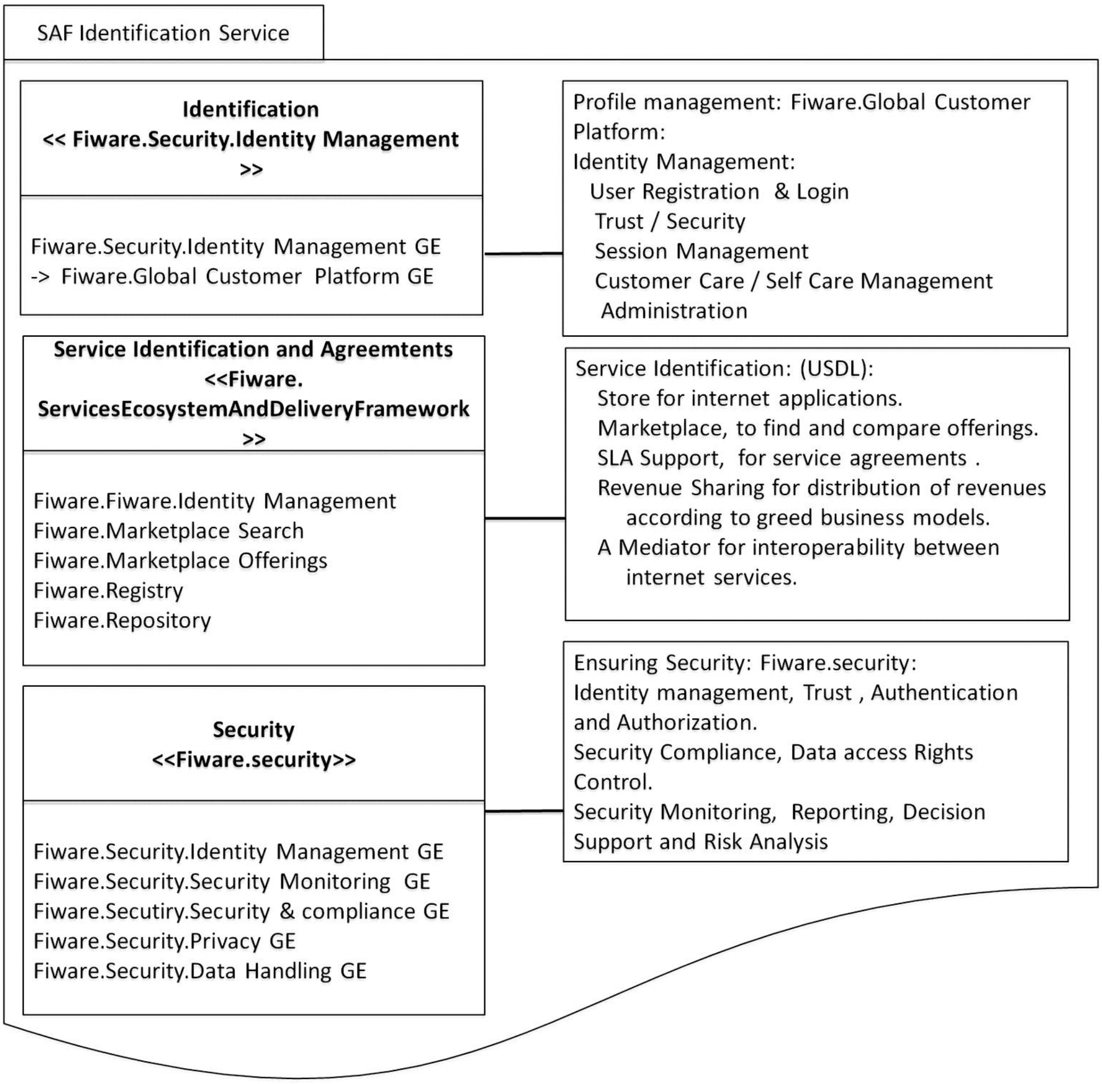

Figure 3-33: FI-WARE Generic Enablers used in SAF Identification Service

3.3.4.6 Generic Enablers involved

Functionality	Involved GE	GE Group
Identification of users	Identity Management (IdM)	FIWARE.ArchitectureDescription.Identity Management Generic Enabler
Platform generic for user identity management	Global Customer Platform (GCP)	FIWARE.Feature.Security.IdM
Registration of users	Customer Self Registration	FIWARE.Feature.Security.IdM
Login of users	Customer Login using OpenID	FIWARE.Feature.Security.IdM
User account management	Customer SelfCare	FIWARE.Feature.Security.IdM
Integration of a shop into the IdM system	Shop Onboarding	FIWARE.Feature.Security.IdM
Ensuring security of user transactions	Security Monitoring & Compliance	FIWARE.Feature.Security
Privacy for system users	Privacy	FIWARE.Feature.Security
Data security for users	Data Handling	FIWARE.Feature.Security
Facilitate marketplace commerce	Marketplace	FIWARE.ArchitectureDescription.Apps
Registration, archiving, listing and search at the marketplace	Marketplace Registry, Repository, Registration, - Marketplace Offerings, - Marketplace Search	FIWARE.ArchitectureDescription.Apps
Service specification	Unified Service Description Language	FIWARE.ArchitectureDescription.Apps
Service security specification	USDL Linked Data Vocabulary for Security	FIWARE.OpenSpecification.Security

3.4 Other FI-WARE compliant services

For the purpose of this section we have studied the other Use Case projects of the FI-PPP initiative and analysed and extracted those functionalities that, being specific for their domain, have some or full applicability in our scenario,

This analysis was done mainly in two levels: the first one at a functional level, based on the documentation available where the scenarios are described; the second one, at a more technical level, taking into account the requirements published in the FI-WARE wiki [12] and also on the deliverables of the other Use Case projects. For this second level of the study we have obviated the requirements that deal directly with the system's backbone(Cloud, Data, interfaces, etc), as they are mostly common for all the projects, and have focused on the ones that are more directly related to the functional aspects of the platforms, hence, much domain-specific.

Our sources of information to start with are the Requirements published in the FIWARE wiki and the public documentation available in the corresponding UC web sites.

Note that the level of detail of the functionalities/requirements may differ from one Use Case project to another, as the quantity and quality of the resources are not the same for all the projects, and that is not taken into account if the identified functionalities are actually being developed / deployed in this phase.

As a next step of this study, a more technical analysis of the identified services shall be done in order to know how they could be integrated into our SmartAgriFood solution.

3.4.1 INSTANT MOBILITY

3.4.1.1 Summary

The Instant Mobility project [8] has created a concept for a virtual "Transport and Mobility Internet", a platform for information and services able to support radically new types of connected applications for scenarios centred on the stakeholder groups:

- multimodal travellers
- drivers & passengers
- passenger transport operators
- goods vehicle operators
- road operators & traffic manager

3.4.1.2 Services and functionalities with applicability in the Agrifood supply chain.

Two main functional blocks that could be usable in our domain, especially related to the transport management; hence, for our project, the sub-domain that could benefit most would clearly be the Logistics one.

A more detailed description of the (potentially usable in our domain) modules, as it is written in the Instant Mobility project's deliverables, is shown below.

Itinerary booking and real-time optimized route navigation

The Itinerary booking and real time optimized route navigation application provides key functionalities to the scenario which in particular the Load sharing and optimizing and the Dynamic time/place drop point applications rely upon.

Load sharing and optimising

A barrier to make better use of the distribution vehicles' capacity is that consignors and consignees are unaware of available transport capacity and that transport operators are largely unaware of the true real-time transport demand. Combining information on distribution vehicles' positions, itineraries and loads with real-time transport need can help allocate shipments to transport vehicles in a better way. Taking this one step further may even imply interconnecting the production plans of factories or the order handling systems of shops and web shops with the transport planning

Dynamic time/place drop point

The application aims at increasing the flexibility in the delivery of goods by dynamically pointing out the right time and place for delivering a package. This is achieved by letting the transport operator take part of the consignee's calendar or that the consignee through other means share information on his or her whereabouts, location and plans; information which can be taken into consideration when the transport operator plans the delivery of the goods. If a more suitable time or location for delivery of the goods than the previously agreed is identified, a suggestion which has to be accepted is made to the consignee. Business models for this kind of application can for example be based on charging an additional fee for keeping the time and location of the delivery flexible; if not choosing the "flexible delivery" option, delivery is performed in the traditional manner to the location specified by the consignee at the time suiting the itineraries of the transport operator with the inconveniences it implies to the consignee.

Eco-optimised driving, vehicle and driveline control

Although above it has been shown how transport operations can become more efficient through for example better allocation of goods to suitable vehicles, it is unavoidable that goods will have to be transported within cities and that at least parts of these transports will be conducted by trucks or delivery vans. The eco-optimized driving, vehicle and driveline control service does not intend to lower the total vehicle distance travelled but to ensure that the vehicle consumes as little energy as possible when travelling the given distance. The application contribute among others to reducing emissions and noise within cities and to a calmer and more predictable traffic environment as a result of less acceleration/deceleration. At the same time the application provides commercial benefits to the transport operator in terms of reduced cost of fuel. As far as the smart farming area is concerned, this module could also be used to tractors in inside farms. For example, optimizing a pending task e.g., tillage, harvest, etc would lead to reduce the cost as well as the emissions.

The service takes a dual approach to reduce the energy consumption by first coaching and teaching the driver how to drive more efficient and, second, impede the ways in which the vehicle can be driven depending on the surrounding traffic situation.

