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Inventory of Future Capabilities of Internet to Meet Future Long and Short Term Needs of the Food Sector

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Authors:	Robert Eigenmann, Nikola Vucic, Markus Dillinger, Katalin Viola, Florian Meyer, David Quesada Pimentel, Jack Verhoosel, Alexandros Kaloxylos, Ioanna Lampropoulou, István Gábor, Carmen Perea Escribano, Harald Sundmaeker
Contributors:	ASI, AST, ATB, ATOS, CBHU, CENTMA, DLO, HWDU, KTBL, MTT, NKUA, OPEKEPE, TNO.
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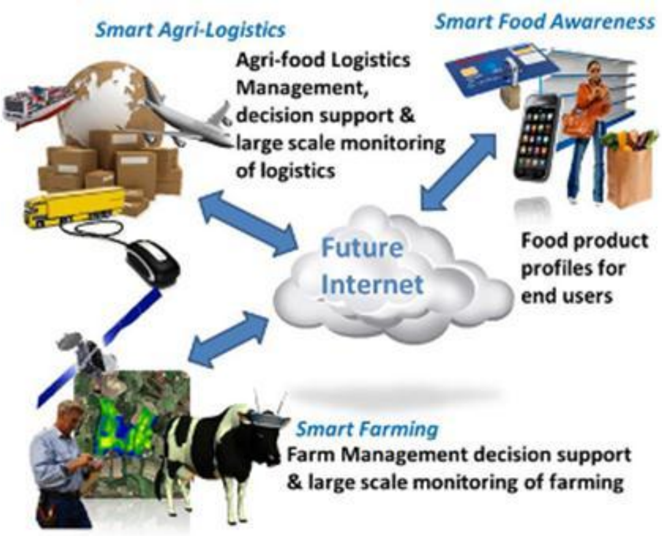
The SmartAgriFood Project

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.

Project Consortium

- LEI Wageningen UR; Netherlands
- ATB Bremen; Germany
- TNO; Netherlands
- CentMa GmbH; Germany
- Atos ORIGIN; Spain
- ASI S.L.; Spain
- Huawei; Germany
- MTT Agrifood Research; Finland
- KTBL e.V.; Germany
- NKUA; Greece
- UPM; Spain
- Campden BRI Magyarország; Hungary
- Aston University; United Kingdom
- VTT; Finland
- OPEKEPE; Greece
- John Deere; Germany
- Wageningen University; Netherlands
- EHI Retail Institute GmbH; Germany
- GS1 Germany GmbH; Germany
- SGS S.A.; Spain
- Bon Preu SAU; Spain

More Information

Dr. Sjaak Wolfert (coordinator)	e-mail:	sjaak.wolfert@wur.nl
LEI Wageningen UR	phone:	+31 317 485 939
P.O. Box 35	mobile:	+31 624 135 790
6700 AA Wageningen	www.smartagrifood.eu	

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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)	

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Executive Summary

The Future Internet Public-Private Partnership (FI-PPP) Programme has been launched by the European Commission in 2011 with the aim to increase the effectiveness of business processes and infrastructures supporting applications in different areas (e.g. food, transport, health or energy) and to derive innovative business models that strengthen the competitive position of European industry in sectors such as telecommunication, mobile devices, software and services, and content provision and media. It will deliver the core platform of the future internet, which will be an open architecture and a reference implementation of a novel service infrastructure, building upon generic and reusable building blocks. This core platform will be provided by the FI-WARE project, which is collecting requirements from eight different usage areas. The SmartAgriFood project is one of the eight use case projects with the goal to identify, analyse and verify the requirements from the Agri-Food sector for the future internet. In the SmartAgriFood project, three usage areas have been identified and will be handled in parallel in order to deep-dive into the technical challenges of the specific usage requirements: Smart Farming, which is dealing with the efficient food production, Smart Logistics, which handles the transportation of agricultural products and Smart Food Awareness, which analyses the requirements from the consumer point of view on transparent information about the goods.

This work is performed in the scope of the Task 720 – ICT Community Involvement. Its main purpose is to instigate a dialogue between the agri-food and ICT worlds by informing each other about the existing and the planned functionalities of the Future Internet.

We followed the approach to first get feedback from the food chain users on their needs and expectations on the future internet. Second, the current internet solutions and available technologies have been investigated in order to identify existing information and communication solutions that potentially can be used today. Then, the generic and reusable building blocks (the “generic enablers”) of the future internet core platform are explained to the user community, providing application examples related to the collected requirements. In order to best explain the future internet to the user community, technical terms have been avoided where possible and examples in the usage areas have been provided.

Future Needs of Food Chain User:

In total 135 questionnaires in 6 countries and 8 focus group discussions with 69 participants in 5 countries have been performed and analysed, collecting feedback on the interpretation of the future internet capabilities from the user’s perspective, the current use of internet applications in their daily work and today’s problems or limitations resulting in the expectations and requirements to the future internet.

The test showed that the most important function of the Future Internet is the protection of private data: Ensuring of safety and security of data and information is been seen as the essential element of the Future Internet. Most of the users were worried about unauthorized use of their data, when enabling functionalities like cloud hosting. Availability of databases should be regulated and controlled to guarantee the data security and protection. Second important function is the interoperability of networking devices: The professional users require that services and business processes should be available and maintainable on any equipment or device, independent from the location. Further demands address the affordability of Internet solutions and devices, which is expressed especially from small and medium enterprise stakeholders. It is expected that especially the cloud hosting services will provide benefit for small enterprises, which need not 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.

Just a few respondents use really advanced internet technologies available already today. The majority of the respondents use basic and simple systems and applications as mailing systems, browsers and web-sites, or proprietary tools. It may be concluded that the potential benefits of the Internet to simplify work processes, support interactions of different stakeholders and enrich the work with supporting information is not yet transparent to the stakeholders. When suggesting concrete potential Future Internet applications to the users, the response became more specific:

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

For the logistics section of transportation and distribution of food, appealing Future Internet applications are to share online monitoring information from trucks during the transport of cargo, a flexible solution for on-demand dock reservation and an integrated freight and fleet management. In general, all the selected applications have the same practical benefits as cost reduction, better coordination and better information for decision making, and the proactive control of processes leading to increasing efficiency and effectiveness. 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 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. According to the logistics area, today's solutions are hindered by missing standards on data interfaces and processes. In addition, the widespread use of the RFID tags or QR codes needs to available at a low cost.

Available Internet Functionalities

Today's Internet already provides a wide range of functionalities, services or applications, which are already applied - or could be more intensively applied in the agriculture business. The "Internet" is regarded as the principle of information exchange based on the Internet Protocol (IP), covering carrier networks (e.g. LAN or mobile networks), client/server solutions (e.g. database servers and reporting clients), network devices (e.g. PCs, smartphones), services (e.g. voice calls, Email, WEB-browsing), applications (e.g. Google search, Wikipedia) and security (e.g. data encryption, authentication).

With regard to the main user requirements stated previously, data from different locations have to be linked and joined, while at the same time guaranteeing data access policies. Today's cloud products, data warehouse services and policy management solutions already provide the platform for this requirement, even with the potential to restrict IT costs for small companies through "renting" of the infrastructure or software on demand. However, existing solutions are specific and proprietary, mostly having their own specifications about the functionality they provide and the means to interwork with other services. Further, 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.

The Future Internet

With the FI-WARE project, the core platform of the Future Internet will be developed. As the basic principle, FI-WARE is aiming to provide an open architecture which shall be applicable for any industrial area, open to any vendor and supporting the creation and delivery of any service. It will provide a set of commonly used functional modules (the Generic Enabler, GE) that can be re-used through a standardized Application Programming Interface (API). Although the Generic Enabler will be defined by partners in the FI-PPP project consortium, any company can provide a FI-WARE compliant platform product with own pricing strategies. Through the open API and the modular concept it will be possible to select appropriate FI-WARE platform products provider from a set of vendors. Further, there will be FI-WARE instance providers which bundle a set of FI-WARE platform products and potentially enrich the functionality with Specific Enablers for differentiation on the market. Those FI-WARE instance products could e.g. implement a specific Agri-Food FI-WARE instance by integrating domain specific services, e.g. the link to weather forecasting services or the interface to specific databases for e.g. tracking and tracing. Finally, FI-WARE applications on top of a FI-WARE instance will provide the tools for the users.

The generic Enabler and their relevance to AgriFood are:

- Cloud Hosting: The "Cloud Hosting" concept is the basic enabler for providing scalable computation, software, data access, and storage services. With a cloud, users can rent software as a service or only an infrastructure (e.g. data storage), keeping investments for small companies low. Small software companies will be competitive, as the cloud provides the possibility to focus on the application development without the need to implement a full functional platform. This also reduces time to market for new developments.
- Data/Context Management: The Data and Context management implements facilities for transfer, conversion, storage, analysis and access of huge amount of data through the cloud. Further, instead of just processing "data", the meaning of the data is linked, allowing end-users to interpret the data in the context. This functional block will enable a manifold of applications, e.g. intelligent decision support systems for farming or logistics, video or image processing for surveillance of the product quality or the integration of food or product specific ontologies or vocabulary.
- Internet of Things Services Enablement: Instead of only connecting computers and servers, the internet of things (IoT) takes all physical objects into account and extends the capabilities of entities to process information autonomously, react proactively and context sensitive to their current environment. It will support the communication, resource management, data handling and process automation of sensors, RFID systems, or pee-to-peer machinery communication. It would support scenarios of e.g. online greenhouse management, remote machinery diagnostics or tracking of goods and their quality.
- Applications/Services Ecosystem and Delivery Framework: These GEs will enable the creation, composition, delivery, monetization, and usage of applications and services on the Future Internet. It also supports business aspects related to the service provisioning, such as offering, accounting, billing and SLAs. Through composition of components developed and provided by different parties, new services tailored to the needs of specific usage areas can be provided. It offers the potential for e.g. Farm Management Systems, virtual market places for goods and services (e.g. transportation, spraying), legal compliancy and quality certifications, advisory services (e.g. e-veterinarian) or discussion groups of stakeholders.
- Interface to Networks and Devices: A broad range of devices will be enabled to communicate in the Future Internet through any wireless or fixed physical network connection at any place. Users will have their working environment and their applications, independent of the device, the location, the service provider or local (legacy) infrastructure. This enabler ensures one of

the top priority demands of the food chain users, having a seamless service anywhere and anytime with any device.

- Security: Common to any application is the strong requirement of privacy, integrity and security, providing the foundation to get acceptance and trust from all stakeholders. It handles aspects of encryption, data access policies, fraud- and intrusion detection and identity management. The success of a manifold of Future Internet scenarios will rely on a proper implementation of the security aspects, ensuring that data will be only accessible from an authorized set of stakeholders and for the agreed purpose.

As a summary, the Future Internet will provide the missing link of today's already available (mostly) proprietary solutions through a open architecture and standardized interfaces. This allows a flexible composition of services to specific solutions in the Agriculture business. The enablers are fully supporting the demands of the food chain users in terms of a technical platform.

However, the Future Internet will not solve the issue of missing domain-specific standards (e.g. vocabularies, certificates, processes), which are required to have an end-to-end transparency of food and related attributes.

The deliverable is organized in the following way. The introductory Section 1 starts by briefly summarizing the detected user needs in the food sector, as well as their expectations from the FI. This section is complemented by an overview of general FI trends and their potential reflections in agriculture-related applications from the ICT experts' point of view. The following Sections 2-4 focus on the three sub-usage areas of Smart Farming, Smart Agri-Logistics, and Smart Food Awareness defined in the SmartAgriFood project. In these sections, firstly, the possibilities of the ICT solutions, which are already available but seem to be underused, are presented. This is followed by explanations of the envisioned FI generic enablers (GEs). The GEs in this document are mainly based on the related work of the FI-WARE (Core Platform) project in the FI PPP programme. The explanations of the enablers are of high-level nature and encompass a minimum amount of technical details necessary to understand the matter. As these GEs are applicable in many fields of interest (energy, environment protection, multimedia, ...), their presentation is tailored to the above-mentioned agricultural sub-usage areas at hand. The exposition is illustrated by a number of potential applications of these enablers in the respective areas, proposed by the ICT partners in the SmartAgriFood project. Finally, the report is concluded in Section 5.

Abbreviations

3GPP	3rd Generation Partnership Project
AAA	Authentication, Authorization, and Accounting
A-GPS	Assisted GPS
API	Application Programming Interface
CAPEX	Capital Expenditures
CDI	Connected Devices Interface
CT	communication technology
D	Deliverable
E2E	End to End
EDI	Electronic Data Interchange
EDI-teelt	Dutch standard for data exchange in arable farming
EIC	Electronic Identity Card
eID	Electronic Identity
EPC	Evolved Packet Core
EPoS	Electronic Point of Sale
ERP	Enterprise Resource Planning
ETL	Extraction, Transformation, Load
ETSI	European Telecommunications Standards Institute
FI	Future Internet
FI-PPP	Future Internet Public Private Partnership
FI-WARE	Future Internet (FI) Core Platform Project
FMIS	Farm Management Information System
FODM	Field Operations Data Model
GE	Generic Enabler
GML	Geography Markup Language
GPS	Global Positioning System
GSM	Global System for Mobile Communication
IaaS	Infrastructure as a Service
ICT	Information and Communication Technology
IDaaS	Identity as a service
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IoT	Internet of Things
IP	Internet Protocol
IP	Internet Protocol
ISOBUS	Data bus mainly used in agricultural application. Compliant to ISO 11783
IT	information technology
ITU	International Telecommunication Union
LAN	Local Area Network
LTE	Long Term Evolution
M2M	Machine to Machine
MANET	Mobile Ad-Hoc Network
NetIC	Network Information and Control
NFC	Near Field Communication
OLAP	Online Analytical Processing
OWL	Web Ontology Language
P2P	Peer to Peer
PaaS	Platform as a Service
PALM	Precision Agriculture Markup Language
PDA	Personal Digital Assistant
PIN	Personal Identification Number
QoE	Quality of Experience
QoS	Quality of Service
QR code	Quick Response Code (two-dimensional)
RADIUS	Remote Authentication Dial In User Service
RDF	Resource Description Framework
RDFS	Resource Description Framework Schema
RFID	Radio Frequency Identification
ROOL	RISC OS Open Limited
S3C	Service, Compatibility, and Control
SaaS	Software as a Service
SAP	Systems, applications, products
SCADA	Supervisory Control and Data Acquisition
SLA	Service Level Agreement

UDDI	Universal Description, Discovery and Integration
UMTS	Universal Mobile Telecommunications Network
UN/Cefact	United Nations Centre for Trade Facilitation and Electronic Business
USDL	Unified Service Description Language
VANET	Vehicular Ad-Hoc Networks
VoIP	Voice over IP
W3C	World Wide Web Consortium
Wi-Fi	Equiv. WLAN, wireless LAN
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
GS1 Germany GmbH	GS1	Germany
SGS International Certification Services Ibérica, S.A.	SGS	Spain
Bon Preu, S.A.	BonPreu	Spain

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1 Introduction

1.1 SmartAgriFood Project Abstract

This section shall give a rough overview about the project objectives and contents from the SmartAgriFood description of work.