Real-time traffic and route information

The vehicle acts as a probe for traffic estimation sending data to a traffic service on the Internet; these data are mashed up with other sensor data coming from the road infrastructure to give real-time traffic conditions over the full road network. Drivers can receive the information using their personal device through an on-line and updated map including traffic data (continuous map download and updates).

Area-wide optimization strategies

This application will focus in the provision of a modular solution that can collect data from different sources and mashup it by applying different strategies of aggregation. Furthermore, this service will concentrate into provide as an outcome analyzed data from different perspectives and summarizing it into useful information that can feed algorithms and strategies of traffic management. Strategies of self–learning will be applied and algorithms for traffic network flow prediction. Specific objective of the application is to collect, aggregate and validate data from different and innovative sources, in order to give traffic information and forecasts in non-monitored zone, for example linking to any 3rd party data in a city that directly or indirectly collects traffic info, creating specific APIs that link cloud content providers and making use of mash-up technologies.

3.4.1.3 Related FIWARE requirements [19]

INSTANTMOBILITY.Epic.Data.TrafForecast

Description: I want to be able to process all the information gathered (traffic load, disruption of service, weather forecast, pricing) in real time and provide the end user (traveller, driver or float manager) with the best route.

INSTANTMOBILITY.Epic.Data.RealTimeLocation

Description: To find the best solution in real-time, I have to provide my location anytime, anywhere (indoor/outdoor) so the service provider can update the solution, As a traveller my mobile handset could provide this information.

INSTANTMOBILITY.Epic.Data.GenericScheduler

Description: This component provides functionality for creating resource schedules by assigning a set of mergeable schedulable items onto resources, taking existing resource schedules into account and by finding an optimal way of merging the schedulable items, based on a merging algorithm supplied as input. Different data sources for the input (schedulable items, resources and resource schedules) and output (resource schedules) can be supported through input- and output adapters.

INSTANTMOBILITY.Epic.IoT.VehicleDiscovery

Description: To answer the request of the best solution for a journey, as a Service provider I want to identify all vehicles available between A & B to manage with my algorithms the optimal way. Each vehicle should provide its own capabilities (available seats or volume for goods, planned routes, location…)

NSTANTMOBILITY.Epic.IoT.PeopleProfile

Description: As a traveller, I define some profiles depending what kind of urban move I expect to do (home-office, home-school, home-commercial center) and publish the relevant profile to multimodal service providers when I'm looking for a multimodal solution, My profiles are stored in my personal handset.

[19] http://forge.fi-ware.eu/plugins/mediawiki/wiki/fiware/index.php/Unclassified_Themes/Epics/Features_Backlog#INSTANT_MOBILITY

INSTANTMOBILITY.Epic.IoT.TrafficJamEvent

Description: As a driver or a traveller, I want to provide in real-time information about traffic jam status (location, speed) to optimize the next steps of my journey: new routes for drivers, new transport solutions for traveller.

INSTANTMOBILITY.Epic.IoT.GoodsTraceability

Description: As a good operator, I want to know where are the parcels in a city and based on their profiles if it is possible to transfer them in another trucks to optimize route & loading based on traffic constraints.

3.4.2 FINEST

3.4.2.1 Summary

Transport and logistics is concerned with the planning and execution of the world-wide shipment of goods and people. In this highly competitive, distributed, and agile industry, novel ICT solutions for optimizing the collaboration and information exchange in cooperative business networks are highly desirable. Future Internet technologies can facilitate radical improvements in business efficiency in this industry with positive impacts for society and the environment. The ultimate aim of the FInest project [9] is to develop a Future Internet enabled ICT platform to support optimizing the collaboration and integration within international transport and logistics business networks. This shall be realized as a domain-specific extension of the FI PPP Core Platform.

3.4.2.2 Services and functionalities with applicability in the Agrifood supply chain.

Having a lot of common functionalities with the ones described in Instant Mobility, this UC projects branches its focus to the business aspect of the logistics domain.

FInest Business Collaboration Module (BCM)

The Business Collaboration Module (short: BCM) introduces an infrastructure to securely manage end-to-end networks between transport and logistics partners. It integrates information from different sources – such as the Transport Planning Module (TPM), the E-Contracting Module (ECM) and the Event Processing Module (EPM) as well as external legacy systems (e.g. ERP) and user input – and makes it available for the different stakeholders. The main task of the BCM is to provide an overview of the current status of logistics processes and it acts as the central data storage component of the FInest platform. All information relevant to a specific logistics process is kept in a centrally managed storage, with access-control and provides customized views on the data for each involved stakeholder.

To enable this, the BCM uses so-called Collaboration Objects (CO) that implement a data-centric modeling approach. Each CO encapsulates information about a certain aspect of the overall transport and logistics chain (e.g. a certain transportation leg or an involved carrier) and the process fragment associated with this aspect. Hence, a CO consists of two different elements: a data element and a process or lifecycle element. The combination of different COs describes the end-to-end transportation process and establishes a global view of the entire process. In addition, the distribution of information about the various aspects of the transport process over multiple COs enables privacy management due to the fact that only the information that is contained in the particular process aspect which a stakeholder is authorized to see is actually presented to this very stakeholder.

Related to the applicability in our Logistics sub-scenario, similar modules are considered in WP300. Maybe on Generic or Specific Enabler level, some functionalities could be reused.

FInest E-Contracting Module (ECM)

The FInest E-Contracting Module (ECM) is being designed to address the highly manual nature of transport and logistics contracting and the problem of downstream transparency to contracted SLA conditions by exploiting solutions form e-contracting. It is important to remark that the legal terms and conditions of a contract are not in the focus of the ECM. The e-contracting module is envisioned as providing support for:

- Electronic model for representing the SLA attributes of T&L contracts (e.g. SLAs, pricing, escalation processes, etc.);
- On-line management and review of contracts with automatic notification of contract end dates and renegotiation time fences;
- Execution of semi-automated e-contracting selection (offering, bidding, choosing), establishment (negotiation and agreement), and management (reaction to deviations in the execution of established contracts).
- Integration of marketplaces to support (semi)-automated partner selection, bidding, and negotiation

Undoubtedly, this module would be useful not only to merchandisers but also to farmers who would like to sell their products on their own. Also, since the food sector produces all the raw data needed for the goods that have to be shipped, the inputs that this module would need are now easily traceable and likely to be more accurate. This module was not considered exhaustively in WP300 yet. It could be a complementary and useful module.

FInest Transport Planning Module (TPM)

The aim of the FInest Transport Planning Module (TPM) is to overcome business-critical shortcomings by making real-time information about resource status available across actors and organizational boundaries, which shall constitute a significant improvement in planning and optimization processes for international transport and logistics.

Under consideration of the relationship with the other FInest Core Modules outlined above, the primary capability of TMP is to create an overall, operational transport plan for a multi-modal transport chain handling goods by utilizing the relevant and most recent information that is available at the time of planning. The resulting transport plan encompasses the relevant information on the items to be transported as well as all details on the LSPs, transport legs, and required documents for executing the transport; this transport plan is then initiated within the BCM module (s.a.) for handling and controlling the execution. The second capability of the TPM is to support transport re-planning: an event related to an existing, ongoing transport

This module could be approached as a complement to the Exception Reporting module in WP300. It could serve functionalities like reacting on exception reports by re-planning of transports.

3.4.2.3 Related FIWARE requirements [20]

FInest.Epic.Data.TransactionNonRepudiation

Description: All inter-company transactions must be documented and their status (sent, received, rejected, responded to, etc.) archived to ensure that all parties to a transaction can prove what occurred with the transaction. This service must be implemented for any commercial use of an inter-company service if it is to be legally acceptable to the parties and in a court of law should a dispute arise

3.4.3 ENVIROFI

3.4.3.1 Summary

Large European communities generate significant amounts of valuable environmental observations at local and regional scales using mobile communication devices, computers and sensors which are mostly connected to the internet. These communities' environmental observations represent a wealth of information which is currently unused and therefore in need for integration with other fragmented data and information sources, traditionally managed by research and educational institutions and industries.

ENVIROFI [10] will explore the advances needed by the stakeholder communities for secure access to decentralized, interactive Internet-enabled geospatial and intelligent fusion services using data from authorities, researchers, people and private sector organisations. It will allow all these participants to plug in their personalised experiments and also feedback into the ENVIROFI Environmental Observation Web

3.4.3.2 Services and functionalities with applicability in the Agrifood supply chain.

The spectrum of usable-for-SmartAgriFood functionalities offered by this project focus mainly on the sharing of environmental information from and to real end-users, which could complement the SmartFarming Management Information System providing not only environmental information from external legacy services, but also from the other users(farmers), which could be in plenty of cases more precise, useful and trustworthy.

Personalized environmental information

This scenario is the core piece of the Personal Environmental Information System (PEIS) as it provides the user access to a plethora of environmental data in particular for air quality and meteorological events and the other scenarios cannot work without the data provided here. This includes past and upto-date observational data as well as forecasts derived from appropriate models for arbitrary locations.

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20 http://forge.fi-ware.eu/plugins/mediawiki/wiki/fiware/index.php/Unclassified_Themes/Epics/Features_Backlog#FINEST

In contrast to the other scenarios, the user is provided here with raw data which he has to interpret for himself.

Building a community of users (User input)

In addition to passively using the data from existing networks, the users can act as mobile sensors and supply (mostly qualitative) observations back into the system. In this way the user provides an additional layer of information to the PEIS and it will be possible to build a community of environmentally aware users. Within this scenario we identified so far two types of possible user reports, namely observational and health report. While the first type can in general be validated either by other users or the system, the second type is highly subjective.