The SmartAgriFood project addresses farming, agri-logistics and food awareness as an extreme use case for the Future Internet. The intelligence, efficiency, sustainability and performance of the agri-food sector can be radically enhanced by using information & decision support systems that are tightly integrated with advanced internet-based networks & services. Concurrently, the sector provides extremely demanding use cases for Future Internet design from physical layer all the way up to the service layer. This project will focus on three sub systems of the sector - smart farming, focussing on sensors and traceability; smart agri-logistics, focusing on real-time virtualisation, connectivity and logistics intelligence; and smart food awareness, focussing on transparency of data, availability of information necessary to informed decisions and knowledge representation. Using a user-centred methodology, the use case specification will be developed with a particular focus on awareness (which cover the case when the consumers and customers have needs for facilitating their informed decisions and the case when they need additional information, because they feel uncertainty about the verity of claims and feel of risks – this later is called as transparency) and interoperability of data and knowledge across the food supply chain.

Project results will include:

- Use Case descriptions for smart farming, including sophisticated and robust broadband sensing and monitoring of animals and plants
- Use Case descriptions for smart agri-logistics, including intelligent transport and real-time logistics of agri-food products
- Use Case descriptions of smart food awareness, focussing enabling the consumer with information concerning safety, health, environmental impact and animal welfare to allow informed decisions.
- Identification of generic requirements for the generic enablers
- Extensive community and user organisation involvement both in requirements gathering, pilot demonstration, and evaluation
- Specification of interfaces and functionalities for integration to Core Platform,
- Significant contributions to standardisation and regulatory bodies in Europe.

1.2 Future Needs of Food Chain Users

In the task 710 of the SmartAgriFood project the objective was to screen the users' expectations in a more general, broader scope e.g. to identify their operational problems and their ideas for new (current and future) internet based functions and services. The additional objectives of this task were to collect more information and knowledge about the users' expectations and needs and to collect ideas about possible applications in the future which complement the use case scenario specifications carried out in work packages on Smart Farming (WP200), Smart Agri-Logistics (WP300) and Smart Food Awareness (WP400).

A questionnaire survey was carried out in six countries (Germany, Hungary, Finland, Greece, United Kingdom and Spain, which volunteered to carry out the interviews) to provide an input for the development of the focus group discussion guide in three different areas of the agri-food chain which were Smart Farming, Smart Agri-Logistics, and Smart Food Awareness.

Altogether 135 interviews were carried with respondents representing all stakeholders of the targeted application area of the food chain (Table 1).

Table 1: Details of Interviews

Country	Total	Sub-use case Area			Method of the interviews		
		Farming	Logistics	Food Awareness	personal	phone	self-filling
Hungary	47	15	16	16	32	12	3
Finland	18	8	1	9	1	13	4
Germany	32	15	7	10	9	15	8
Greece	15	15	0	0	5	6	4
Spain	17	8	2	7	0	7	10
UK	6	1	2	3	4	0	2
Total	135	62	28	45	51	53	31

After the mutual approval of the focus group discussion guide two or one focus groups per country were carried out in five countries (Hungary, Finland, Germany, Greece and United Kingdom) to have a better understanding about the needs and expectations related to the functions of the Future Internet of the food chain members, based on the findings of the interviews (Table 2).

Table 2: Details of focus groups

Country	Total number of participants	Number of focus groups	Sub-use case Area		
			Farming	Logistics	Food Awareness
Hungary	16	2	12	2	2
Finland	6	1	3	1	2
Germany	20	2	12	2	6
Greece	19	2	19	0	0
UK	8	1	4	2	2
Total	69	8	50	7	12

In addition a short presentation and a list were developed in Task 720 by the ICT expert members of the consortium on the envisaged advanced capabilities and functions of Future Internet for creating awareness of the food chain members. This list of the functions of Future Internet was discussed between CBHU and Hungarian ICT experts and was converted by CBHU for non-ICT professionals in the agrifood-chain. This list was presented to the respondents before the interviews and was shown to the participants of focus groups.

1.2.1 Functions of Future Internet as interpreted by non-ICT specialist users

1. **Function 1.** The Internet is not limited to self-standing PCs – direct communication is possible between the machines, equipment, sensors, mobile phones, household refrigerators etc. With integrated PCs:

- Services and access to the network do not depend on the location, they are available everywhere
- Direct control and harmonization of machines and equipment for a higher efficiency and saving time
- Integrated services, integrated evaluation of information
- A practically applicable standardization is a prerequisite.

2. **Function 2.** There is mobile equipment as data collector, data viewer (display) and information transmitter.

3. **Function 3.** Quick and real-time exchange of large amount of data/video/3D information is possible.
    - Presentation of information by 3D technology – e.g. labels of a packaging can be readable by rotating in space
    - Virtual design facilities, 3D technologies.

4. **Function 4.** Content based browsing - intelligent distribution and caching of content – each piece of information and each object gets an individual ID code. We need to specify properly what we want to know, but we don't have to know where to find it.

5. **Function 5.** Services of customized information – automatic integration of information on demand
    - Users can determine the selection and filtering criteria what type of information should the information pack contain what they receive.

6. **Function 6.** It is possible to positioning with higher accuracy for exact identification of objects, and controlling of the (agricultural) machines, equipment.

7. **Function 7.** Cloud computing – it is able to handle tasks requiring high data processing, computing capacity. Users do not need to have their own infrastructure; it is available and accessible through the internet at low cost, when it is necessary. Interworking is possible between local sub-systems and global system (cloud).

8. **Function 8.** Higher privacy which guarantees the protection of personal data.

9. **Function 9.** Global data warehousing and management capability is available (application for diseases, pesticides, fertilizers, foreign body, reference samples, etc.).

10. **Function 10.** Ability to monitor meeting set technical requirements and initiate automatic corrective actions and/or alarming system operators.

During the focus groups the participants were asked about the importance of the listed functions by ranking them from the most important one to the least important one. The total test showed that the two most important functions of the Future Internet by the opinion of professional users were **Function 1** (the Internet is not limited to self-standing PCs) and **Function 8**. (higher privacy - guarantee for the protection of personal data).

Beyond the expectations and ideas which are included in final reports on Smart Farming, Smart Logistics and Smart Food Awareness use cases there are some additional ideas and expectations derived from the questionnaire survey carried out in Task 710.

The findings and the results of the questionnaire survey are summarised below.

1.2.2 Current use of electronic applications

Based on the results of the implemented questionnaire survey we recognized that there are several advanced **electronic applications** which are used in the area of three sub-use cases. However these applications have several limitations which need to be solved to make the exchange of information easier, quicker and more efficient.

There are several advanced electronic applications which are used and have a specific role in area of farming.

- Using precision soil sampling with GPS and satellite technology for planning fertilization and pest control. The satellite positioning system makes it possible to separate the areas requiring different treatments within the field and to collect exact area data about the patterned field. Due to this the most effective crop production can be performed on the specific field areas.
- Using on-board computer in grain harvesting machines which shows the changing yield and moisture values during work. The change of the suspension volume during fertilization is monitored on the fertilizer spreader's computer.
- Using Pear Technology System to map where pest controls and fertilisers have been used.
- Using farm management system for controlling “herd”, estimation of production, yield estimates, recording data of production, organization of breeding in order to achieve better farm management and fulfil their expectations.

In logistics the most developed applications are the electronic ordering system (EDI) and the stockholding system:

- Electronic ordering systems (e.g. EDI – Electronic Data Exchange), which offer the opportunity for the contracted parties to record the details of their orders and the ordered products/services into the common system and to modify the details of their orders (e.g. change the amount of the ordered products, change the delivery time, etc.).
- Stockholding systems, which include:
  - a central database (often after a manual data record);
  - RFIDs – to store the relevant information about the product;
  - mobile devices and scanners (PDA) for recording the data;
  - networks within a site or company to ensure the connection between the database, the RFIDs and the scanners.
- Email marketing services to e.g. DotMailer [1] to contact suppliers and collect contact information.
- EPoS (Electronic Point of Sale) to record stock movement.

Regarding to food awareness and food processing methods along the supply chain there are several systems and applications which are used and have specific role, as:

- Using semi -automatic business management software and system (e.g. SAP, ROOL) for helping companies to get the most out of their IT investments, to maximize their business performance with control of production (e.g. production monitoring, production management, trade coordination, transport scheduling, invoice handling, etc.). The database is based on an internal system, which is isolated and manually operated.
- Using detectors for visualising the physical contamination in the products during food processing (e.g. colour sorters, metal detector, X-ray detector, image analyser, etc.). Some of these detectors are calibrated by standards or image identification is made by comparison of the actual images with those which are available in the local library of the machine.

- EPoS provides businesses a fast and convenient way of transacting sales, while at the same time recording vital business information.
- DotMailer is email marketing with an intuitive, easy to use email marketing platform.
- Online accounts for members "through a web service".

Just a few respondents use really advanced technologies; the majority of the respondents use basic and simple systems and applications as mailing systems, browsers and web-sites.

The most general devices and applications which are used in every use case are GPS systems, video control systems, mobile devices, sensors, data recorders and different industry - or sector - specific software programs (planning and documentation software, FMIS solutions, ERP system, etc.)

1.2.3 Problems and limitations

The uses of new electronic and/or internet-based solutions and applications have several **problems and limitations**. These limitations can be observed in different areas such as quantity and quality of information, communication, data transfer and operation of devices and applications.

Information and communication flow:

- The lack of the automated processes and activities in data recording, transferring and exchanging make the required information flow slow.
- There are limited information and accessible databases available on the current internet.
- In many cases most of the available information is inaccurate and unreliable.
- Sensitivity: The systems are sensitive under weather changes and don't provide reliable measurements.
- Most of the respondents are using paper based communication and using manual data recording.
- Large sized files, photos and videos cannot be transmitted.
- In many regions there is no complete network coverage in place (e.g. the web is not accessible) or the internet services are hobbling because of network congestion.
- Morphology: Not all places have access to the internet or other networks.
- Sensors are not connected to local systems via Internet, thus the information flow is not adequate.
- Limited precision of the current GPS systems.

Compatibility:

- The current devices and files cannot be combined with each other and are not standardized.
- The different applications for different processes (e.g. invoicing, accounting, stockholding, ordering systems) are not compatible with each other within a company.
- The different applications are not compatible between the systems of the different partners.

Price and usability of technologies:

- There are no appropriate applications or the applications and solutions are too expensive; in addition the use of these applications is often very complicated.
- There are no appropriate sensors for specific tasks or the existing sensors are inaccurate.
- A common problem of companies that they have a lack of financial resources, thus they can't invest in the development.

Users' experience:

- Users usually have limited information about the new technologies and devices or they cannot use the new application.
- The users do not see a need to change the system they are already using.
- Complexity: many systems are not user friendly so they can't be used by all users. In fact they offer many features in complicate interfaces.
- Multilingual support: (Electronic Point of Sale) Most of the systems don't offer native language user interfaces so people, who are not familiar with English or other languages have a difficulty to operate them.
- Moreover, the lack of ensuring the appropriate privacy and accessibility increase the distrust between the partners.

There are some common **demands and expectations**, which need to be realized in the future to eliminate the limitations and problems mentioned by users.

Basic demands for the cost:

- 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. If a company handles a smaller stock, the operation of these technologies is not cost-effective.

Basic demands for the accessibility and privacy:

- Ensuring the accessibility to the data, which are secure and can be restricted.
- Availability of databases should be regulated and controlled to guarantee the data security and protection.

Basic demands for the data exchange:

- **compatibility** of the different applied devices, programs and systems or **integrated systems** instead of different connected applications;
- **longer range** in data exchange/transfer and in communication (to extend the range of currently used most advanced technologies like WiFi);
- **higher accuracy** in positioning: measured and recorded value should be delimited to an area as small as possible – for more accurate estimations and control (e.g. cm accuracy of GPS instead of meters);
- 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 - the measured and recorded information and data should be available in a database automatically.

1.2.4 Expected applications

In the different sub-use cases there are some **future internet or electronic based solutions and expected applications** of overriding importance, which may be relevant and efficient in the future. The expected applications are listed on order of priority, first is the most applicable; last is the least applicable by the participants' opinion of focus groups, who were asked to divide the ideas into two groups (applicable and not applicable). Detailed explanations of the below listed applications are given in deliverable D 700.1 (Inventory of Long and Short Term Future Needs of Food Chain Users for Future Functions of Internet). Below we just list them.

I. Smart Farming

- System for selecting the cultivated plants based on a database
- Monitoring environment for farms and plants – Advisory system
- Barcode/RFID system -Traceability system facilities
- Improvement of the daily work of the farmer/breeder
- Shared infrastructure
- Yield information system
- Monitoring environment for animal welfare, sensors in barn/stable
- Risk assessment
- System for extraneous and foreign bodies' identification

II. Smart Agri-Logistics

- Road monitoring application
- Dock reservation system
- Integrated freight and fleet management for vending machines and small retail outlets
- Secure banking system
- Flexible parking system for delivery to shops
- Smart household storage
- Service-halls" in the basement of apartment buildings
- Small depots for personalized supply of perishable foods

III. Smart Food Awareness

- Monitoring of food quality
- Improved awareness information system based on traceability
- Communication of product-related information towards the consumer
- Exchange of product-related information between agri-food enterprises
- Informed decisions of consumers based on tailor made information selected according to their criteria
- Profile specific newsletters and dissemination of information
- Virtual shops and virtual visits
- Connected automatic systems
- Improved diet and health through personalised nutrition
- Foreign material identification

1.3 Envisioned Future Internet Capabilities for FI-PPP

Today we see already a trend, that web computing for enterprises increasingly leads to better business efficiency. These web computing capabilities are supported by latest browser technologies (Internet Explorer, Safari, Firefox, Opera, etc.) and require data centres or clouds to run web based computing. FI-PPP capabilities have to support contextual, semantic, programmable, social and mobile solutions for the complete agri-food chain. Already today we see increasingly, that enterprises deal with consumer markets than with business markets. Farmers, supermarket chains will have an advantage when addressing end users over companies that don't. FI-PPP should support present and future cloud solutions.

Two basic approaches are emerging as competitive solution architectures: cloud-hosted and cloud-optimized.

Cloud-hosted applications are based on legacy software which runs on virtual machines in cloud. Solutions require a minimal amount of redevelopment, while preserving portability, but do not leverage the elastic properties of cloud-optimized solutions.

Cloud-optimized software takes advantage of elastic usage of cloud resources when needed. For instance, if applications need additional cloud resources they can be allocated on demand. The owner of this application must then pay for extended resource consumption. Solutions take advantage of the new computing (and payment) models possible in the cloud, and, within this category, additional architectural divergence is the norm.