At this point, we can understand that both types of data are crucial for the smart farming sector. A proper service could be deployed by the SmartAgriFood project that has the ability to process this incoming info and provide significant results not only to an end user but to the whole food chain and their stakeholders. For example, if an area is radioactive, this service can transfer the data to expert modules and possible to other services in order to be decided whether the goods that are produced within this range are eatable.

3.4.3.3 Related FIWARE requirements [21]

ENVIROFI.Feature.Security.GeospatialConstraints

Description: As a service provider need to define security-related authorization rules based on some geospatial constraints.

ENVIROFI.Epic.Data.ContextAwareMapService

Description: I as a developer/service provider of geospatially enabled applications I need a way to adapt "views" to a particular user's context before visualizing them.

ENVIROFI.Theme.VGI- Volunteered Geographic Information

Description: VGI is basically a form of crowdsourcing where volunteers submit **observations**. Concept of observations derives from OGC Sensor Web Enablement, and basically means "a structured piece of information, containing a temporal+spatial context, at least one value, some contextual information (e.g. units, uncertainty) and whatever else we deem appropriate.

ENVIROFI.Epic.Data.EnvironmentalAlertServices

Description: Allows both experts and the general public to setup and register alerts associated with environmental data, such as threshold levels in sensor datasets or categories of alert condition in environmental models.

ENVIROFI.Epic.Data.ObservationTrustManagementService

Description: The idea behind the enabler is that certain sources of data generators (volunteers as individual participants or groups, established sensor networks and stations owned by government

[21] http://forge.fi-ware.eu/plugins/mediawiki/wiki/fiware/index.php/Unclassified_Themes/Epics/Features_Backlog#ENVIROFI

agencies and entreprise, research institutions) may be more (or less) reliable than others. Therefore, we may wish to assign a priory higher level of trust to some data and information than others prior to the process of aggragating data and information for achieving situation awareness about the state of the environment. The primary target for this enabler (in ENVIROFI) is the data provided by participatory volunteers providing important localised observation data; inluding their own subjective sensing("human sensing"). This enabler should also be usable for data trust assessment generated by other organisations(public and private) that provide environmental observations using their own sensor networks and stations as well as model forecasts

ENVIROFI.Epic.Data.EnvironmentalResourceCatalogues

Description: Allows groups of environmental resource providers (data and services) to upload details of their resource for other providers and users to discover

ENVIROFI.Epic.Data.LinkedOpenEnvironmentalDataServices

As a scientist, decision maker, company or citizen interested in the state of the environment, I need (i) environmental data to be available; and (ii) a light-weight technical solution that allows me to browse and connect available pieces of information.

3.4.4 OUTSMART

3.4.4.1 Summary

The goal of OUTSMART [11] is to contribute to the Future Internet (FI) by aiming at the development of five innovation eco-systems. These eco-systems facilitate the creation of a large variety of pilot services and technologies that contribute to optimised supply and access to services and resources in urban areas. This will contribute to more sustainable utility provision and, through increased efficiency, lower strain on resources and on the environment. Reaching this goal requires the whole value chain, namely city authorities, utilities operators, ICT companies as well as knowledge institutions in order to have an industry driven approach when developing advanced services and technologies.

3.4.4.2 Services and functionalities with applicability in the Agrifood supply chain.

Amongst the great spectrum of functionalities present in this project, i.e. Water and Sewage, Street Lighting, Waste Management, Water and Environment, Sustainable Urban Transport, only a small portion has been identified as really useful for our Use Case, which comprises those dealing with waste management. These services offered by OUTSMART could be usable for those stakeholders that generate big quantities of waste product, and they could help these stakeholders to deal with the waste management in a more efficient, sustainable and automatic way. Water and sewage might also be a useful area since farmers pay attention in irrigating their farms with water that comes from the sea – processed or not. Also, since the water is a primary factor for the development of crops, the stakeholders of the farming area would be interested if ICT modules would help them reduce the risk of irrigating their farms with inappropriate water. So, data that come from the functionalities of Water and Sewage as well as Water and Environment could be composite in order to provide meaningful inputs to the Smart Farming Area.

We focus our study in the Waste Management Cluster, operated in Berlin, whose main focus is to develop and deploy a network of intelligent and communicative waste baskets throughout the city in order to optimize waste management in different aspects

"Intelligent" Waste Basket

IDEA

- Development of "intelligent waste basket" in order to optimize waste management
  - Waste basket knows about its own status and is able to communicate

DESCRIPTION

- Monitoring the fill level and frequency of use in waste bins
- Managing other incidents like defectiveness
- Gathering and evaluating the data from the waste baskets
- Adapting the logistics according to statistical/real time data
- Adapting the process of waste basket maintenance

BENEFIT

- Reducing costs by improving the logistics and the process of waste bin emptying and maintenance
- Reducing CO_2 emission
- Citizen benefits by paying lower / constant prices for waste collection

3.4.4.3 Related FIWARE requirements [22]

N/A. All of them are on the backbone layer, not on the (end-user) functional level.

[22] http://forge.fi-ware.eu/plugins/mediawiki/wiki/fiware/index.php/Unclassified_Themes/Epics/Features_Backlog#OUTSMART

3.5 Summary of Generic Enablers used by the subsystems

The SmartAgriFood system addresses all six GE chapters defined in FI-WARE (cf. section 2.1):

- Cloud Hosting – the fundamental layer that provides the computation, storage and network resources, upon which services are provisioned and managed.
- Data/Context Management Services – the facilities for effective accessing, processing, and analysing massive streams of data, and semantically classifying them into valuable knowledge.
- Service Delivery Framework – the infrastructure to create, publish, manage and consume FI services across their life cycle, addressing all technical and business aspects.
- IoT Services Enablement – the bridge whereby FI services interface and leverage the ubiquity of heterogeneous, resource-constrained devices in the Internet of Things.
- Interface to the Network and Devices –open interfaces to networks and devices, providing the connectivity needs of services delivered across the platform.
- Security – the mechanisms that ensure that the delivery and usage of services is trustworthy and meets security and privacy requirements.

The GEs targeted by each of the subsystems (Smart farming, Smart Logistics, Smart Food Awareness) linked to the architecture is listed in the table below. In addition, the table lists several generic SAF services that target the use of GE enablers, either by using them directly or by extending them by means of DSEs.

		Smart Farming Subsystem	Smart Logistics Subsystem	Smart Food Awareness Subsystem	Certification Services	Product Information Services	Business Relation Service	Identification Service
Cloud Hosting	Service management						X	
	Object storage		X	X				
	Cloud Edge		X					
Data/context management services	Multimedia Analysis			X				
	Metadata preprocessing		X					
	Query Broker					X		
	Pubish/Subscribe Broker		X			X		
	Complex event Processing		X			X		
Service Delivery Framework	Market Place	X					X	X
	Aggregator	X						
	Mediator	X					X	
	Registry							X
	Repository							X
	Registration							X
	Market Place Offerings							X

		Smart Farming Subsystem	Smart Logistics Subsystem	Smart Food Aware-ness Subsystem	Certification Services	Product Information Services	Business Relation Service	Identification Service
	Marketplace Search							x
	Unified Service Description Language (USDL)							x
IoT	Device management (Gateway)		x					
	Device management (Device)		x					
Security	Identity management					x	x	x
	Security Monitoring & Compliance							x
	Data handling					x	x	x
	Privacy							x
	USDL Linked Data Vocabulary for Security							x
Epic	Security, trust, Reputation					x	x	

4 References

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5 Appendix

5.1 Information processed, exchanged and shared – a detailed analysis

Here we present the results of the detailed analysis of relevant information to be processed, exchanged and shared over the entire value chain in form of a table:

	Data/Information definition				**Internal Data Only**	**Provision/Availability of info to actors**									
Actor	**Information Concept**	**Sub-concept**	**Types of values**	**Data format (binary, numerical, etc.)**		**Source of this data (yes/no)**	**Available to Farmer**	**Available to Marketing Coop**	**Available to Trader**	**Available to Logistics**	**Available retailer**	**Available to end consumer**	**Available to regulator/certifier**	**GS1 technology applicable/ Relevant Ontology**	**Comments**
Farmer	Farm (organisation)	Resposible person		String	No	Yes	Yes	Yes	Yes	No	No	No	Yes		
		Farm name		string	No	Yes	Yes	Yes	Yes	No	No	No	Yes	AGROXML/	
		GLN		GPS co-ordinates(?)	No	Yes	Yes	Yes	Yes	No	Yes*/No	Yes*/No	Yes*/No	GeoNames	yes, if branded products with label on the packaging (e.g. Landgard)
		Address	street/road	string	No	Yes	Yes	Yes*	Yes*	No	No	No	Yes	vCard	legally required traceability information farmer + next stages
			locality	string	No	Yes	Yes	Yes*	Yes*	No	No	No	Yes	vCard	
			county	string	No	Yes	Yes	Yes*	Yes*	No	No	No	Yes	vCard	
			region	string	No	Yes	Yes	Yes*	Yes*	No	No	No	Yes	vCard	
			zip/postcode	string	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	vCard	
		Country		string	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	vCard	

	Certification Details	- Scheme		string	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	AGMES	information required to market produce
		Certification Agency	Person		No	Yes	Yes	Yes	Yes	No	No	No	Yes	AGROXML	
		- Approval date		string (date ranges)	Yes	Yes	Yes	Yes	No	No	No	No	Yes	DateTime ontology	
		First Certification Date	date	string (date ranges)	No	Yes	Yes	Yes	Yes	No	No	No	Yes	AGROXML	
		Ambit		string	No	Yes	Yes	Yes	Yes	No	No	No	Yes	AGROXML	
		Validity	start date, end date	string (date ranges)	No	Yes	Yes	Yes	Yes	No	No	No	Yes	AGROXML	
		Agricultural Certification Code	string	string	No	Yes	Yes	Yes	Yes	No	No	No	Yes	AGROXML	
	Farm product	Cultivar/ Species		string	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	AGROVOC/AGROXML	legal information
		Variety		string	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	AGROVOC/AGROXML	
		Brand		string	Yes	Yes	Yes	Yes/No	No	No	No	No	No	AGROVOC/AGROXML	yes, if central procurement , no if not
		plant/seed Supplier	address	string	Yes	Yes	Yes	Yes/No	No	No	No	No	No	DAPLOS	yes, if central procurement , no if not
		Reference Part Of Field		string	Yes	Yes	Yes	No	No	No	No	No	No	AGROXML	
		Reference		string	Yes	Yes	Yes	No	No	No	No	No	No	AGROXML	

		Field													
		Primary / Secondary Product		prod-uct	Yes	Yes	Yes	No	No	No	No	No	No	AGROXML	
		GM State-ment			Yes	Yes	Yes	No	No	No	No	No	YEs	AGROXML	In accordance with EC 1829/2003 and EC 1830/2003
															yes, if central pro-curement , no if not
	Produc-tion	Growing Parameter	Weath er Condi-tions	string	Yes	Yes	Yes	Yes/N o	No	No	No	No	Yes*	Weather Ontology	* on demand for certification and control by authori-ties
			Soil Tex-ture	string	Yes	Yes	Yes	No	No	No	No	No	No	AGROVOC/A GROXML	
			Soil pH	nu-meric in some stand-ard meas-ure	Yes	Yes	Yes	No	No	No	No	No	No	AGROVOC/A GROXML	
			N conc.	nu-meric in some stand-ard meas-ure	Yes	Yes	Yes	No	No	No	No	No	No	AGROVOC/A GROXML	
		Glasss-house	Mul-tipe data	string	Yes	Yes	Yes	Yes	No	No	No	No	Yes*	AGROVOC/A GROXML	* on demand for certification and control by authori-

															ties
		Open field	Mul-tipe data	string	Yes	Yes	Yes	Yes	No	No	No	No	Yes*	AGROVOC/AGROXML	* on demand for certification and control by authori-ties
		Foil/No foil	Mul-tipe data	string	Yes	Yes	Yes	Yes	No	No	No	No	Yes*	AGROVOC/AGROXML	* on demand for certification and control by authori-ties
		planting date	Date/Time	string (date rang-es)	Yes	Yes	Yes	Yes	No	No	No	No	Yes*	DateTime ontology	* on demand for certification and control by authori-ties
		cultivation method	Stand-ard system	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	ISOBUS	* on demand for certification and control by authori-ties
			Growth Medi-um	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	AGROVOC/AGROXML	* on demand for certification and control by authori-ties
		Tillage	num-ber of appli-cations	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	ISOBUS	* on demand for certification and control by authori-ties
			Date/Time	string (date rang-es)	Yes	Yes	Yes	No	No	No	No	No	Yes*	DateTime ontology	* on demand for certification and control by authori-ties
			Meth-od	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	ISOBUS	* on demand for certification and control by authori-ties
		Pesticide Use	num-ber of appli-	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	AGROVOC/AGROXML	* on demand for certification and control by authori-

			cations												ties
			Type	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	AGROVOC/AGROXML	* on demand for certification and control by authori-ties
			Date/Time	string (date rang-es)	Yes	Yes	Yes	No	No	No	No	No	Yes*	DateTime ontology	* on demand for certification and control by authori-ties
			Quani-ty	nu-meric in some stand-ard meas-ure	Yes	Yes	Yes	No	No	No	No	No	Yes*	SI units ontology	* on demand for certification and control by authori-ties
			By whom	string	Yes	Yes	Yes	No	No	No	No	No	Yes*		* on demand for certification and control by authori-ties
		fertiliser used	num-ber of appli-cations	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	AGROVOC/AGROXML	* on demand for certification and control by authori-ties
			Type	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	AGROVOC/AGROXML	* on demand for certification and control by authori-ties
			Date/Time	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	DateTime ontology	* on demand for certification and control by authori-ties
			Quani-ty	nu-meric in some	Yes	Yes	Yes	No	No	No	No	No	Yes*	SI units ontology	* on demand for certification and control by authori-ties

				standard measure											
			By whom	string	Yes	Yes	Yes	No	No	No	No	No	Yes*		* on demand for certification and control by authorities
		Irrigation	Method	string	Yes	Yes	Yes	No	No	No	No	No	Yes*	AGROVOC/AGROXML	* on demand for certification and control by authorities
			Date/Time	string (date ranges)	Yes	Yes	Yes	No	No	No	No	No	Yes*	DateTime ontology	* on demand for certification and control by authorities
			Quanity	numeric in some standard measure	Yes	Yes	Yes	No	No	No	No	No	Yes*	SI units ontology	* on demand for certification and control by authorities
			Flow rate	numeric in some standard measure	Yes	Yes	Yes	No	No	No	No	No	Yes*	ISOBUS	* on demand for certification and control by authorities
		Harvest	Date/Time	date (point rather than range)	No	Yes	Yes	Yes	No	No	No	No	Yes*	DateTime ontology	* on demand for certification and control by authorities

			Batch No.	string	No	Yes	Yes	Yes	No	No	No	No	Yes*	DAPLOS	* on demand for certification and control by authori-ties
			Field/Lot	string	Yes	Yes	Yes	Yes	No	No	No	No	Yes*	DAPLOS	* on demand for certification and control by authori-ties
			Quan-itity	nu-meric in some stand-ard meas-ure	Yes	Yes	Yes	Yes	No	No	No	No	Yes*	SI units ontology	* on demand for certification and control by authori-ties
			Quality	String	Yes	Yes	Yes	Yes	No	No	No	No	Yes*	EFSA	* on demand for certification and control by authori-ties
			Price	nu-meric (cur-rency)		Yes	Yes	Yes	Yes	No	No	No	Yes*	EDIFACT	* on demand for certification and control by authori-ties
		Machine Work	Ma-chine used per process	Ma-chine	Yes	Yes	Yes	No	No	No	No	No	No	AGROVOC/AGROXML	
		Person Work	Work-ers used per process	Person	Yes	Yes	Yes	No	No	No	No	No	Yes*	AGROVOC/AGROXML	
	Post-Harvest treat-	- which		string	Yes	Yes	Yes	Yes*/No	Yes*/No	Yes*/No	Yes*/No	Yes*/No	Yes*	AGROVOC/AGROXML	yes, if legally re-quired (e.g. Thia-bendazol on Or-

	ment														anges) + on demand for authorities / irrelevant if only dealing with cucumbers and tomatoes
		Date/Time		date (point rather than range)	Yes	Yes	Yes	No	No	No	No	No	Yes*	DateTime ontology	* on demand for certification and control by authorities / irrelevant if only dealing with cucumbers and tomatoes
		- quantity		numeric in some standard measure	Yes	Yes	Yes	No	No	No	No	No	Yes*	SI units ontology	* on demand for certification and control by authorities / irrelevant if only dealing with cucumbers and tomatoes
	Packaging	- packaging type	RTI (returnable Crate), Cardbord, single units	string	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	EDIFACT	legal + obviours, * part of the order from traders
		- units		numeric in some standard measure	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	SI units ontology	legal information, * part of the orders from traders

		- GRAI (BoxID)		nu-meric in some stand-ard meas-ure	No	Not col-lecte d	Yes	Not col-lected	Not col-lecte d	Not col-lecte d	Not col-lecte d	Not col-lecte d	No	EDIFACT	
Marketing Coopera-tive / Trader	Trader Details	- GLN		GPS co-ordi-nates(?)	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	GeoNames	traceability infor-mation
		Address	street/ road	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	EDIFACT	traceability infor-mation
			locality	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	
			county	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	
			region	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	
			zip/pos tcode	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	
		- country		string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	EDIFACT	
		- responsi-ble person		string	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	EDIFACT	
	Certifica-tion Details	- Scheme		string	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	EFSA	information re-quired to market produce
		- Approval date		date (point rather than range)	Yes	Yes	No	Yes	Yes	No	No	No	Yes	DateTime ontology	
	Stock infor-mation	- Product (GPC)		string	No	Yes	Yes	Yes	Yes	No	Yes	No	No	EDIFACT	
		- Quantity		nu-	Yes	Yes	No	Yes	Yes	No	No!	No	No	SI units	no! = confidential

				meric in some standard measure										ontology	information not to be shared at all!
		- Supplier / Member		String	Yes	Yes	No	Yes	Yes	No	No!	No	No	EPCIS	no! = confidential information not to be shared at all!
		- packaging type		date (point rather than range)	No	Yes	No	Yes	Yes	No	No!	No	No	DateTime ontology	no! = confidential information not to be shared at all!
		- Arrival date/time		date (point rather than range)	Yes	Yes	Yes	Yes	Yes	No	No!	No	No	DateTime ontology	no! = confidential information not to be shared at all!
		- Storage duration		string	Yes	Yes	No	Yes	Yes	No	No!	No	No	EPCIS	no! = confidential information not to be shared at all!
		- certification		**string**	No	Yes	Yes	Yes	Yes	No	Yes	No	No	EFSA	
	Demand Information	- Product (GPC)		string	Yes	Yes	Yes	Yes	Yes	No	No!	No	No	EDIFACT	no! = confidential information not to be shared at all!
		- Quantity		numeric in some standard measure	Yes	Yes	No	Yes	Yes	No	No!	No	No	SI units ontology	no! = confidential information not to be shared at all!
		- certifica-		String	Yes	Yes	Yes	Yes	Yes	No	No!	No	No	EFSA	no! = confidential

		tion details													information not to be shared at all!
		- packaging type		string	No	Yes	No	Yes	Yes	No	No!	No	No	EDIFACT	no! = confidential information not to be shared at all!
		- Order date/time		date (point rather than range)	Yes	Yes	Yes	Yes	Yes	No	No!	No	No	DateTime ontology	no! = confidential information not to be shared at all!
	Quality Control	- Pre-harvest Laboratory analysis		numeric in some standard measure	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes*	SI units ontology	* on demand for certification and control by authorities
		- Inspection results		numeric in some standard measure	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes*	SI units ontology	* on demand for certification and control by authorities
	Distribution Information	Order		numeric in some standard measure	Yes	Yes	No	Yes	Yes	Yes	No	No	No	SI units ontology	
		- Customer		string	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	EBXML	traceability information
		- Product		String	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	EPCIS	traceability infor-