Application developers may choose to construct custom-made cloud applications atop infrastructure as a service, without the benefits of cloud application infrastructure, which requires advanced knowledge of parallel programming, concurrency and scalability, but provides the maximum amount of platform flexibility. Alternatively, they may choose a cloud application infrastructure, such as application platform as a service, which provides a robust combination of development tools and frameworks and a programming language, and constructs optimized for multi-tenancy and concurrency, and a runtime container that supports natively the cloud computing constructs.

In Figure 1 we see a state-of-the-art farm management system and its logical interfaces for Smart Farming (Future Farm EU project, [2]).

We can see similar local architectures for Smart Logistics and Smart User Awareness, i.e. proprietary solutions lacking of interoperability between disjoint systems. In addition, the needed transactions between dedicated solutions are neither standardized nor specified.

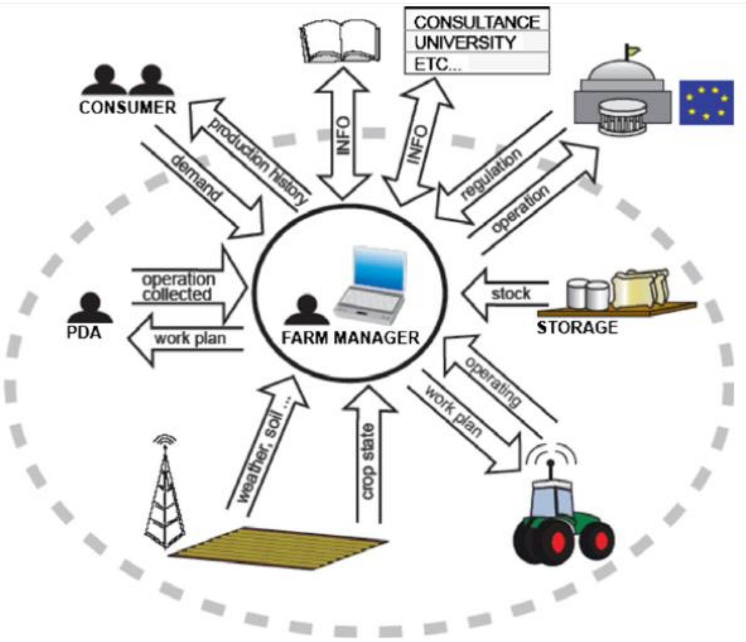

Figure 1: State-of-the-art FMIS

The local architectures do not consider the Future Internet capabilities. In FI-PPP we expect locally installed systems, which may only have temporary connection to the Internet. The local systems will provide selected functions and data from the cloud services for offline usage, while synchronizing with the global cloud servers. This concept is known as the "cloud proxy" in FI-WARE.

For a better interworking, the following aspects need to be addressed by FI:

- Information Standards (product/article codes, logistics information codes, messaging, standards for identification systems (e.g. RFID))
- Chain Information Management (e.g. integration of enterprise systems to a Virtual Integrated Enterprise (VIE) which ensures end-to-end cooperation between single enterprises, logistic and quality tracking and tracing, identification systems in supply chain (e.g. RFID)
- Enterprise Information Systems (status and planning of products and processes within one enterprise
- Enterprise-to-Government (information exchange between enterprises and government)

Above systems must address key topics for a broad adoption of stakeholders:

- Existing standards such as ISOBUS, AgroXML [3], EDI-teelt, UN/Cefact, etc. need to be harmonized or efficient interworking needed by e.g. a protocol/data conversion in the FI network. FI must cope with present standards and their future modifications.
- Design approaches for FI software solutions following the Internet of Things and Services paradigms currently under development in FI-PPP
- Policy and stakeholder profile specifications are needed
- Policy servers and their proxies for privacy, storage, transport (QoS), data processing, etc. which enforce stakeholder requirements in the network, such as:
  - Flexible privacy settings for storing sensitive data and transactions
  - Flexible storage of information, data processing functions and local decision makings based on communications constraints (e.g. precision farming in patchy cellular environment)

  – Network resilience mechanisms for reliable and safe communications

- Intrinsic use of geographical information, security, weather info, etc. in information transport. For instance, a stakeholder can specify in which regions he places his advertisements and internet routers must prevent routing in forbidden areas

In the following paragraphs we extend the architecture to cater for local and global subsystems. The goal is to ease communications between different stakeholders and to minimize ICT investments for these stakeholders. Cloud services with generic enablers will facilitate such minimal investments.

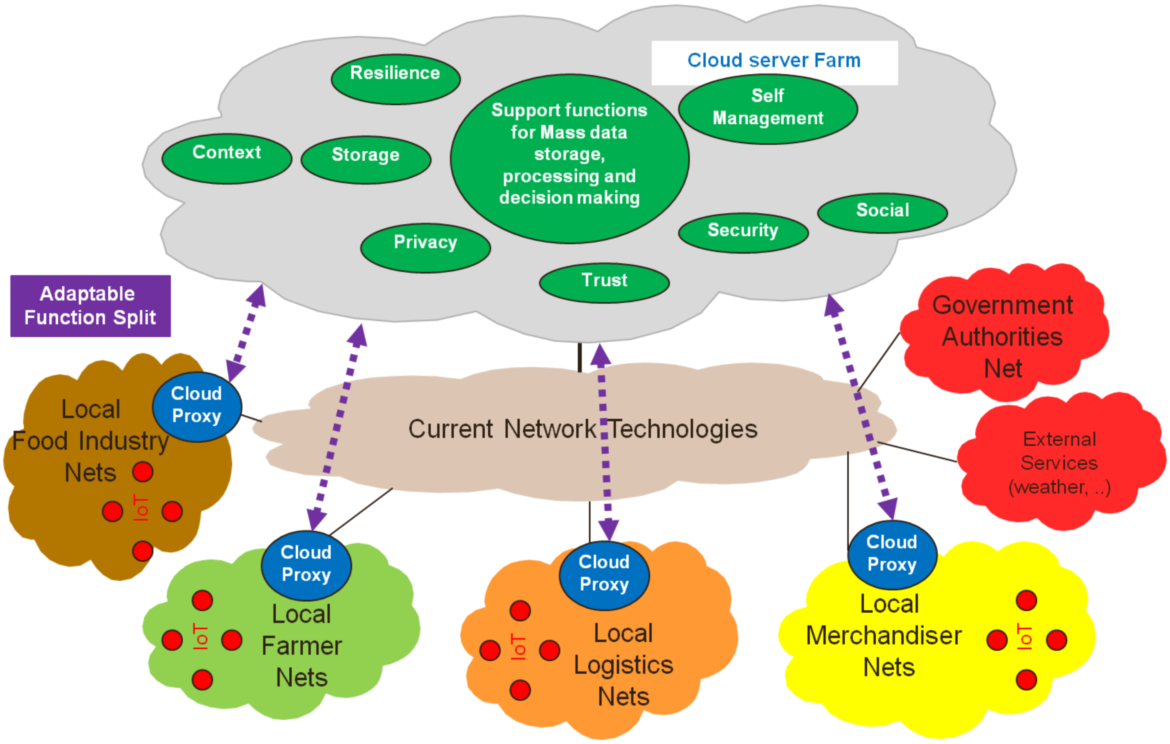

Figure 2: Interworking between local subsystems and global system (cloud)

Figure 2 gives an overview about the components for support functions in the cloud. It is about data, policy management and cloud applications. As the system core, centralized services will enable the interworking of applications with the data provided from distributed sources. The main centralized service is a data warehouse, keeping all relevant data in a consistent way for all applications (see Figure 3). It will provide facilities of loading, transformation, aggregation and selection of data from the sources. Analytical services will provide the meaning to the data for applications. The type of required analytical function is typically controlled by the application and given in the query. Authentication and authorization services ensure data integrity and privacy for data access through applications and authorize sources to upload data (push) or trigger the upload directly (pull).

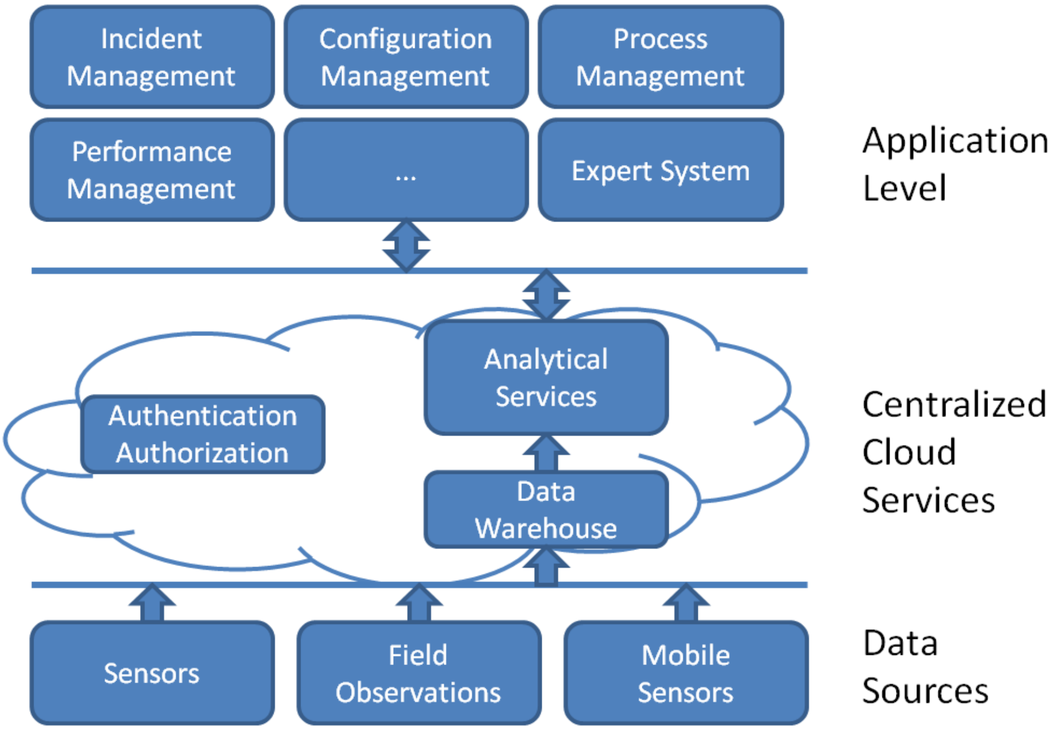

Figure 3: Data flow to and from cloud servers

Primarily, cloud applications will request data from the warehouse for performing specific analytical operations, e.g. providing geographical information. However, an application may also share processed data with other applications in a consistent view, thus getting permission for storing information or processed data back in the data warehouse.

Data sources continuously provide information used about the surrounding (e.g. sensors), external influences (e.g. rain radar) or information about system relevant information. Context Management is part of the Meta Data kept in the Data Warehouse.

In the long term, we expect FI network to be intelligent by making a function split between cloud and network entities as shown in Figure 4:

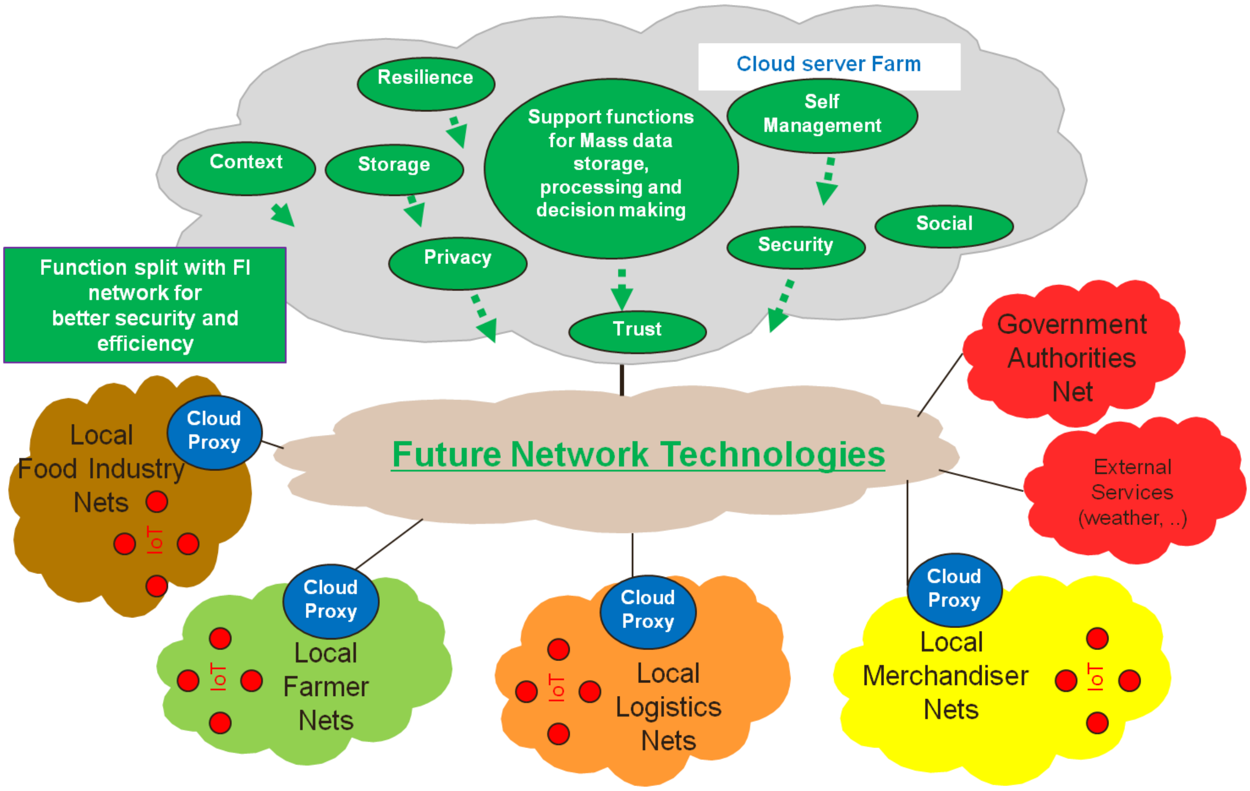

Figure 4: Long term view for SAF architecture

FI will have to cope with yet unknown terminals and services (even users), in a number and heterogeneity never seen before. Flexibility or adaptability will be considered as one of the most important design principles. This approach will demand different kind of awareness both in the ends and in every node in the FI network. Virtualization and 'everything as a service' is a promising paradigm to guarantee this flexibility. The bit-pipe service neutral network paradigm needs to be replaced by moving functions as shown in Figure 4.

Potential Applications of FI in Agriculture are divided into 3 sub-cases: farming, logistics, and awareness. All three paragraphs should cover possible short and long-term applications of FI. The latter can be based on generic enablers defined in the FI-WARE documents, other generic enablers (if any) which resulted from the research in the project so far, and planned future applications of domain-specific enablers.

1.4 List of scenarios from sub-usage areas

The scenarios identified in the smart farming sub-usage areas have been analysed in D200.1 (see [4]) and listed below in the following Table 3.

Table 3: Scenarios from sub-usage area smart farming.

Name of Scenario	Description
Yield measurements system	To collect and analyse data from the field that will help farmer plan his activities, make assessments for sales, schedule harvesting, manage nutrients etc. Also to prepare a history yield map.
Extraneous and foreign bodies identification	To collect the appropriate data to be used by machines and farmers about foreign bodies (foreign material can be: glass, bottle, splint, flinders, plastic, metal, stone, etc.) so that they can be identified and excluded before the food processing.
Collaborative Spraying	Several machines are coordinated within a fleet to work together on the same task.

Name of Scenario	Description
Plant disease forecast for spraying	Plant disease spraying is an important task in crop production. This scenario provides a step by step in depth into the utilization of plant disease forecast services for plant disease warning and recommendations for performing spraying. It also considers the tools and infrastructure needed for achieving this scenario. The scenario also shows the need and importance of fluent and reliable information flow between several actors, services and information sources for performing a spraying operation under demanding environmental conditions.
Preparation and setup for plant disease spraying	Before a plant disease spraying operation, the farmer has to prepare and set his machine up for the operation. This scenario describes the procedure in the setup process.
Dealing with bad weather during spraying	The operator of the tractor, the tractor and the sprayer, utilizes sensor information and internet services for weather situational awareness and control and decision-making during the spraying operation to prevent any disasters.
Cooperating harvesting	Several self-propelled forage harvesters (SPFH) and transporting vehicles (tractor with trailer) are coordinated for harvesting for a biogas plant. Several emergencies could take place such as defects on SPFH, trailer, etc. Reorganization of cooperative harvest should be operated.
Online Firmware Update	This use case describes the necessity of updates of new firmware for a tractor, as well as their downloading and their installation.
Analysis of logged Date for Process Optimization	Data mining procedures that run in the cloud process collected data from relevant machines such as tractor settings, fuel consumption, implement settings, implement state and data about the current task and about the environment and provides optimized solutions.
Remote Machine Control	This use case describes a scenario where a tractor with a trailer is steered remotely by a SPFH during loading.
Remote Machine Diagnostic	A farmer or machine operator would like to be informed whether his machine malfunctions. A proper notification is sent to him as well as recommendations for further actions on how to solve the specific emergency.
Greenhouse Management-normal operation-local data storage-system data storage	This scenario describes the normal operation of a decision system for a greenhouse case. A farmer has installed a number of sensors inside his greenhouse measuring a number of physical quantities such as temperature, humidity etc. All the sensed data are analysed and combined with external data i.e. meteorological data, existing agricultural laws, etc. is informed about emergencies as well as possible actions that he can do in order to handle them.
Faulty operation of sensors inside a farm	A number of sensors, consisting a sensor network, are installed inside a farm and take measurements. A specialized module (either located locally, or in the cloud) checks periodically the integrity of the incoming information and detects whether a sensor is faulty. In this case, the respective farmer is informed and the specific sensor should be isolated.
Agricultural related news coming from outside the world	Farmers may be interested in specific kind of data that come from the outside world and may affect their productions. Such information could be: • Meteorological disorders • Alterations in policies • Subsidies • New threads for cultivations e.g. organic products and animal farming • Recent fluctuation of prices of commodities
Providing a farmers information to different external entities/players	A farmer's related information is gathered for further use, either by him or by external entities. The farmer could advertise himself through his profile by uploading data, such as photos or videos in order to make his profile friendlier. Based on who is interested of, different form presentations are loaded. For example, for an electronic advisory service, specific aggregated data are needed. Similarly, global markets are more aware of other kind of summarized information e.g., data that certify if a product is based on bio standards.
Subscription to an electronic advisory service over the internet	A farmer wants (e-agriculturist, e-veterinarian) to receive recommendations that are relevant to his farm. These suggestions may refer to emergencies and how to handle them, or general advices for his crops or cattle.
Different farmers exchange data	Collaborative mechanisms could be developed in order to help farmers exchange various data i.e. statistical data that are related to their farms, dialogues for different issues that bother the agricultural community, etc.
Statistics management	A farmer would like to be informed about statistical analysis that refers to issues that is concerned of. Those data may be: • External information e.g., meteorological and climate issues • Internal Information e.g., percentage of faulty sensors

Name of Scenario	Description
Multimedia Transfer	This use case describes the capability of the system to leverage multimedia transfer (photos, videos HD). These data could be stored and used for further use e.g. identification of extraneous bodies inside a crop, disease of a plant by analysing its leaves, etc.
Notifications are sent to more than one available end terminals	A farmer, who holds more than one device e.g. pc, laptop, pda, mobile phone etc., would like to get any notifications irrelevant of the devices he uses. The scenario also depicts the possibility of a smooth transition between two different devices without packet loss.
Decision making is provided by the local system	A farmer requests from his FMIS to work properly regardless his internet connection. This scenario presents the data flow as well as the operations that should be done in order to ensure that the provided services are robust.
Farm Management – Small Scale Barcode/RFID system - Traceability system	The farmer has the need to print in an automatic way a basic barcode/ RFID label for his final product before their storage or shipment. This barcode label will contain related information with the farmer and the specific product.
Production of a cultivation plan for new farmers	A farmer provides information about his location and his preferred crops and a cultivation plan can be produced. The system, combines aggregated data that come from the neighbouring farms and decides whether the crops he is willing to sow are profitable or not and how to act in order to succeed the maximum profits.
Advanced search engine	The farmer or any visitor can search any desired information using multiple criteria. Data come from different sources e.g., sensor data, data provided by the advisory services, data collected from other FMIS, etc.
Access to common infrastructure	A producer, the owner of a small farm can't invest a big amount of money to buy automatic and new sensors for his cultivation. The most crucial information for him is the knowledge of weather conditions for the specific area. Another one issue could be a catastrophic disease that may affect his farms. The agricultural community will be reinforced providing each other inexpensive knowledge and information that are aware of. Then the expected value could be
Providing a farmers information to certification authorities players	A farmer's related information is gathered for further use by various authorities. These data can be formatted automatically in an appropriate format for presentation that will be useful by other involved entities such as certification authorities, government authorities, payment authorities etc.
Information service for farmers interested in selling/buying animals	The owner of a dairy farm has a number of animals. He is interested in buying some animals but he wants to check that they are healthy, are well taken care of and if it is possible to have access to milk quota data. He is also interested in fertilization some of his animals with others from another farm.
Qualitative products of dairy farms	Farmers use a variety of sensors that improve the management and collection of data of their dairy farms. Those data can be used in order to be certified if a product is bio. Customers that are interested of knowing the origin of a product can have access to that information.

The scenarios identified in the smart logistics sub-usage areas have been analysed in D300.1 (see [5] and listed in the following Table 6.

Table 4: Scenarios from sub-usage area smart agri-logistics.

Name of Scenario	Description
Intelligent Supply Chain Event Management (SCEM) systems for the future food supply chain.	Use SCEM (Supply Chain Event Management) to achieve inter-organizational visibility over logistical processes enabling companies to detect critical exceptions in their supply chains in time.
Exception notification based on fruits/vegetables chain.	Enable the timely notification of actors in the food chain about produce related exceptions (e.g. bacteria, pesticides, contamination) and to finally avoid the consumption of harmful produce.
Real-time and Trusted Information regarding Product Specifications and Compliance	Reliable management of real-time information on product specifications regarding fulfilling compliance criteria in the process chain
Legal compliance and quality control	To warrant aspects such as legal compliance, security, transport security, energy efficiency, information security, food quality/safety, occupational health and safety and others relevant aspects in order to reach a smart and more efficient agri-logistic management.

Name of Scenario	Description
Quality Controlled Logistics in the Flower Chain	Allow each organization in the chain to get access to their needed information through the entire chain about history, tracking/tracing and quality conditions of products. By doing this, the organizations (1) can monitor the status of products, (2) can be notified about exceptions for which simulation and control actions have been taken and (3) can make measurements for the long term based on history that is stored.
Intelligent retail store replenish-ment of fresh products	Optimization of order process of fresh products from retail shop to warehouse and the delivery management of the product order to the store.
RFID implementation on pallets from warehouse to retail store	Nowadays the retailer cannot control the goods that leave the warehouse to the retail stores. When products cross warehouse gate, the retailer doesn't receive any feedback (information) since the product leaves the supermarket (a consumer buys it). So, there is an information gap in this part of the logistic chain that has to be covered, otherwise if an anomaly happens the information takes lot of time or never notify the retailer. This scenario aims to fill the gap by using RFID technology on pallets in order to control them from ware-house gates to retail store entrance.

The scenarios identified in the smart food awareness sub-usage areas have been analysed in D400.1 (see [6]) and listed in the following Table 7.

Table 5: Scenarios from sub-usage area smart food awareness.

Name of Scenario	Description
Binding user identify and user's equipment to supermarket service infrastructure	*"As Laura approaches to the shopping trolley, it identifies her mobile phone and recognizes that she has been a previous customer."* **User identification**: it is available at every place as a built in function of the system **User's equipment identification and binding:** enabling communications with whatever user's equipments. Integration of networks protocols for enabling universal equipment interworking **Activating service infrastructure based on user's profiles and user's equipment characteristics**: integrating user's capabilities into the service network. Provision of uniform and universal access to user's data whatever they are located, by the means of access protocols, and interworking of data semantics.
Selecting services guided by users profiles	*"As she is a gluten intolerant, she selects a service that make use of her medical profile, stored in her mobile phone, in order to monitor that products she puts into the trolley are gluten-free"* **Selection of services by user's profile:** The user receives services related with their profiles. Selection of services and service components by profiles and preferences (users, network, etc.) **Access to personal (confidential) data:** Access to user specific data, even included user owned information
Integrated services instead for a pool of user perceived services	The shopping activity of Laura integrates several events: *"specialized applications and services, running on her personal device, collect and integrate these data as well as to combine them with existing personal data in order to optimize the current shopping"* *"the shopping list is synchronized with the information from the woman's fridge"* *"the trolley also warns the woman about any product will expire while she is on her coming vacations"* *"using her own mobile device, the woman can pay the receipt without making any mistakes, and being sure that she has been save enough money for her daughter's birthday cake"* **Access to users data:** Access to users data even when those data are stored on remote domains and Collaboration with other applications sharing relevant information. In general, Open access of user's data, sharing data and information with others users (under the control of the owner of the data)

Name of Scenario	Description
User created and configured services	*"a new service created by her that as being called GIVE ME MORE,downloads the service template, personalized it and installed in her personal device "* **Prosumer concept:** Users creates their own services or services templates, by downloading service templates created by other users, customizing this template in order to create a new service and installing and publishing the new service, so it is ready for their own use and for the usage of others users. The tools and interfaces should offer the suitable complexity in order to allow expert users and non-expert users to define their own services. Users should be able to identify relevant services and download them in order to adapt them to their own preferences. They should be able to adapt service templates to their specific service requirements. Finally, The user should be able to install and publish their own fully working service.

1.5 Description of Future Internet Generic Enablers

This section provides a description of the generic enablers as defined in the FI-WARE project for the Future Internet core. A "generic enabler" is a functional block which is common to any application or service in the future internet. The descriptions provided here are mainly referring to the FI-WARE high-level description [7].

1.5.1 Cloud Hosting

The "Cloud Hosting" concept is the basic enabler for providing scalable computation, software, data access, and storage services (see Figure 5). With a cloud, users can rent software as a service or only an infrastructure (e.g. data storage), keeping investments for small companies low.

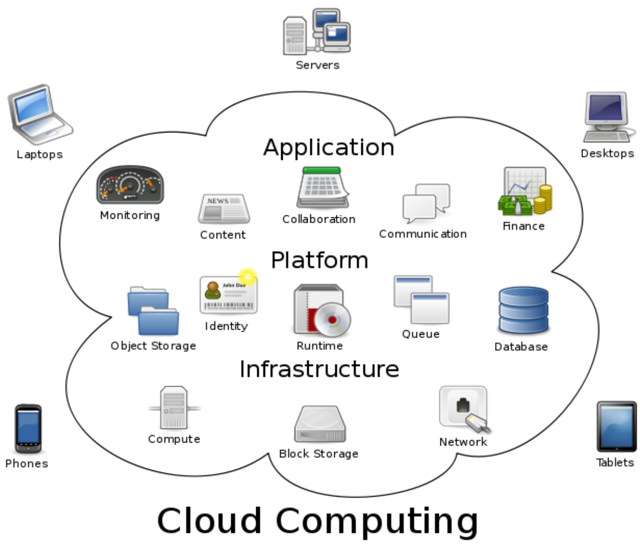

Figure 5: Cloud computing (image from wikipedia.org)

An important concept for privacy in cloud computing is the separation between public- and private clouds:

- Public Clouds: given services are generally available to the public and hosted externally (with restricted access permissions and security mechanisms)
- Private Clouds: operated for a specific organization, either within their own data centres or hosted by a third party

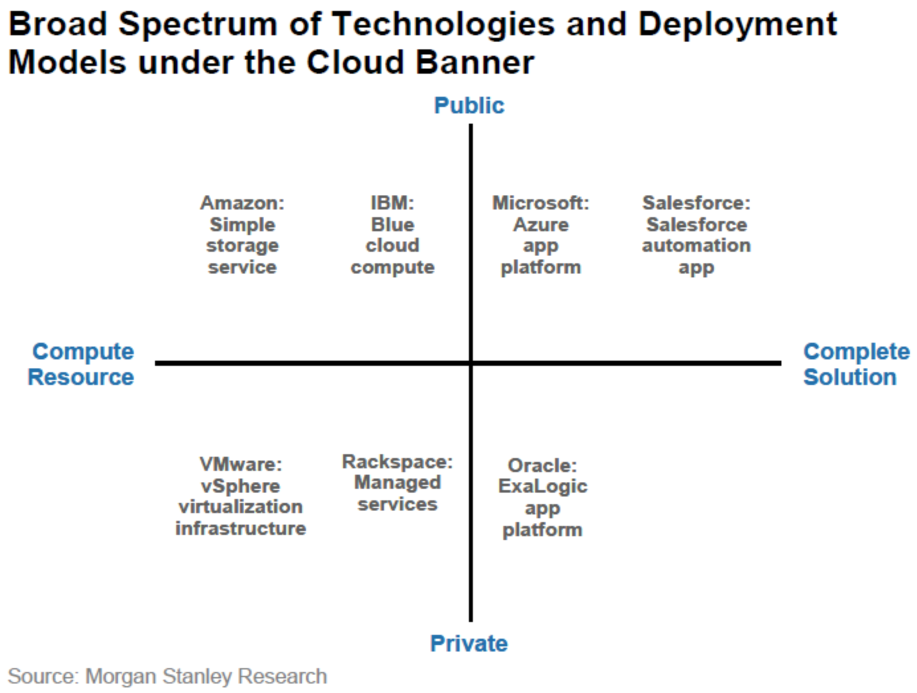

Figure 6: Public and Private Cloud Solution Companies.