		(GPC)													mation
		- Quantity		numeric in some standard measure	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	SI units ontology	traceability information
		- Order Date		date (point rather than range)	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	DateTime ontology	traceability information
		- Haullier / LSP		String	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No	EPCIS	traceability information
	Goods outward	- Order		numeric in some standard measure	No	Yes	No	Yes	Yes	Yes	Yes	No	No	SI units ontology	
		- Distribution date		date (point rather than range)	No	Yes	No	Yes	Yes	Yes	Yes	No	No	DateTime ontology	
		- Quantitiy		numeric in some standard measure	No	Yes	No	Yes	Yes	Yes	Yes	No	No	SI units ontology	

Trad-er/Distributor	Haulier Name/Company	Name		string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	EPCIS	
		- GLN		GPS co-ordi-nates(?)	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	GeoNames	traceability infor-mation
		Address	street/ road	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	traceability infor-mation
			locality	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	
			county	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	
			region	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	
			zip/postcode	string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	
		Country		string	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	vCard	
		- responsi-ble person		string	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes		
	Certifica-tion Details	- Scheme		string	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	EFSA	
		- Approval date		date (point rather than range)	Yes	Yes	No	Yes	Yes	No	No	No	Yes	DateTime ontology	
	Tour Infor-mation	- Vehicle registration number		string	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes*	EDIFACT	* on demand for certification and control by authori-ties
		- Trailer ID number		string	Yes	No	No	No	No	Yes	No	No	Yes*	EDIFACT	* on demand for certification and control by authori-ties

		- Recent loads	Load 1	string	Yes	No	No	No	No	Yes	No	No	Yes*	EPCIS	* on demand for certification and control by authori-ties
			Load 2	string	Yes	No	No	No	No	Yes	No	No	Yes*	EPCIS	* on demand for certification and control by authori-ties
			Load 3	string	Yes	No	No	No	No	Yes	No	No	Yes*	EPCIS	* on demand for certification and control by authori-ties
	Monitor-ing Infor-for-mation	- Vehicle Position		GPS	Yes	Yes	No	No	No	Yes	No	No	No	INSPIRE	
		- Tempera-ture		nu-meric in some stand-ard meas-ure	Yes	Yes	No	No	No	Yes	No	No	No	SI units ontology	
		- Humidity		nu-meric in some stand-ard meas-ure	Yes	Yes	No	No	No	Yes	No	No	No	SI units ontology	
		- Vehicle Status		string	Yes	Yes	No	No	No	Yes	No	No	No	INSPIRE	
		- Fuel us-age rate		nu-meric in	Yes	Yes	No	No	No	Yes	No	No	No	SI units ontology	

				some standard measure											
		- Fuel Quantity		numeric in some standard measure	Yes	Yes	No	No	No	Yes	No	No	No	SI units ontology	
		- … other Sensor data		numeric in some standard measure	Yes	Yes	No	No	No	Yes	No	No	No	SI units ontology	
	Delivery Details	- Arrival Date / Time		date (point rather than range)	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	DateTime ontology	
		- Delivery handed over to		string	No	Yes	No	Yes	Yes	Yes	Yes	No	No	ebXML	
		- Temperature at delivery		numeric in some standard meas-	No	Yes	No	Yes	Yes	Yes	Yes	No	No	SI units ontology	

				ure											
		- Quantity		nu-meric in some stand-ard meas-ure	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	SI units ontology	
		Desination	street/ road	string	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	vCard	
			locality	string	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	vCard	
			county	string	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	vCard	
			region	string	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	vCard	
			zip/pos tcode	string	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	vCard	
Sensors	Obser-vation Meas-urement	result	value	dou-ble	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	SensorML	
		phenome-nonTime	when	date	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	SensorML	
		resultTime	when	date	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	SensorML	
	System	location	where	gml	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	SensorML	
		position	where	gml	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	SensorML	
		interfaces	ac-cess inputs and out-puts	string	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	SensorML	
		inputs	type	string	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	SensorML	
		outputs	type	string	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	SensorML	

Retailer	Retail details	- GLN		GPS co-ordi-nates(?)	No	Yes	No	Yes	Yes	Yes	Yes	No	No	GLN/GeoNames	traceability infor-mation
		Address	street/road	string	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	vcard	traceability infor-mation
			locality	string	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	vcard	
			county	string	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	vcard	
			region	string	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	vcard	
			zip/postcode	string	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	vcard	
		- country		string	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	vcard	traceability infor-mation
		- responsi-ble person		string	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	foaf	
	Stock infor-mation	- Product (GPC)		string	Yes	Yes	No	No	No	No	Yes	No	No	EPCIS	
		Batch number		nu-meric	Yes	Yes	No	No	No	No	Yes	No	Yes	EDIFCAT	
		- Quantity		nu-meric in some stand-ard meas-ure	Yes	Yes	No	No	No	No	Yes	No	No	SI units ontology	
		- Supplier / Member		string	Yes	Yes	No	No	No	No	Yes	No	No	EDIFACT	
		- packaging type		string	Yes	Yes	No	No	No	No	Yes	No	No	EDIFACT	
		- Arrival date/time		date (point rather than	Yes	Yes	No	No	No	No	Yes	No	No	DateTime ontology	

				range)											
		- Storage duration		string	Yes	Yes	No	No	No	No	Yes	No	No	EDIFACT	
		Refrigeration		numeric in some standard measure	Yes	Yes	No	No	No	No	Yes	No	yes*	SI units ontology	* on demand for control by authorities
		- certification		string	Yes	Yes	No	No	No	No	Yes	No	No	EFAS	
	Quality Control	- Laboratory analysis		numeric in some standard measure	Yes	Yes	No	No	No	No	Yes	No	yes*	SI units ontology	* on demand for control by authorities
		- Quality Inspection results		numeric in some standard measure	Yes	Yes	No	No	No	No	Yes	No	yes*	SI units ontology	* on demand for control by authorities
	Order Information	- Product (GPC)		string	Yes	Yes	No	Yes	Yes	No	Yes	No	No	EPCIS	no! = confidential information not to be shared at all!
		- Quantity		numeric in some stand-	Yes	Yes	No	Yes	Yes	No	Yes	No	No	SI units ontology	

				ard measure											
		- certification details		string	Yes	Yes	No	Yes	Yes	No	Yes	No	No	EFAS	
		- packaging type		string	Yes	Yes	No	Yes	Yes	No	Yes	No	No	EDIFACT	
		- Order date/time		date (point rather than range)	Yes	Yes	No	Yes	Yes	No	Yes	No	No	DateTime ontology	
		Purchase Price		numeric in some standard measure	Yes	Yes	No	Yes	Yes	No	Yes	No	No	SI units ontology	
Consumer	Farm product	Vegetable type		string	yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	AGROVOC/AGROXML	
	Processed food product	Commercial name		string	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Not always	EDIFACT	
		Ingredients	type	string	No	Yes	No	No	No	No	Yes	Yes	Yes	EDIFACT	
		Allergy status		string	No	Yes	No	No	No	No	Yes	Yes	Yes	EFAS	
		Certification	type	string	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	EFAS	
		carbon footprint		numeric in some stand-	No	Yes	No	No	No	No	No	Yes	No	SI units ontology	

				ard measure											
		water footprint		numeric in some standard measure	No	Yes	No	No	No	No	No	Yes	No	SI units ontology	
		Origin	Geographic	GPS coordinates(?)	No	Yes	Yes	Yes	No	No	Not always	Yes	Yes	geoNames	
		Distance travelled	kilometres	numeric in some standard measure	Yes	Yes	No	Yes	Yes	Yes	Not always	Yes	No	SI units ontology	
		Chemicals used	cf. above	numeric in some standard measure	No	Yes	No	No	No	No	No	Yes	Yes	SI units ontology	for example: organic farming certificate

5.2 Stakeholder Needs and Requirements

Here we provide a description of the requirements on the super-scenario from the direct stakeholders' perspective regarding the facilitation of Future Internet technology. Much of this material is based on research undertaken within WP700, and some results have already been presented in D700.1:

Direct Stakeholders:

One of the most significant challenges facing the agri-food sector is the very large number of small- and medium sized actors in the early stages and large-sized enterprises at the later staged of the food sector as well as their heterogeneity. This leads not only to differences of coping with private and public requirements, but also in differences in the readiness of adopting ICT solutions and their effective facilitation. Especially in rural areas, the **most important precondition and requirement is the training of the users**, as most of them do not have appropriate experience about using the Internet, due to so called white spots, where broadband internet access was not possible in the past.

1. Producer (Farmer)

Critical success factors:

– yield
– quality
– meeting requirements (GAP)
– price

Costs

– Farmers need affordable ICT solutions with low investment barriers. But also, the food industry needs to boost ICT investments to cut down on production costs and to increase operational efficiency.
– Low-cost IT solutions, lower costs for implementing the new or advanced applications is also a priority, as currently the price of the technologies required is too high particularly for smaller enterprises.

Timeliness and scale of the data/information exchange

– Longer range in data exchange/transfer and in communication and timely provision of data to react to relevant events on time.
– User-friendly applications and interfaces, improved filtering and systematic organization of the received, stored, sent or browsed data - even on demand by a predetermined profile –should support the users in the future.

Compatibility

– Interoperability between services and systems from different providers
– compatibility of the different applied devices, programs and systems
– full integration of systems instead of different connected applications.
– Rule-based processing of huge amounts of data (e.g. from sensors) in order to detect critical situations
– The future applications should be easy to use and easy to setup (Plug and Play, automation of functions, decision support, etc.)

- Optimization of farming through process automation and faster reactions to changing conditions (enabled through real-time data acquisition and decision support from the system).

Security and privacy

- To protect the environment and humans against hardware and software defects and to prevent unauthorized access to private data of the farmer and to protect against data tampering.

A farmer (owner) should have the opportunity to:

- Avoid possible fruit and vegetables quality degeneration and machine damages based on real-time monitoring information to enable reactions to critical conditions.
- Increase yield and produce better quality and safer products by using less pesticides, enabled by effective control and monitoring of plant diseases and stress in order to enable the efficient application of chemical agents.
- Cultivate the right crop based on advisory system even without previous own experience in order to enable a better facilitation of resources and maintaining natural resources (e.g. soil)
- Manage farm resources more efficiently in general with comprehensive farm management systems.
- Decrease the cost of investment
- Advertise his products easily
- Get immediate access to technical support
- Link and exchange easily with other stakeholders
- Better link with government and certification authorities
- Reduce tractor and other agricultural machines down-times and increase maintenance and repair cycles
- Optimize spraying volume by ICT farming, thereby saving costs and increasing revenue
- Reduce the effort to meet legal requirements and requirements of the major buyers (food manufacturers, retailers)
- Better meet the consumers' expectations

2. Trader/Distributor/Retailer

Critical success factors of trader:

- Quality
- Safety
- Price

Critical success factor of distribution centres:

Costs

- Affordable solutions for SMEs
- Low costs for implementation and system maintenance
- Integration into existing ICT infrastructure
- Training of employees / users for efficient use

Timeliness and scale of the data/information exchange

- Real-time exchange of product and process related data
  → better coordination (timing of delivery, route planning, fleet management etc.) and better information for all actors within the logistics chain for decision making
  → order-to-delivery lead-times may be reduced significantly
- Rule-based processing of huge amounts of data (e.g. from sensors) in order to detect critical situations
- Exchange of information between companies ad hoc without developing individual interfaces by linking existing systems in a flexible and easy way.
- Responsive logistics networks for proactive control of processes.
  Support a timely and error-free exchange of logistics information and provide functionality for intelligent analysis and reporting of exchanged data to enable early warnings (for e.g. Surgical response in case of food alert, for quick and precise recall/withdrawal of products) and advanced forecasting (for e.g. establish and forecast considerable stock changes)
  → possibility to ensure food safety and quality, increase efficiency and effectiveness
  → cost reduction in respect of all logistics processes.

Availability

- Solutions independent of geographic locations (always available, independent of the current location)

Traceability

- Flexible tracking and tracing systems encompassing the whole value chain
  → informed decision support and possibility to ensure food safety and quality
- Possibility of the identification of shipping units (crates, boxes)

Compatibility

- Standardization
  → compatibility and possibility for interoperability, because users in the chain may have different systems, services and devices, which currently often cannot communicate or act together.
  → standardisation of content, especially of product quality and safety information

Security and privacy

- Secure exchange of process & product related data (incoming / outgoing)
- Anonymity and secure access to data (access control)
- Secure Payment Support: payment platform for a secure money transfer for B2B services.

3. Consumer:

Cost

- Reducing time and money in the shopping act are both fundamental issues to be covered in the system design.
- Costs for access to information
- Systems and devices

Product information (quality, origin, ingredients)

- A consumer wants to obtain information on the products he/she buys, in a fast, easy, reliable and thorough way. Consumers expect to be able to access this information while doing the shopping in the supermarket in order to identify which products best matches their interests, demands and needs. This information may also be accessible to the consumer after shopping using an on-line service for post-shopping information, which can be provided by the supermarket.
- Additional support while shopping, fitting the users' interests and expectations on food.
- Direct contact with food producers can be supported.
- Create an ecosystem for food information and awareness, leveraging the concept of prosumer, i.e. a consumer is able to create new services (based on templates and customization) that can be shared with other consumers with similar interests.

Trust: Reliablity of product information

- Quality aspects are very important for consumers; they expect to be informed when food alerts regarding quality and security anomalies are detected.

Additional requirements:

- Mobility: Get information everywhere (mobile app, PC home).
- Search: find product retailer according to product attributes (e.g. tomato from Greece).
- Privacy: no digital footprint about usage of services, location, personal data protection.
- Payment capability: Possibility of performing secure payments via the mobile phone.

5.3 Materialization of Domain Specific Enablers for the Product Information Service

5.3.1 Peer-to-Peer Connectivity

In the last years P2P networks had become generally known from file sharing networks, such as Napster, BitTorrent, etc. Beside of that P2P networks are also used for Grid Computing (e.g. SETI@home) and for internet broadcasting services (e.g. Spotify). What they have in common is that each computer in such a network can act as a server and a client simultaneously, because of that all participants in this network are called peers. For the product information service this means that a peer can act on one hand as an information or service provider, and on the other hand as a service or information consumer.

On top of that these peers (servers and clients) are able to spontaneously create a self-organised network, which offers a great flexibility to the software developed on top of this network and also maps the business relationships between the actors in the product supply chain. Summarised the P2P network can be seen as an overlay or virtual network on top of the real physical network (see Figure 5-1).

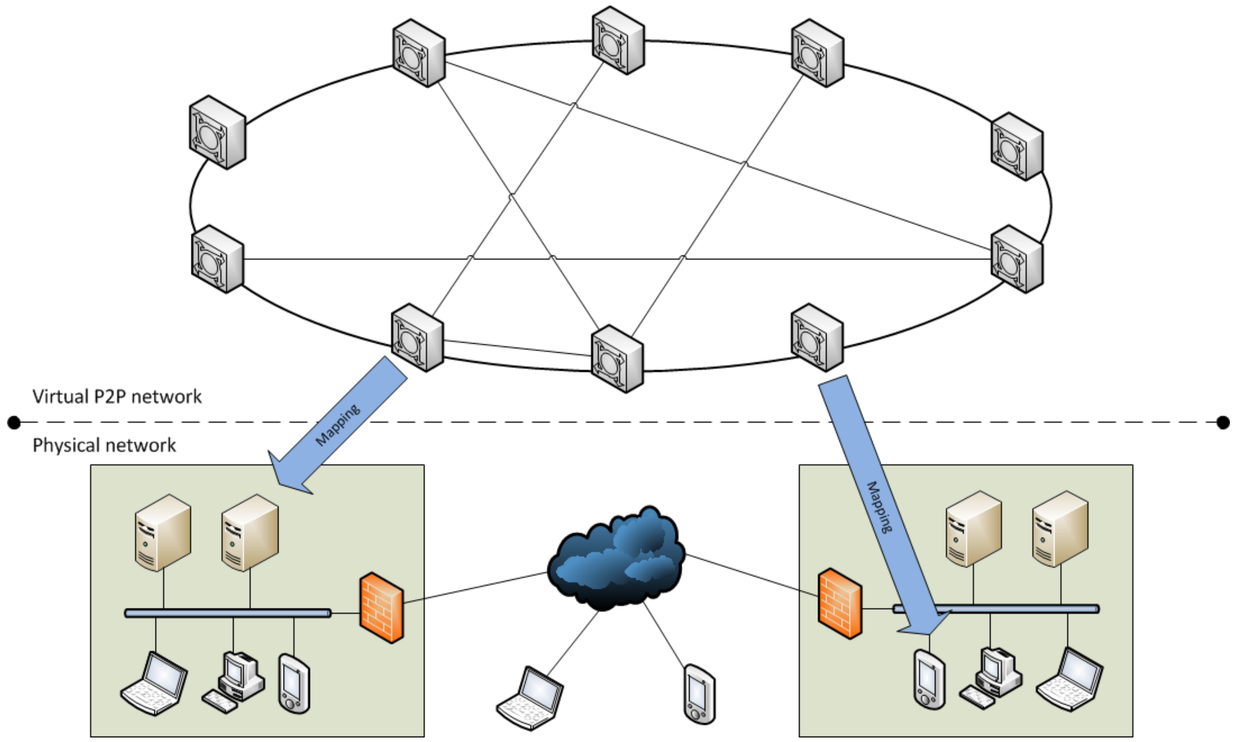

Figure 5-1 Mapping between physical network and P2P network

While P2P often refers to a totally decentralised system, most of the developed systems are having a certain degree of centralisation depending on their needs and visions. One can differ between three types of P2P networks:

- Pure P2P: In a pure P2P system all nodes are totally equal; this means that there are no “special” nodes establishing a basic infrastructure.
- Centralized: In a centralised P2P system a central server is used to bootstrap the network and has the ability to lookup for other peers, services and content.
- Hybrid: Hybrid means a combination between the peer-to-peer (P2P) and centralized approach, by establishing some nodes with special capabilities to establish an infrastructure in-

cluding indexing capabilities, enabling them to support routing and lookup within the network. The determination of these nodes is not configured a priori, since all nodes can become such an infrastructure node.