Morgan Stanley's blue paper [8] provides a comprehensive overview about suppliers and service providers in the cloud business with their different focus areas on infrastructure (e.g. Amazon's Enterprise Compute Cloud, EC2), Platform (e.g. Microsoft's Azure and Google's AppEngine) or Software (e.g. Salesforce.com Sales Force Automation application) (see Figure 6). In addition, telecommunication companies like Huawei provide E2E cloud services including consulting, planning, design and delivery on top of their cloud-based infrastructure and communication networks.

The main concepts implemented with the cloud hosting generic enablers are:

- Infrastructure as a service (IaaS): Customers rent raw computing and storage resources from an infrastructure cloud service provider, e.g. capacity for data storage. Access to the data is provided through the internet from any place and with any client
- Platform as a service (PaaS): Applications can be developed re-using software modules of the "cloud platform". Developers don't have to care about the mechanisms to access the infrastructure, which is implemented by the platform. This speeds up application development.
- Software as a service (SaaS): Typically end-users rent software from a cloud software provider without the need for installation or maintenance. Resources for storage and processing are provided with the cloud. SaaS can be executed on low-budget computers without the need to care about administration.
- "Cloud Proxies" allow to locally using cloud services without the need of permanent connection to the internet.

1.5.2 Data/context management

The Data and Context management implements facilities for transfer, conversion, storage, analysis and access of huge amount of data through the cloud. Further, instead of just processing "data", the meaning of the data is linked, allowing end-users to interpret the data in the context. Main enablers and benefits for the farming use case are:

"Publish/Subscribe Broker" to exchange information on events:

An event in general is a piece of information, which is made available to anyone of interest. The publish/subscribe broker is controlling, who is able to "post" events and who wants to receive them, either by notification ("push" service) or by actively querying the broker.

"Complex Event Processing" for real-time interpreting, processing and handling events:

Intelligent and flexible processing enables to get a better interpretation of the event in a user-friendly consumable format, allow an event-based routing, support rules for the correlation and post-processing of different events (e.g. count events or detect pattern) and enable the definition and assignment of actions. Further, actions can themselves issue further events (like "completed" or "failed"), allowing to implement complex ticketing services. An event may be issued by the publish/subscribe broker, an automatic analysis of the cloud-data or through an application with interfaces to external information (e.g. weather forecast).

"Big Data Analysis" for distributed analysis of huge data sets and streams:

The "Big Data Analysis" allows parallel processing of huge data sets at distributed locations, either from previously stored data or continuous data from streams. The "map-reduce" function from Google is the basic analytical principle, which is extended in FI-WARE to capabilities for processing streams. Further, FI_WARE integrates 3rd party modules as plug-ins during runtime, opening the analysis functionality to a wider area of application. However, it is not clear from FI-WARE, what functionality of 3rd party plug-ins will be supported.

Multimedia Analysis:

This enabler allows extracting meaningful interpretation of images, audio- or video files.

Unstructured Data Analysis:

Information from several internet sources e.g. blogs, news or feeds are not structured to be automatically processed or interpreted. Therefore, this FI_WARE function will extract the semantics behind the input data to be further processed by intelligent analytical tools.

Localization Platform:

This enabler provides the position of mobile devices via Wi-Fi, A-GPS or Cell-ID to FI-WARE applications. Location-aware applications can dynamically react on the location of a user, e.g. by geographical queries. Further, events can be defined, if a user enters or leaves a geographical area.

Query Broker:

The Query Broker is a middleware, providing several API for different query languages (e.g. SQL, XQuery, SPARQL, Multidimensional, Spatial, etc.) to be used from application developers. It ensures access to distributed data repositories or search engines and provides interoperability of metadata formats via schema transformation.

"Semantic Annotation and Semantic Application Support" to understand data:

Semantics annotation allows extending data with meaningful content, e.g. media files, descriptions, tags, etc. It also supports translations into different languages. Users benefit by getting a more comprehensive "intelligent" way to view, search or exchange data.

Intelligent Services:

Several "plug-ins" for the Big Data Analysis enabler have been defined as "Intelligent Services" in FI-WARE: a) Social Network Analysis, b) Mobility Analysis, c) Real-Time Recommendations, d) Behavioural and Web Profiling, and e) Opinion Mining.

These enablers will support an easy interaction of the agri-food community and information exchange.

1.5.3 Applications / Services Ecosystem & Delivery

The primary task of the Application/Services Ecosystem & Delivery group of GEs is to improve creation of the applications in FI, support various business models behind these applications, and enable them to be accessible from a variety of end-user devices. It covers the key business roles of Aggregator, Broker, Gateway, and Channel Maker (cf. Figure 7).

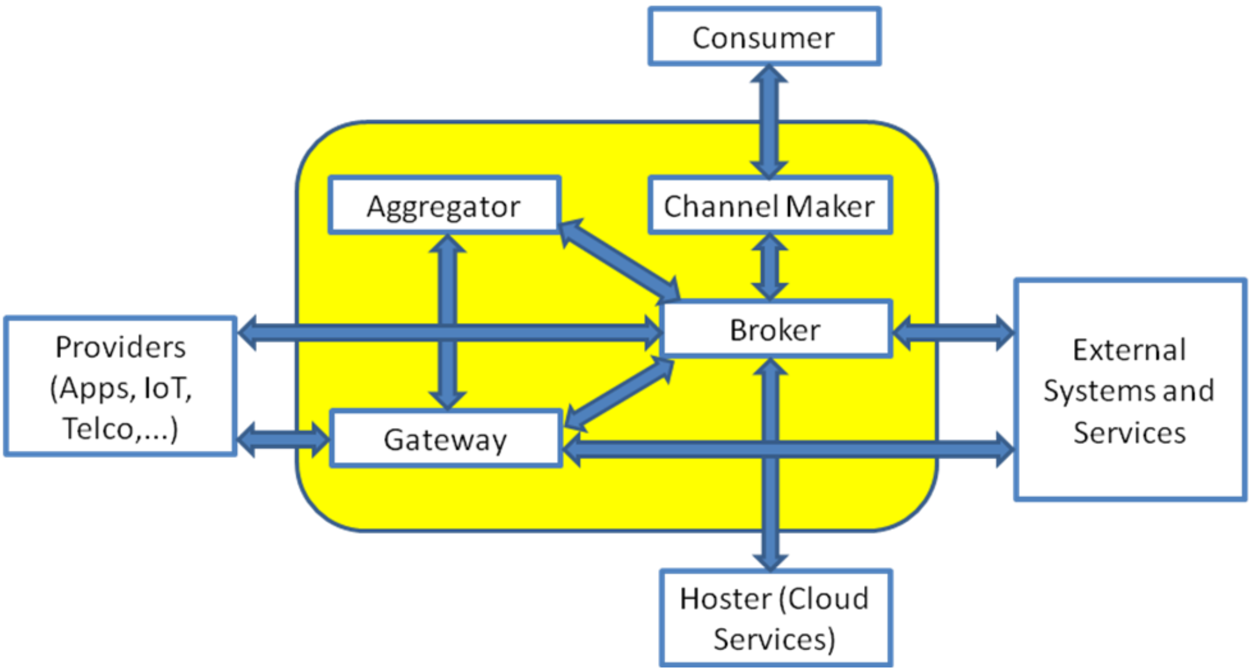

Figure 7: Architecture for Application/Services Ecosystem and Delivery (adapted from the FI-WARE draft specification)

Business Framework:

Business framework GEs are responsible for the Broker role. The Broker function means establishing connections between the providers of various services and end-consumers by creating the corresponding stores (individually owned) and, more generally, marketplaces offering goods from a number of stores. The examples for existing marketplaces are eBay or Amazon, while in the area of software applications there is a number of so called App Stores (Apple, Google, etc.).

The internet stores usually have owners controlling fully their service/app portfolio, which is typically limited in scope. For this reason, the GEs in the FI-WARE aim at creating an open platform for services and marketplaces. The functionality of this platform will include services for searching, browsing and comparing the offers, auctions, advertisements, ratings, and tools for strategic pricing management.

Some of the key GEs from the Business Framework subgroup are related to:

- USDL repository (a repository of commonly structured services, most probably distributed; contains all the services that operate in the system, including a description of their capabilities and availability)
- USDL registry (management of service repository platform, discovery of services; tool for the administration of the service repository used for maintenance and deployment of the services that exist in the system).
- Marketplace and store (marketplace will be developed as a generic enabler with interfaces to individual stores)
- Revenue settlement (sharing of charge among different actors)
- SLA management (mechanisms for quality-of-service (QoS) guarantees).

Composition and Mashup:

Composition and mashup are supposed to enrich the applications and make them more attractive to the end-users. While current composition and mashup applications are mainly in the context of information and multimedia, FI-WARE plans to create GEs which will span the applications and services spaces, as well. In this way, the Aggregator function of the overall architecture (cf. Figure 7) will be completed.

Future Internet will further enhance the involvement of end-users as contributors in various mashup scenarios, making them *prosumers*. The prosumer is a user that both consumes and provides information and services. In this context, a prosumer requires a suitable environment for creating services and service components. At the same time, Service Composition and Execution functions should be supported by locally combining user terminals and environment in order to provide fully adapted services.

One will be able to differentiate between the back-end and the front-end composition. While the back-end assumes complex programming tools and is mainly envisioned for IT experts, the front-end composition will use simpler environments (e.g., graphical interfaces) so that the end-users will be able to easily participate, as well.

Mediation and Multi-Channel/Device Access:

The mediation GEs will incorporate the Gateway functionality. Currently, there exist many data formats in the internet, and this block will resolve the interoperability among them. While performing this function, the privacy of the data will be taken into account.

On the other hand, the Multi-Channel/Device Access group of enablers accounts for the fact that an ever-increasing variety of devices is present in the current global network. Moreover, the end-users are served using a number of channels (social networks, marketplaces, etc.). Therefore, there is a need to enable FI applications to be executable irrespectively of the interface present at the end-user side. The Channel Maker block will encompass the functionalities of creating the channel/device specific interfaces. This will be reflected in adaptation to users' preferences and profiles.

1.5.4 Internet of Things

The current internet consists of an interconnected network of computers or at least electronic devices. Opposite to this idea, the internet of things (IoT) takes all physical objects into account. In addition to this "weak" description, the IoT topic is often linked to research fields such as Ubiquitous and Pervasive Computing, Ambient Intelligence, etc. This extends the capabilities of entities to process information autonomously, react proactively and context sensitive to their current environment, see ([9], [10]).

The GEs for IoT can be roughly classified in 4 groups: IoT Communications, IoT Resources Management, IoT Data Handling, and IoT Process Automation (see Figure 8).

IoT Communications:

IoT Communications group of enablers will handle establishment and management of the communication with sensors and devices accounting for independency of the communication protocols. These GEs will generalize the currently available, fragmented solutions in the areas of RFID systems, wireless sensor networks [11], M2M communication, etc. in order to cover a broad range of application areas. Abstraction layer will provide technology developers with a common, open, and user-friendly APIs to communicate with different devices that use different communication protocols and interfaces.

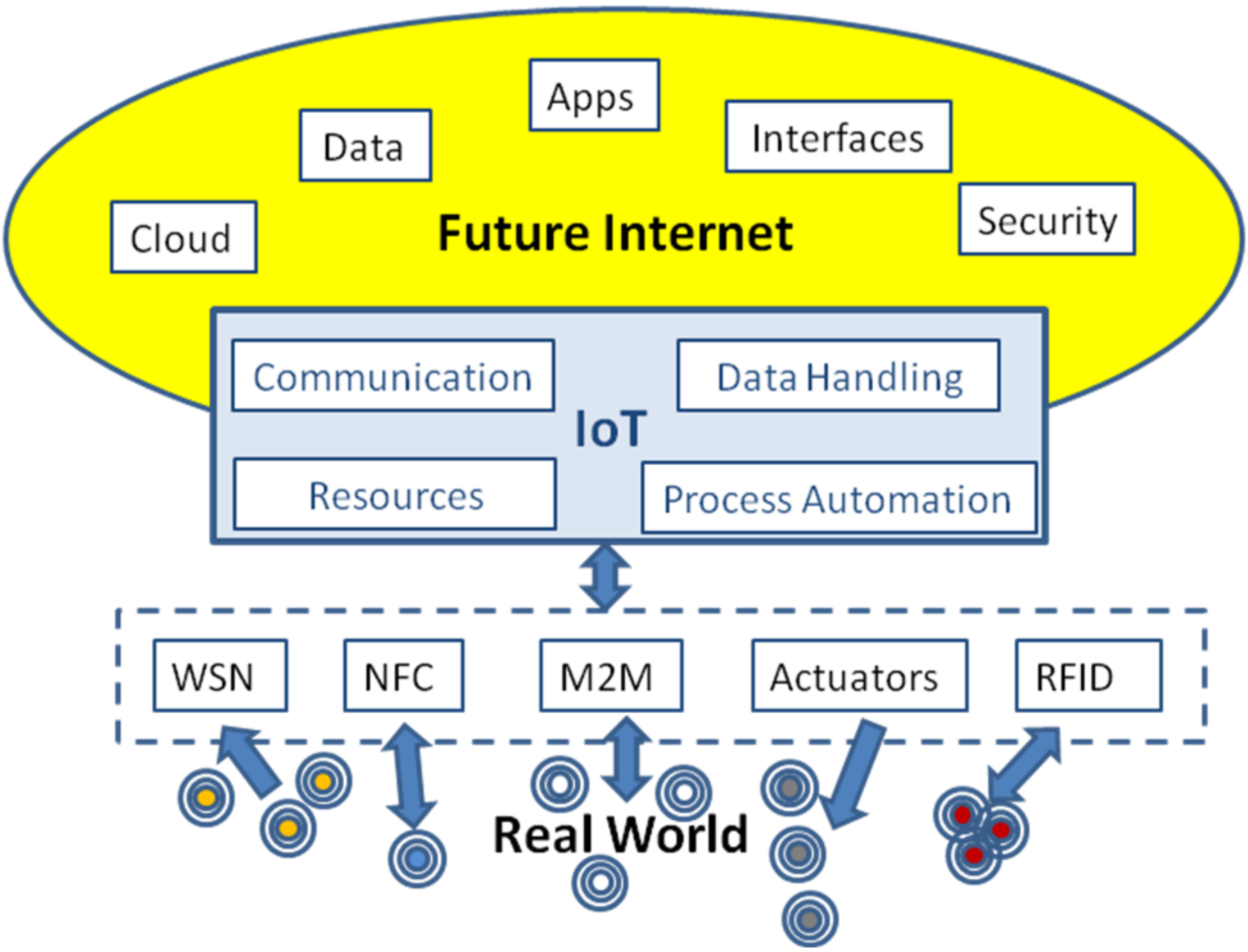

Figure 8: IoT communication with the real world.