Within the product information service we will focus on the latter approach and materialising it with the open-source framework JXTA (JXTA). Because the future of JXTA and its fork Chaupal is unclear, the development also keeps in mind to support different P2P protocols such as Gnutella2.

5.3.1.1 Service advertisement and discovery approach in hybrid P2P networks

One of the biggest problems in P2P networks this discovery of information and services. In opposite to centralised networks in which one instance is in charge of a set of information or knows where to find them, P2P networks offering the ability to offer information and services in a distributed manner.

To solve this problem the Product Information Services uses a service advertisement approach, which allows all peers within a network to publish their capabilities to the network. These advertisements are sent to special peers within the network, the rendezvous peers. Rendezvous peers are realising the indexing of advertisements and act as a search and discovery hub. On top of that they are also forwarding received advertisements to other known rendezvous peers (see Figure 5-2), which can be seen as a subnet within the P2P network. To fulfil their roles within this subnetwork, they should be stable and reachable most of the time, keeping in mind that “response time, message and query throughput, and advertisement cache management are all important performance factors for a rendezvous peer“ (Halepovic, Deters, & Traversat, 2004).

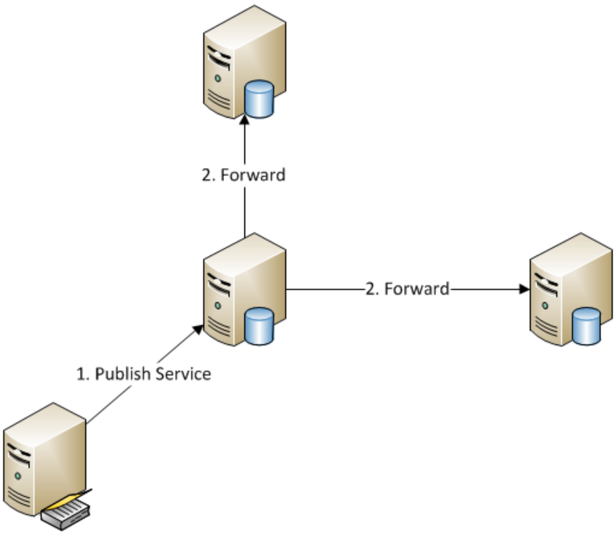

Figure 5-2: Service advertisement

The second important role of the rendezvous peers is the support of the discovery process. If a peer is searching for some sort of information or service, it queries the rendezvous peer it is connected to. If this peer doesn’t know any peer offering the desired service, it propagates the request to all known rendezvous peers. When the propagated request reaches a rendezvous node which knows a peer offering that service it forwards the request to the service provider. The service provider sends its advertisement directly to the querying peer (Figure 5-3). If the querying peer receives more than one advertisement as result it can decide which one it will use.

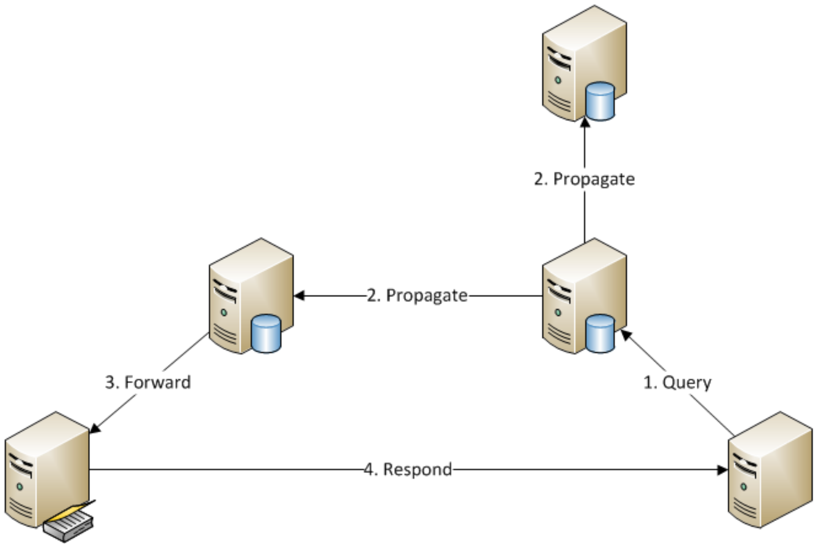

Figure 5-3: Service Lookup

5.3.2 Information Lookup Services

5.3.2.1 Object Naming Service

The Object Naming Service (ONS) is part of the EPCGlobal Network. The mechanism behind describes how to resolve an EPC to services related to the product behind the EPC. To achieve this goal the ONS facilitates the DNS mechanism for resolving domain names.

The first step is to convert the EPC into a format a DNS server understands. This is done by creating an artificial subdomain of the GS1 domain "onsepc.com" illustrated in Figure 5-4 and described in the GS1 ONS specification.

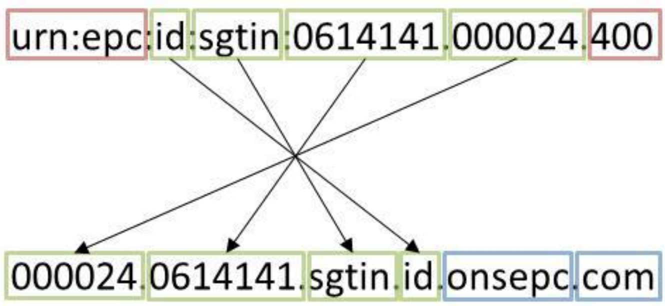

Figure 5-4: Example EPC to DNS Query Transformation

Afterwards the query is passed to the ONS server, which returns (if available) a list of NAPTR records. Each record presents a service pointer which consists of six fields:

- Service Type: A short string to identify the type of service which is attached to this record, starting with the prefix "EPC+". To reference an EPCIS it will return "EPC+epcis".
- Priority: The ONS will always return 0.
- Preference: This number allows the ordering of different services. An ONS client should prefer services with lower values first.
- Flag: The ONS will always return the flag 'U' for URI.
- Regular expression: Per default NAPTR records include a regular expression string, to allow the client to construct a URI out of their request by applying the pattern. ONS reduces the complexity by allowing only a full replacement with some URI.
- Replacement: The ONS will always return a single period '.'.

Advantages

Because ONS is based on DNS, which is a centralised and hierarchal system, the speed to find the right ONS server and query it is quite high and comparable to a common query for A or CNAME records.

On top of that, the only person who is allowed to change or add an entry to the ONS server is the owner of the EPC. If any other company wants to register a custom service or attach information to such an ID, it has to ask the EPC owner first, who can check and verify the trustworthiness of the source. This helps to guarantee the genuineness of the registered information sources.

Disadvantages

The advantage of the administrated registration of information services can also been seen as a disadvantage. If someone has information about a given product, but the owner of the EPC is not willing or does not care to add it to an ONS server, other users might not be able to discover this information.

On top of that the owner of the EPC might also be able to identify the whole chain of distribution, which might have a detrimental effect on the competiveness of a stakeholder.

5.3.2.2 Passive P2P Lookup Service

The passive P2P approach allows the registration of more than one ONS server, in fact everybody can create an ONS server to allow the registration and usage of own information systems like EPCIS. To reach this goal this approach utilises the P2P service advertisement described before, by publishing its own capabilities to resolve IDs to service URIs. According to Figure 5-5 this happens in two independent steps:

1. Peers with ONS capabilities advertise to and register their services on the rendezvous peer they are connected to.
2. EPCIS servers which have information about a certain product, promoting this to trusted ONS peers.

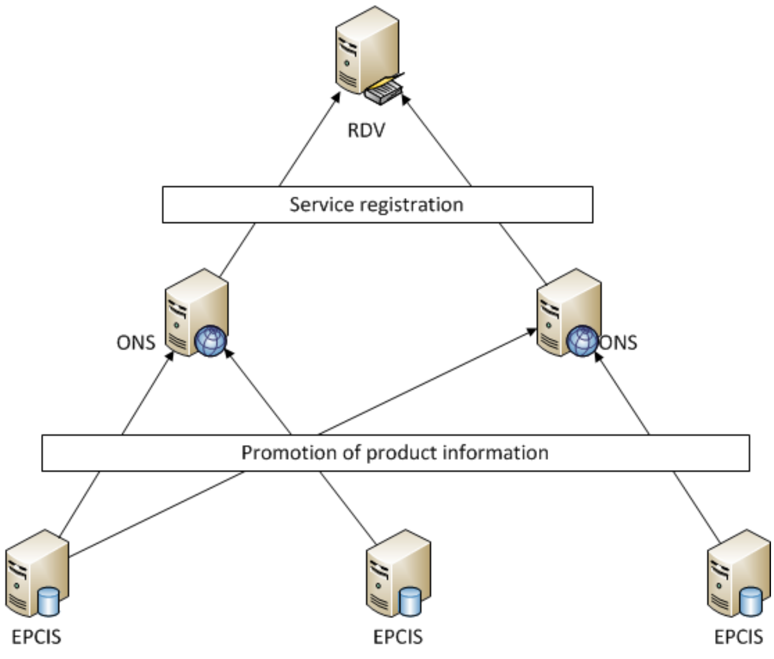

Figure 5-5: Passive P2P Lookup Service establishment

After all necessary information is published the system is ready to be queried by a peer. This procedure can be split up in three steps (see Figure 5-6):

1. The peer searches for available ONS peers by querying the rendezvous peer it is connected to. If some peers are found there advertisement is returned asynchronously to the querying peer.