IoT Resources Management:

For supporting management of IoT resources, a service and device description directory will be created. In this directory characteristics and properties of IoT enabled devices and services will be identified and described, with the capabilities published. Further, the mechanisms for efficient identification (e.g. naming, translation issues), resolution, discovery and linking of resources will be utilized by applying solutions based on research work in projects such as SENSEI, see [12]. This will enable easier search in a multitude of things using various selection criteria. In general, given the infrastructure of different smart objects that compose the network, self-configuration mechanisms should take place, as well. Therefore, wherever possible, the management of things will be performed in an automatic manner.

IoT Data Handling:

In order to manage the collection, filtering and distribution of data generated by sensors, this GE will support the system component that will gather all the raw data incoming from the sensors, filter it in a way that all unusable information is deleted, combined into usable information, and delivered to the next component in the information flow chain. Essentially, many of the Data/Context Management GEs will be adapted to work on distributed devices, often exploiting P2P communication. Various data representation formats and data types (instantaneous, local and global) will be supported, taking into account the security constraints, as well.

IoT Process Automation:

IoT Process Automation will establish mechanisms to automatically trigger actions involving IoT components. Namely, it is necessary to support a unified model for the description of domain specific rules. The result will be a more autonomous management and operation of IoT resources. This GE will be in charge also for knowledge generation from long term observations of things.

1.5.5 Interface to Networks and Devices

Connected Devices Interface (CDI):

To monitor different quality parameters in heterogeneous systems it is eligible to have a generic layer accessing all monitoring devices and sensors in the same way. This functionality is provided by the CDI layer. The CDI GEs will also create smart communication pipes by exploiting the status of devices. The relevant information from the device might be the battery status, various device features, information from device sensors, location, etc.

An important aspect in CDI GEs is ensuring the quality-of-experience (QoE) for the end-user. Rather than only adopting some technical QoS parameters, which might be not so transparent for the end-user, its actual experience with the service will be incorporated for system optimization.

Network Information and Control (NetIC):

The NetIC GE utilizes the information about the network in order to optimize it and ensures that SLAs promised to the customer are satisfied. The service provider will obtain the information about the interfaces, topologies, statistical information (paths, traffic), and control of paths and traffic. It will also enable the customer to obtain some additional service which he/she did not originally subscribed to (e.g. a high definition video), by setting up the necessary connection and calculating the extra charge. This GE will also resolve the problem of different standards in the usage areas (IETF, 3GPP, ETSI, ITU, IEEE).

Service, Capability, Connectivity, and Control (S3C):

S3C GE will support the necessary modification of the core network (Evolved Packet Core – EPC) for FI applications. The EPC was developed as an IP-based control platform that integrated various wireless access technologies (UMTS, LTE, WiFi, etc.). Being designed for communication among humans, the EPC is, however, not suitable to support the envisioned applications in FI, which will rely primarily on M2M communication. The number of connections in this type of communication is much higher, while the amount of transmitted data per call is typically small (although, there are also some high data rate applications, as well). In the current EPC, each connection is accompanied with certain overhead (e.g., the setup and configuration of the connection, etc.). It is the signalling storm resulting from the accumulated overheads which prevents the wide spread of M2M communication using the current core network.

1.5.6 Security

Although the security aspect does not directly result in applications in the Smart Agrifood environment, it is an essential functionality to give trust in usage of the future internet. In principle, the requirements from the Smart Argrifood Use Cases are aligned with the enablers defined in the FI-WARE document:

- Secure two- or multi-factor authentication
- Location- and application independent authentication and authorization
- Flexibly grant or deny access to own data by stakeholders (e.g. staff, contractors, consumers, ...), user groups (e.g. farms, production plants), equipment (e.g. sensors, machinery, ...) and services
- Secure data transfer through encryption

FI-WARE has defined valuable generic enablers related to security, but above requirements are not yet covered completely. However, the question marks and open topics have been identified by FI-WARE and relevant excerpts for smart farming listed at the end of this section.

Below, selected FI-WARE security generic enablers are explained:

Fraud and intrusion detection through Security monitoring:

This enabler detects and monitors unauthorized access and detects manipulation of data.

Identity Management:

Identity service providers will enable a single-sign-on authentication procedure for all FI-WARE applications.

Question Marks and Open Topics related to Security:

In the FI_WARE document, a set of open topics have been identified for further specification. As pointed out in the previous section, the security of personal data will be an essential functionality for the SmartAgriFood stakeholders to accept the FI-WARE approach. Below the most relevant topics are cited with may impact the trust of stakeholders and need to be solved:

Authentication & Authorization (Cloud Hosting):

Users must first be authenticated to carry out various operations upon the resources and services that the cloud hosting chapter will offer.

For efficient operations in a provider who may have multiple but related services, this authorisation should be of the single-sign-on type. Although a user may be authenticated, they may not have the credential to carry out certain actions.

As a result it could be required that policy GEs be required to enable such policy enforcement.

Privacy Management (Data/Context Management):

Mechanisms ensuring that applications cannot process data nor subscribe to data without the consent of its owner should be put in place. (...).Supporting this will require to carefully define the concept of "data ownership. A mechanism shall be put in place for an automatic control of the privacy issues by, e.g. formal rules (policies) accessed and asserted by data owners and government authorities (regulators) entities and processed by a sort of policy enforcement.

Service Registry & repository (Applications/services ecosystem & delivery):

Management of identities and authorization for the publication/management of service descriptions in the repository.

Revenue Settlement and Sharing System (Applications/services ecosystem & delivery):

Confidentiality and integrity during the payment process. Strong authentication to verify the payment origin and destination. Privacy protection of the sensitive payment information (Credit cards, traces, logs etc.), Accountability to keep trace about the payments. Secure payment (virtual money ?)

2 Smart Farming

In recent years, a lot of efforts have been put in smart farming. These efforts deal with a number of factors (e.g., ecological footprint, product safety, labour welfare, nutritional responsibility, plants and animals health and welfare, economic responsibility and local market presence). Some of their goals are to facilitate the execution of daily agricultural tasks, to support information transparency in the food chain and to automate the transactional activities for all the involved stakeholders. An important shortcoming of these efforts is that the new capabilities from the envisaged Future Internet have not been taken into consideration.

This section first gives an overview about existing technologies that potentially can be used to enhance today's information and communication solutions in the area of smart farms. It will be shown, that already today a manifold of cloud technologies and components are available, which could be combined to build advanced smart farming solutions. However, to avoid isolated proprietary solutions, the Future Internet Core will provide a standardized and open platform upon generic and reusable building blocks. The second part of this section will explain those building blocks (the "generic enablers") and their relevance to smart farming.

2.1 Non-Exploited Available Internet Functionalities Which Could be Used for Smart Farming

This section provides an overview of available products and solutions from the areas of information technology (IT) and communication technology (CT), which are in principle available for the smart farming usage area, but applied currently only to a limited extent.

For clarification, the term "available internet functionality" is regarded as a wide concept for Internet Protocol (IP) based information exchange and services, including

- carrier networks (e.g. LAN, Internet, WiFi, Zigbee, cellular)
- client/server solutions (e.g. database servers + reporting clients)
- network devices (e.g. PCs, smartphones, wireless sensors)
- services (e.g. VoIP, Email, HTTP, FTP, peer-to-peer, streaming)
- applications (e.g. Google search, Facebook, Wikipedia)
- security (e.g. encryption, authentication services)

There already exists a large variety of IP-based products and solutions from software companies or farming equipment suppliers to support smart farming, see D700.4.1 Section 3.3.2 for a comprehensive study of vendors and competitors. Main topics are listed below, where Farm Management Systems (FMIS) may integrate functionalities below:

- Machinery Control & Steering Systems
- Crop Production Lifecycle Management (Planning, Measuring, Control)
- Production facilities management and automation (e.g. greenhouse)
- Herd management
- Environmental Information Systems (e.g. sensors data networks, soil, weather, ...)

However, existing solutions are specific and proprietary, mostly having their own specifications about the functionality they provide and the means to interwork with external services. Facing future smart farming scenarios, there is a need towards:

- Support of low-cost and intelligent solutions for small farms, which cannot invest in professional equipment or software

- Handle significant increase in the amount of data to be gathered and processed (e.g. photos / videos for foreign body detection or environmental sensor data)
- Getting benefit from the integration of different farming services into the own IT infrastructure, e.g. by getting advices of when and how to fertilize in combination with a service to schedule and book a spraying contractor.
- Full mobile access to the farm management services everywhere and anytime, e.g. through smartphones or tablet PCs.
- Having internet services with focus on the local or regional information for e.g. disease management or contracting local business partners.
- Provide valuable information about the own products and their history (e.g. origin of seeds, applied pesticides) to the public.
- Integration of different information sources in a user-friendly way, providing interactive and geographic information services.

Having listed the required extensions to existing solutions, an overview about available internet solutions will be given in the next sections.

2.1.1 Cloud Computing

Referring to section 1.5.1, a lot of existing solutions and services could be applied or designed according to the smart farming use-case or individual needs. However, there is a lack of standardized interfaces, requiring the FI-WARE solution to be implemented.

2.1.2 Authentication Mechanisms

Users have major concerns about storing their potentially private data in a cloud, so authentication and data access policies play an important role for the user acceptance. Where data access management is handled by the service providers, authentication requires

1. Registration: an institute or authority to proof a person's identity
2. Electronic Authentication: to identify a person during the logon procedure

Regarding a pan-European approach for e-government services, the "European Network and Information Security Agency" (ENISA) has issued an overview about the e-Identity management projects, see [13]. One of the findings from the report is:

"The legal frameworks, which govern the provision of electronic services across European borders, are not aligned to the point where service providers and citizens can easily assess the implications of a cross-border deployment, especially in respect of data privacy and issues of liability. A European community framework, which is comparable to the one established for electronic signatures by the EU directive 1999/93 (Community framework for electronic signatures), is not (yet) in place."

However, lots of approaches for authentication exist in today's IT environment, which could be applied for secure authentication of users.

- Electronic Identity Card (eID or EIC): Extension of the conventional identity card issued by the national government, containing machine readable content and potentially biometrical pattern. The user needs a smartcard reader, middleware software and eventually a PIN for authentication. In Italy, Germany, Belgium, Netherlands, Romania and Spain, national solutions are available, but no cross-border functionality is given.
- Identity as a service (IDaaS): A service provider is offering functionalities for registration, identification verification and authorization of an individual user or an organization.

Typically, a credential ID (e.g. token) is combined with a username and password for a secure two-factor authentication. Solutions are provided from e.g. VeriSign authentication services [14], partnering with RSA SecurID [15] for providing credentials.

- Remote Authentication Dial In User Service (RADIUS): A client/server networking protocol that provides centralized Authentication, Authorization, and Accounting (AAA) management for (remote) devices to connect and use a network service. Radius servers are typically installed within the (virtual) private infrastructure of a network operator or company to grant remote access to the network resources. Main vendors are Cisco, Lucent or Huawei. AAA services could be implemented in local farming IT and communication networks for controlling access to local data.
- E-payment services for trading farming goods or contracting, e.g. PayPal.

2.1.3 Data Warehouses and analytical services

For handling large sets of distributed data, data warehouses provide a solution for data loading, storage and analysis (Figure 9).

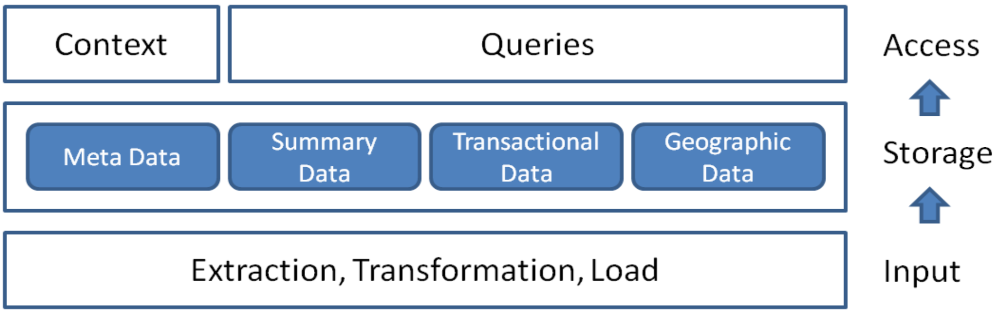

Figure 9: Structure of a Data Warehouse

By structuring data in multidimensional “cubes”, data warehouses enable a quick analysis of data by aggregation or filtering through any data attribute or dimension, e.g. time, product, supplier or farmer. This on-the-fly data processing is known as “OLAP” (Online Analytical Processing). Data mining tools are further advanced analysis services of a data warehouse.

A data warehouse can be either installed locally at the premises of a farmer or combine distributed data sources from e.g. a farming community or sensor networks.

Main players on the market provide complete solutions including ETL, storage and analytical services: Oracle’s Data Warehouse Products [16], Microsoft’s SQL Server Analysis Services (SSAS) [17] or IBM’s InfoSphere Warehouse [18].

2.1.4 Expert Systems

Lots of smart farming use cases are based on an efficient and transparent way of making decisions, which are implemented by expert systems, machine learning and knowledge model techniques. Depending on the complexity of the farming application, analysis services from a data warehouse provider can be used or 3rd party solutions applied for reporting, data mining or decision making. Two main basic methodologies are known for the decision making process: Fuzzy systems and Bayesian Networks (also: Probabilistic networks, Causal networks).

For smart farming, a lot of use cases require intelligent decision support functions:

- Foreign body recognition and identification
- Decision on need for spraying and according chemicals based on disease, weather and environmental conditions

- Automation and control of production environment
- Remote machinery control and diagnostic
- Identification of faults and failures of equipment (e.g. sensors)
- Animal health diagnostics
- Creation of a cultivation plan

The decision engine may be integrated in an automated software solution or in a WEB service, interactively asking questions to the user and provide solutions based on the underlying knowledge model. Decisions are based on the modelled knowledge, which could be collected dynamically from the farming community based on their experience and observations.

Commercial products are Analytica [19], TreeAge [20], Hugin [21], Vanguard [22] or Netica [23], shipping with graphical interfaces for influence diagram modeling and Java / C++ APIs. For research and academic use, GeNIe, SMILE, and SmileX are available free of charge for non-commercial use from the Decision Systems Laboratory of University of Pittsburgh, see [24].