   The querying peer now asks all or a subset of the available ONS peers, if they know EPCIS servers which can provide more information about a given product. If these peers have a registered EPCIS for this product they can return correspondent NAPTR records (see section 5.3.2.1).
   Note: ONS peers can also deny the resolution of the ONS query based on different criteria (e.g. access rights, etc.)

2. The received NAPTR records can now be used to finally query the available EPCIS servers for information about the product.

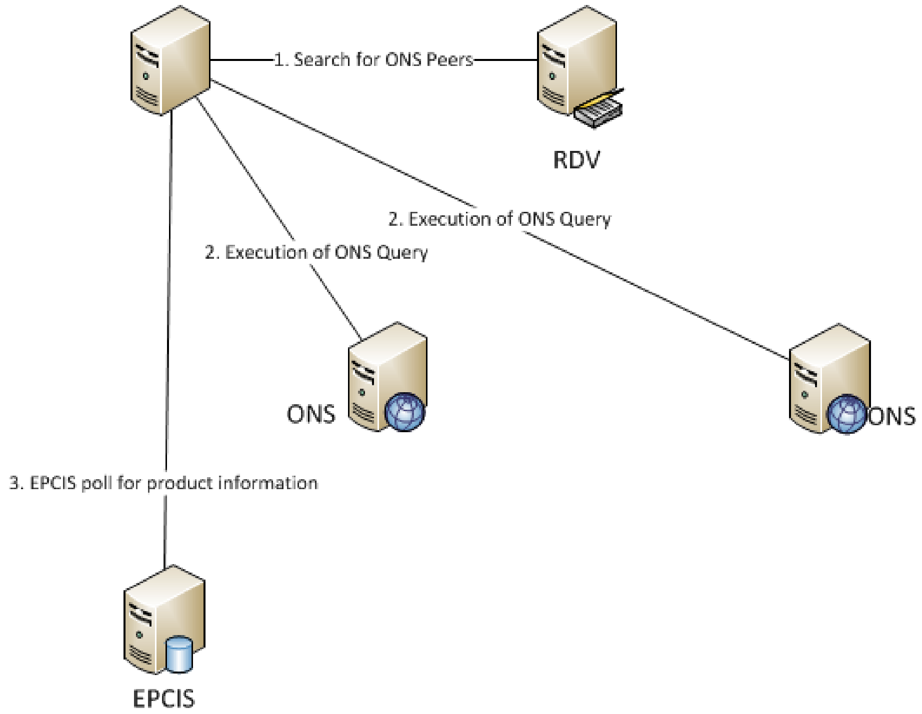

Figure 5-6 Passive P2P Lookup Service Querying

Advantages

In opposite to the official ONS approach everybody is allowed to add and offer information to any identifiable product. On top of that this approach doesn't reveal the business relations, because each ONS peer can decide on its own which information sources will be revealed to which querying peer. This also holds for the EPCIS servers, which can decide what amount of information is shown to the client.

Disadvantages

Depending on the amount of available peers offering ON-Services the scalability of the system can quickly become a problem, because each available ONS peer must be queried for the targeted ID. While the cost function is still linear (see Equation 5.1), the amount of available ONS peer can reach high values inside the whole supply chain. The worst case would be that each actor will host its own ONS peer.

$$O(n+m)|n = number\ of\ ONS\ peers \wedge m = number\ of\ EPCIS\ servers \quad 5.1$$

A solution of this problem might by the establishing of dedicated ONS by associations or similar cooperative entities. A different approach is discussed in chapter 5.3.2.3 and 5.3.2.4.

Another problem is that everybody can claim to have information about a product. This raises the need to establish mechanism to ensure and check the reliability of these nodes.

5.3.2.3 Active P2P Lookup Service

In contrast to the passive lookup service described in the chapter before the EPCIS are publishing the availability of product information directly to the P2P network. The publishing of the availability of information is quite similar to the publishing of services, but instead of creating a service advertisement the EPCIS peers are publishing a content advertisement for each of the known products (see Figure 5-7).

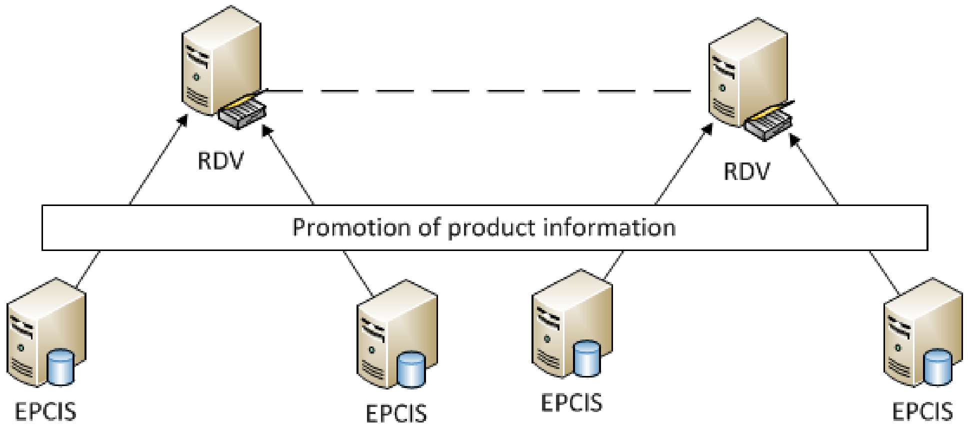

Figure 5-7: Active P2P Lookup Service establishment

To discover the needed information the searching peer directly queries its connected rendezvous peer for the product. If this peer doesn't know a peer offering this information, it will propagate the query to known rendezvous peers (see Figure 5-8). This action is almost identical to the approach of the passive ONS, but allows the peer to query directly for the information, by dropping the ONS-Peer layer.

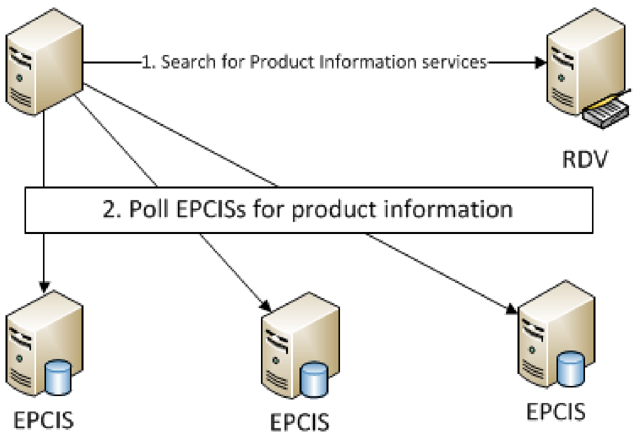

Figure 5-8: Active P2P Lookup Service Querying

Since it would be quite ineffective that each rendezvous peer propagates the query to **all** known peers (so called flooding search), it creates one to k so called random walker (Liv, Cao, Cohen, Li, & Shenker, 2002). A walker is basically a message which is sent to a randomly selected neighbour node, which will propagate it to the next one until the information is found or a number of walks is performed. The number of walks is defined through time-to-live (TTL) field inside the walker itself.

Advantages

The elimination of the ONS layer has a high impact on the scalability of the network, while reducing the number of queries needed for searching information from $O(n+m)$ to $O(m)$(see Equation 5.1). Since this approach is quite similar to file sharing networks, it is already tested and applied in real life scenarios.

Disadvantages

The probability to find all information inside an extremely large P2P network can't be guaranteed by 100%, because the number of queried rendezvous peer n (and because of that the information search) is limited by the time-to-life value t used by the random walker algorithm and the amount of walkers k created:

$$n = t \cdot k \qquad 5.2$$

This leads to the question, is there an optimal value for $\boldsymbol{k}$ and $\boldsymbol{t}$ by a given $\boldsymbol{n}$ which allows an optimisation between a tolerable network load and a high search quality? While (Liv, Cao, Cohen, Li, & Shenker, 2002) recommend an amount of 16-64 walkers, this must be adapted and evaluated to the current situation on the network and the priority of the request.

5.3.2.4 Local ONS

Another decentralised approach is the installation of a local ONS inside a company. Because the order and the delivery of products are based on real life business contracts, the companies already know each other. This allows the exchange of the location of product information sources through traditional mediums, such as mail, phone, etc. These locations can be stored on a company based ONS system, which allows the company to find the right information source based on the product sender/receiver.

On top of this approach a hop-to-hop communication can be established, which supports the forwarding of a request to the next pre-/successor(s) in the chain, until the current owner or the actual producer is reached.

Advantages

This materialisation of the information lookup has the lowest querying cost because only the local ONS has to be queried which directly points out to the information sources of the product. On top of that the security and reliability is higher than in two approaches before, because new information sources can only be added by known companies and their pre-/successor(s), which results in a high probability that companies who claim to have product information, own(ed) the product. This cannot be guaranteed in the two procedures before.

Disadvantages

The system works extremely well until a predecessor or successor in chain is not willing or cannot provide such an information service. This will highly limit the result, because the information flow and query propagation is cut off on this "dead" node. Furthermore this can also lead to a high amount of (relay-) traffic, which may not be applicable to be handled by each company. This would also turn such a company to a dead node.