2.1.5 Mashup services

Mashup techniques provide an efficient way to combine information from different sources and render a single representation. These methods have received quite a lot of attention in the IT community in recent years, which resulted in several solutions for enterprise, consumer (e.g., the ones using Google Maps [25]), and data mashups ([26], [27]). The potential applications and advantages of using mashups in smart farming are numerous. Consider maps, which present a typical example of data to be combined. Smart farming could clearly benefit from merging

- geographic maps (countries, regions, communities, properties, fields) and plans (farms, buildings, greenhouses, …)

with

- weather information (precipitation, sunshine, winds, extreme weather conditions and warnings),
- sensor data (sensor locations, humidity, temperature, light and CO_2 levels, sensor status information such as battery level or correct operation),
- data regarding the spread of diseases,
- planned and actual routes of machines on fields,
- status information of machines/devices (e.g. fuel and pesticide tank, window position, failures),
- links to various advisory or regulatory systems (e.g. disease management, certification bodies), stakeholder contact information, etc.

While many mashup tools are already available or appear to be within easy reach from the technical perspective, they seem to be rarely utilized in currently available FMISs (one lonesome example would be the well-known weather map). This could be partially explained by a fragmented approach in original FMIS development and many proprietary solutions. Moreover, the initial mashup applications assumed a lot of manual work and, correspondingly, high cost. However, the latter problem was alleviated by introducing numerous development tools and frameworks, such as the ones provided by Yahoo, Google, Microsoft, Intel, or IBM (cf., e.g. [28], [29], [30]). For example, the costs of the centralized enterprise mashups solutions developed by IT experts are reduced significantly by having the users exploiting some of the available tools and creating mashups in a distributed way.

2.1.6 Communication

A number of communication technologies is already in use on farms. Nevertheless, it seems that the potential of currently available solutions is not fully exploited. In the sequel, an overview of the technologies of interest, which appear to be underused in smart farming, is given.

Sensors and Actuators

Sensors and actuators have already found several applications, primarily in greenhouse management, and precision agriculture and precision livestock farming . Weather stations are a typical example, used in both areas. For indoor solutions, sensors measuring the temperature, humidity, leaf wetness, electrical conductivity, air-flow, light and CO_2 levels, etc., are provided by several specialized companies (e.g. Hoogendoorn, JF McKenna, Argus Controls, etc.). Outdoor measurements, besides weather conditions, assume underground sensors for the determination of soil water content (e.g. IMKO GmbH) or temperature, which can be applied for smart irrigation systems. Actuators usually complement sensor networks in greenhouse management and smart irrigation systems [31].

There are several problems which accompanied sensor networks in the early phases of their deployment, which might explain while many of the potential applications remained on the concept level:

- Most of sensor network based solutions were tailored to a particular application and were of proprietary nature. Consider, e.g. the first-phase, monolithic supervisory control & data acquisition (SCADA) systems. This paradigm is changed as distributed and connected, networked systems are being intensively developed.
- The wired sensor networks, while considered to be very reliable, are associated with high deployment costs. For this reason, wireless sensor networks appear to be of primary interest in future farming, as they have much lower capital expenditures (CAPEX). However, wireless sensor networks exhibit several weaknesses too. The wireless medium is inherently less reliable, and the transmission range of wireless sensors is rather limited because of stringent energy consumption constraints. There have been significant improvements though in these two areas by exploiting sophisticated architectures and energy-efficient routing protocols. Nowadays, wireless sensor networks using ZigBee (based on the IEEE 802.15.4, [32]), Bluetooth (IEEE 802.15.1), or WiFi (IEEE 802.11) are mature enough to be used in commercial, large-scale smart farming applications.
- The sensors in smart farming are expected to operate under hard environmental conditions that can often affect their correct functioning. Many of the currently available products suffer from unreliable sensors, i.e., sensors whose measurements are false, and introduce confusion into the gathered data. The commercial solutions can incorporate though some of the outlier detection methods proposed by the research community, in order to solve this problem.

Cellular wireless systems

Cellular wireless system are often said to become ubiquitous. One should take into account though that the current 2G/3G/4G systems are designed to cover a great majority of the population and not the geographical area of a country. In many farming applications, it is, however, the area that counts. Even in the developed countries, the cellular coverage in rural areas is often not satisfactory. The latter problem could have prevented the farmers from becoming confident in mobile applications. While the 2G (GSM) and 3G (UMTS) network infrastructures reach more and more communities, a fundamental breakthrough in data services is expected to be accomplished by deploying the new Long Term Evolution (LTE) wireless systems. The LTE systems will not only target hotspots and large urban centres, but might be a viable solution for rural areas, as well. An example is the LTE 800M system in Germany, which operates in an 800 MHz spectrum band. This frequency range became free after digitalizing the terrestrial television (the so called “digital dividend”). The transmission in this band is particularly convenient for rural areas as it allows large cell sizes. The first commercial solutions have appeared recently (in Germany, e.g., in Vodafone network using Ericsson and Huawei base stations in 2010). Similar trends are present in other European countries.

While one can expect that the problem of wireless access in inhabited rural areas is resolved or it will be resolved in the very near future, the remaining issue is the provision of coverage in the areas which are not permanently inhabited, but intensively used for agriculture. It is not realistic to demand from mobile operators to deploy cellular infrastructure on all large cultivated fields only for farming purposes. On the other hand, wireless communication on fields is of particular importance for fleet management and precision farming. Fortunately, there exist communication technologies such as ad-hoc networks, which can be used to address this problem (cf. the following section).

Finally, one should mention that the falling prices of smartphones and tablets, followed by a number of supported applications on these devices, might make the wireless technology more attractive for the farming community. An interesting example in this direction comes from a non-European country. In Kenya, the recent success of the Huawei’s entry-level Ideos smartphone turned out to be backed not only by the low price, but by the accompanying *agriculture* and healthcare apps.

Ad-hoc networks

Ad-hoc networks are self-configuring wireless networks without any fixed infrastructure. In smart farming, the mobile ad-hoc networks (MANETs) and vehicular ad-hoc networks (VANETs) are of particular interest. The communication links in these networks can be established, e.g., using licence-free WiFi technology, and they can serve for extension of wireless cellular coverage. The machines on fields, having normally a considerable size, energy, and computational power, can carry easily the transmission/reception electronics and antennas, perform sophisticated routing operations and processing of data. The constant change of network topology is an inherent characteristic of such networks which makes the routing much more involved in comparison with networks having fixed infrastructure. However, there exist already a number of solutions for this problem with concrete applications in the areas of car-to-car communication or wireless robotic networks, which can be adapted to the farming scenario, see [33].

GPS

GPS is one of the technologies which have found a wide-spread application in smart farming. However, the accuracy of standard GPS is not sufficient for all precision farming scenarios. For this reason, assisted GPS (A-GPS) systems are developed. These systems use additional reference signals for more precise position calculations and faster response time. The examples for already available products include Star Fire Mobile Real Time Kinematic (RTK) system from John Deere or mojoRTK system from Leica-Geosystems, which render the accuracy of a few centimetres (cf. [34], [35], respectively).

Further applications of the GPS-enabled geographical information, which seem not to be utilized in smart farming, are in the area of position-based routing for ad-hoc modus in fleet communication [36]. As mentioned in the previous section on ad-hoc networks, the updates of the routing tables appear to be a major problem in MANETs. By exploiting the position information, the routing procedure can be simplified significantly.

P2P Communication

Internet was originally designed for trustworthy users (universities, companies, ...). This made the network susceptible to malicious attacks, which often raises concerns also in the farming community, where certain information might be quite sensitive. Solutions for increased security and privacy are some of the main enablers to be provided by the FI-WARE project. Nevertheless, the already available P2P applications could already be utilized in this context. The examples are the popular Skype software for communication over the internet or BitTorrent for file distribution [37]. P2P applications have no central entity for searching and updating, which makes them not only more robust and network bandwidth friendly, but also more secure.

The P2P principle can be used also for communication in ad-hoc networks, where groups of machines on fields, isolated in terms of communication, can establish ad-hoc, P2P connection in the group, and make intelligent, local decisions regarding possible modifications of the previously assigned tasks.

2.1.7 Existing Standards

The following section cites statements from the deliverable D200.1:

The complexity of farming issues increases due to the huge amounts of data coming from the farms as well as their diversity. Thus, many claim that in order to manage this information and enable different services and system interoperate with each other, we should develop standardized rules applied to all the agricultural information systems; those rules are known as computational ontologies. An ontology is a means to formally model the structure of a system, i.e. the relevant entities and relations that emerge from its observation, and which are useful to our purposes. The OWL Web Ontology Language, proposed by W3C, is deployed for use by applications that need to exploit the content of information, instead of just presenting associative information to humans, facilitating greater machine interoperability of Web content than that supported by XML, RDF, RDFS since it can provide vocabulary and formal semantics.

Vocabulary, known as thesaurus, has to be built upon previous efforts that have already produced a “concept list” of agreed and clear definitions for agricultural terms. Some paradigms are Bio@agro [38], FAO’s AGROVOC Thesaurus [39] which is multilingual, the CAB Thesaurus [40], the National Agriculture Library Thesaurus in United States [41], Encyclopedia of Chinese Agriculture in China, etc.

A high demand to make different machines interoperate efficiently, regardless the diversity and the huge amounts of produced data within the smart farming subsystem is present: the need to manage those data; We have to find a standardized way to exchange them between all involved services, even if every service has its own format.

AgroXML [3], developed by KTBL, is an open source XML – based standard facilitating for definitions of data that mainly refer to farms and plants while schemas concerning livestock is being awaited. A list of cooperating partners has contributed to its development. Also, ISOBUS uses it as an interface among mobile machineries.

Most of the data stored in the Farm Management Information System (FMIS) comes from external services i.e. meteorological stations, states’ policy and information service, etc, each of one has its own way to present its data. Nikkila [42] states that ‘This requires from the FMIS to manage several transformations of data in order to achieve interoperability with all relevant terms and services. Currently, no standards or de facto standards exist for this communication, through some common formats, such as AgroXML and FODM have been proposed’.

Precision Agriculture Markup Language (PALM) was also proposed as a standard language for data exchange. It is based on the model MOSAICo [43] and on the multilingual AGROVOC [39]. It is able to represent geographic objects by including Geography Markup Language (GML [44]) as well as field data. It includes a standardized vocabulary and since it is developed in line with AGROVOC, traditional distinctiveness is not a problem.

Others proposing an auxiliary language, called 'M'. It is an XML- based language that aspires to provide a semantic and contextual computing standard interoperating data between different existing XML standards. In 'M' Dictionary, every word has only one definition and a numeric extension is used for ambiguous words e.g. for the word tractor have tractor.1 meaning a wheeled vehicle with large wheels; used in farming and other applications and tractor.2 meaning a truck that has a cab but no body; used for pulling large trailers or vans. Its goal is to merge different XML schemas into one and transfer this information though internet to involved parties.

Summarizing, we need to clarify that beyond analysing the existing data communication formats, SmartAgriFood aims at determining which of the aforementioned is the most suitable for our system.

2.2 Possible FI Applications in Smart Farming

This section gives an overview about the enablers defined in FI-WARE project and its application potential in smart farming. The sections are corresponding to the FI-WARE high-level description document. The table below gives a short overview about the content, which will be described in more detail in the next sections.

Table 6: Possible Future Internet applications in Smart Farming.

FI Enabler	Application (brief description)	Main Benefit	Time Frame
Cloud Hosting	Farms can rent software, platforms or infrastructure, e.g. storage or processing. Software companies can re-use infrastructure or platform for their own application development. Standardized interfaces for access to infrastructure, platform or software.	Save of investment for small farms. Allow small software companies to compete in the market Seamless integration of different farming applications Scalability to future storage or processing demands.	1-2 years
Data/context management	Effectively loading, accessing, processing and analyzing data. Decision support systems. Fault identification. Sensor data integration. Unified semantic object description. Handling of multimedia, statistical data and transactional data. Localization and geographic services.	Repository of data can be shared and accessed anywhere. Utilization of advanced intelligent analysis and decision modules over the cloud. Capability of processing massive amount of data.	2-3 years

FI Enabler	Application (brief description)	Main Benefit	Time Frame
Applications / Services Eco-system & De-livery	Business framework infrastruc-ture and monetization in smart farming. Infrastructure for composition and mashup in smart farming applications. Support for variety of communi-cation channels and devices.	Creation of virtual market-places for the farmers to offer their products and consume the provided services. Decrease in cost and im-proved functionality of mashup applications. The farmers will be able to access the services using devices they possess.	1-4 years
Internet of Things	Integration of heterogeneous communication technologies on farms. Management of device re-sources on farms. Handling of data collected from devices on farms.	Unified architecture for communication with smart devices on farms. Easy management and discovery of relevant de-vices on farms. Collecting and storage of farming data.	2-5 years
Interface to Networks and Devices	Support heterogeneous access of devices which might be in use on farms. Support of multi-operator sce-narios. Intelligent connectivity to the FI.	The farmers can choose among various operators and communicate over a variety of devices. The service is automatical-ly adapted to the features, connection quality, or loca-tion of the terminals on the farm.	2-5 years
Security	Process the data provided by users in accordance with the rights and user requirements. Security monitoring, fraud and attack detection / prevention. User Authentication.	Users can control, who can access their data, or if the data is strictly private. Authentication ensures a “single-sign-on” to ser-vices. The user needs not to manage different ac-counts. Legal binding contracts and payments are ena-bled.	2-3 years

2.2.1 Cloud Hosting

Cloud Computing is the solution to several requirements in the smart farming scenario:

Low Investment in IT infrastructure through IaaS (infrastructure as a service):

Especially small farms benefit from the “pay-per-use” concept of cloud computing. There is no need for investment in an own infrastructure for data storage or processing. Instead, the cloud infrastructure can be “rented” and used as a service and scalability to changing demands in future is guaranteed. The end-user has not to care about the data backup, administration or maintenance of the infrastructure.

Flexible and low-cost Software through SaaS (software as a service):

Software can be rented as a service from the cloud. As the main processing and data storage is provided from the cloud, simple low-performance devices are sufficient to run the software. This allows applications to be executed also on mobile devices, tablets or computers in the office. Further, the farmer needs not to care about scalability, maintenance or administration of the software. Potential software hosted in a cloud may be: Farm Management Information Systems, Remote Machinery Control or Advisory Systems for e.g. veterinary services.

Time-to-market for new software solutions through PaaS (platform as a service):

Suppliers for e.g. farming machinery or farming software companies can base their development on the cloud platform, which provides specific programming models or components for software development. Thus, application developers need not care about the cloud infrastructure behind. For instance, the weather forecasting functionalities, decision support modules, authentication, billing or methods for integration of distributed sensor data can be provided as a platform.

Share and access information anywhere and with any device:

As any data from any stakeholder (farmers, contractors, suppliers, business partners etc.) stored in the cloud, users can access and share data via fixed access (e.g. DSL) or mobile access (e.g. WiFi or cellular networks) with from any place with portable devices. Of course, access policies have to ensure information security and integrity, allowing users to grant permissions to specific parts of the data provided from the user.

Off-line usage and local data processing with cloud proxies:

The "cloud proxy" concept in FI-WARE ensures, that off-line operation of software is guaranteed, for instance on farming machinery without access to the public cloud or for applications with high demand on local processing of huge amount of data e.g. foreign body identification during harvesting. Cloud proxies can be e.g. home gateways or farming machinery, which provide the ability to host applications and provide local storage and processing facilities.

2.2.2 Data/context management

In the environment of farms, a manifold of data has to be transferred, processed, analysed and understood. The enablers of the data/context management therefore provide the essential functionalities. Incoming data may include sensor data that are produced inside a farm, the status of the farming machinery, data from tracking systems, data that come from external services (e.g. meteorological data, state policies for a product), the outcome of processed data (e.g. data aggregation) as well as the results of actions that have been executed inside a farm. Data is enriched with its meaning instead of simply providing numbers or text. As an example, soil sensor data have context elements like "soil temperature in degrees Celsius" aligned with the location, the owner of the sensor, manufacturer etc. Furthermore, facilities to handle events are provided. Essential enablers for this are:

Publish/Subscribe Broker:

Through the publish/subscribe broker the farming stakeholders can make information public to the community or subscribe themselves to get notifications e.g. the announcement of a new regulation, a post of a farmer in a newsgroup, an alert of machinery or a mobile sensor providing a new measurement value.

Complex Event Processing:

A manifold of farming applications can benefit by utilizing this FI-WARE functionality: Ticketing services, geographically limited distribution of disease warnings, implementation of dashboards for machinery alarms, machinery support systems, message distribution systems e.g. via SMS or Email, etc.

Big Data Analysis:

This enabler supports parallel processing of large amount of data from distributed locations with application in e.g. sensor network data analysis or disease forecasting.

Multimedia Analysis:

Applications may be in video surveillance of fields, health inspection of plants or foreign body identification.

Unstructured Data Analysis:

For farms, this feature could support crawling relevant national internet sources and automatically combine to an EU-wide structured information platform.

Localization Platform:

For farmers, typical applications would be tracking of machinery e.g. during harvesting, finding local contractors for e.g. spraying or distributing messages to a local group of recipients.

Query Broker:

This enabler simplifies application development and enhances the geographical query facilities through the spatial query support.

Semantic Annotation and Semantic Application Support:

Semantic annotation and application supports the integration of existing standards and definitions for multilingual agricultural vocabulary, thesaurus or data exchange. Specific farming definitions can be applied, e.g. in Bio@agro, FOA’s AGROVOC, CAB Thesaurus or AgroXML.

2.2.3 Applications / services ecosystem & delivery

The farming community can exploit several functionalities of the FI Application/Services Ecosystem. First, the goods produced on a farm will find a more direct way to the customers. The farmers can also benefit from advertising their products. For the recipients of goods, it will be significantly easier to search, browse and compare the offers. Both actors could also profit from the feedback, ratings, and recommendations, which the system will support. The GEs in this category will support also revenue settlement and sharing, meaning the split of the charge among the different parties involved (the farmer, marketplace owner, mashup components provider). Finally, it should be mentioned that the envisioned Service Level Agreement (SLA) management as a part of the business framework in FI-WARE can enable the farmers to evaluate the quality of services which is offered to them. Notice that in this case, the farmers are the end-users (consumers). These services can be of various types, and can include not only agricultural, but communication, governmental, or financial services among others, as well.

The farmers can profit from providing additional information to their products. In this context, composition and mashup could play a significant role. A simple example would be a possible customer desire to know the geographical origin of the farming products. Notice that such information is already of significant value in wine industry, but the idea could be of interest for many other products. Information about the pesticides, weather conditions, practices on the farm, recommendations, instructions, or even recipes, might be composed into a unified, comprehensive service, which accompanies the product. Ideally, in FI, a farmer could become a prosumer and generate some of this content without IT experts' help.

Resolving the interoperability among the various data formats in the internet with the Gateway functionality will make the services more accessible for the farmers. Finally, Multi-Channel GEs will provide means for easy use of various channels such as stores/marketplaces, or social networks, where the farmer can act both as an end-customer, and provider of (physical) goods.

2.2.4 Internet of Things

Internet of Things was a visionary concept that is on its way to become reality in the near future, also in Smart Farming. Clearly, the ability to interact with the environment is of key importance in farming. The potential applications are numerous and include monitoring of greenhouses, animals, and agricultural machines, and gathering of information from various sensors and RFID tags. Some of the enabling technologies for these applications are already explained in Section 2.1.6. Unfortunately, the variety of the technologies of interest presents also the main hindrance in deploying the concept on a great majority of farms. Namely, most of the solutions have small target areas, are proprietary and of ad-hoc nature. For this reason, some of the experts describe the current situation as many intranets of things instead of the desired, one Internet of Things. FI will create a unified architecture for the farms to become smarter. By connecting the developed IoT enablers with the other FI GEs, the production, management, and quality of the farming products will be improved.

Farmers can be seen as end-customers of IoT GEs. The IoT instance providers and application developers will directly exploit the developed FI infrastructure, and offer a wide range of services based on smart objects. The new architecture will create competition on the market, so the farmers can expect high quality, comprehensive services at comparatively low prices.

As far as IoT communication aspects are concerned, the technologies of interest, such as networked RFID systems, wireless sensor networks, near-field communication (NFC), and machine-to-machine (M2M) systems will be integrated in a general IoT architecture. The distributed things will communicate with the gateway (typically on the farmer's premises) using interoperable solutions.

The GE for the management of IoT resources will enable easier discovery of the devices of interest on farms by providing an efficient resolution infrastructure. This GE will in combination with the IoT Communication GEs will resolve the addressing issue, possibly by applying the address translating methods.

The things in internet can generate a very high amount of data. Consider for example, the project of a Dutch startup “Sparked” with sensors implanted in cows’ ears that can measure its health conditions and transmit this data to the farmer. Such an application is expected to generate 200 MB of per year per cow. Clearly, a huge number of such beneficial applications can be imagined even if one focuses on the smart farming arena only. Therefore, it is particularly important to determine where and how will all this data be stored. This issue will be partially covered by the IoT Data Handling GEs (a complete solution will require the involvement of Data Management GEs, as well). Data handling in IoT will include also the security aspects. For example, it might be preferred to keep some sensitive data only at the farmer’s premises (local storage) and not in the cloud (global storage).

2.2.5 Interface to networks and devices

One application of the CDI GEs which might be useful in Smart Farming is a dynamic adaptation of content depending on the device the farmer possesses and the current connection quality. The system might e.g. decide to send to the farmer only a brief text message regarding the coming storm if the farmer is currently connected only using a simple mobile phone. However, if the system detects that the farmer currently carries a smartphone or a tablet, the information about the storm can be enriched with weather maps, animated detailed forecast, disease centre recommendations, etc. This GE also supports the location based services. For example, the system could take into account whether the farmer is far from the farm, and, therefore, uses more expensive cellular service, or it is inside its home, where it has a flat-rate WiFi connection. In the former case, it might be more economical for the farmer to receive the minimum amount of information, while the rest can be downloaded later, when the farmer is in the WiFi range. Furthermore, depending on the current position on a farm (home, building for livestock, particular part of field with specific crops, vineyard, garage ...), the farmer can obtain the relevant context-based information (e.g., the current work plan for the vineyard for that day, etc.).

Ensuring QoE by the CDI GEs will be important for the farming community. Namely, the farmer’s feedback will be taken into account when designing the technical parameters of communication systems. In this way, a significantly better service is to be expected. The latter claim is additionally backed by the fact that NetIC GEs will optimize the SLAs and ensure their fulfilment. Indirectly, the farmer will also benefit from interoperability solutions provided by the NetIC GEs, as the current multitude of standards in this area hinders efficient exploitation of the available technologies.

Regarding the S3C GEs, one can notice that the envisioned applications in Smart Farming are one typical example for a burden for the EPC. The EPC was designed with a primary goal of supporting the *human-to-human* communication. The new FI-enabled services in Smart Farming will assume a proliferation of M2M communication (e.g. among sensors on the farms, gateways, computers in the cloud, etc.). This type of communication is characterized by a traffic model which is very different in comparison to communication among humans. The number of connected devices will in future be very high, and corresponding data rates can vary significantly. Consider as examples, a simple temperature measurement requiring only a few bits, an infrared picture of a few megabytes for an animal e-health application, or real-time video surveillance of some sensitive area with high data rate and low latency constraint.

2.2.6 Security

The security enablers will support secure and trusted access to the data from any location (e.g. with mobiles on the field or with the PC premises) through the authentication services. The single-sign-on to cloud services will enable seamless interaction and mash-up of farming management information services, booked services like e-agriculturist, e-veterinarian or weather services. In addition, payment for agricultural marketplace will be supported. Further, through access policies, farmers can control the privacy of their data stored in the cloud.

However, there is still on-going work in definition of the security enablers, see 1.5.6.

3 Smart Agri-Logistics

Smart Agri-Logistics focuses on the logistics flow from primary production (farm) to the market. Generally spoken, Smart Agri-Logistics starts when the primary produce is shipped (farm gate) and ends when the agri-food products are received by the retailer (retail gate). Consequently, the focus is on the roles of outbound logistics, inbound logistics and logistics orchestration. One of the main future internet challenges for logistics is to enable the agri-food industry to deal with high dynamics and uncertainty in supply and demand. It is widely accepted that virtualized networks are an important answer to challenges posed by the markets and the opportunities offered by nowadays affordable new technologies (in particular ICT, Sensors, Automatic Identification and Mobility technologies (including RFID), conditioning, transport, etc.). Virtual logistics networks are information-based rather than inventory-based. Consequently, information systems are important enablers of virtual networks. However, the dynamic nature of virtual networks imposes stringent demands on the enabling information systems. They should facilitate the dynamic construction of temporal supply chains and the real-time and network-wide transparency of the products and resources that are needed to achieve its value proposition. Reliable information must be shared timely throughout the supply chain and subsequently early alerted firms have to respond quickly to changes, taking into account varying quality parameters, organizational conditions and different requirements of market segments.

Current agri-logistics systems build on concepts utilizing central database infrastructures. This approach is overwhelmed by the pure quantity of data that is involved, the need for global management agreements in a sector so dependent on global trade relationships, the need for trust by the large number of independent SMEs involved, and the diversity in technology levels between enterprises and between countries on a global scale. Adoption of internet for basic information services is high, but the use for more advanced functionalities is limited. In the smart agri-logistics use cases, the focus is on real-time virtualization, logistics connectivity and logistics intelligence. Thereby, the enhancement of new types of efficient and responsive logistics networks with flexible chain-encompassing tracking and tracing systems and decision support based on that information are strived for. These systems virtualise the logistics flows from farm to fork, support a timely and error-free exchange of logistics information and provide functionality for intelligent analysis and reporting of exchanged data to enable early warning and advanced forecasting. This section first gives an overview of available internet functionalities that are not yet (fully) exploited for the smart agri-logistics challenges described above. Second, possible new future internet applications for smart agri-logistics are inventoried and described.

3.1 Non-Exploited Available Internet Functionalities Which Could be Used for Smart Agri-Logistics

The following sections explore five functionalities through the whole supply chain, which are already available on the internet, but not well exploited inside the market. Figure 10 outlines non-exploited functionalities throughout the supply chain, which will be explained in detail in the next six sub-chapters.

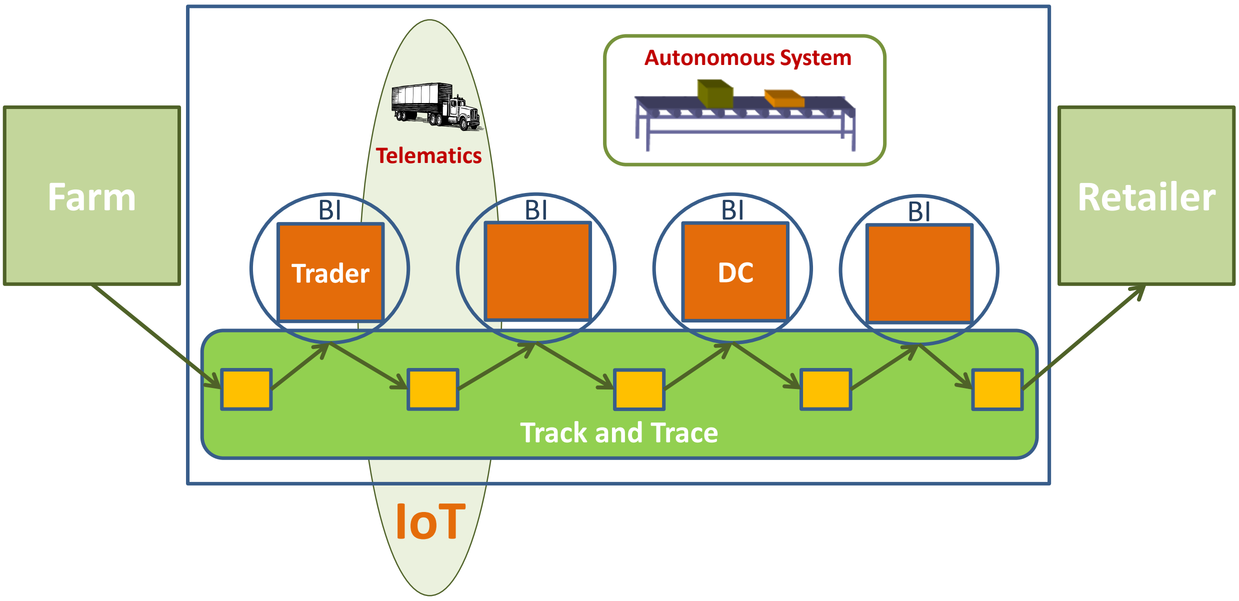

Figure 10: Available internet functionalities and their relation to smart agri logistics

3.1.1 Internet of Things

As mentioned in chapter 2, the Internet of Things was a visionary concept that is on its way to become reality in the near future. At the moment, already various types of sensors (e.g. RFID temperature loggers, GPS, gas concentration) are being used in the logistics sector and thus also in the agri-logistics sector. However, these applications are only limited in scope and focus on specific subparts of the logistics chain.

The potential applications are numerous and include monitoring of goods, transportation means, vehicles, and environment conditions by gathering of information from various sensors and RFID tags. This information can be used to maintain quality and do real-time planning and virtualisation of logistics products.

As mentioned, the communication aspects of the internet of things are already fairly well covered by existing technologies, such as networked RFID systems, wireless sensor networks, near-field communication (NFC), and machine-to-machine (M2M) systems. The next level that needs to be captured is the global sensor information level in which combinations of sensor information can be used to constantly monitor the status and possible exceptions of products in the logistics chain.

3.1.2 Telematics Systems

The quality of goods especially inside the agri-food sector is essential. These perishable goods are often very sensitive to changes of the transport and warehouse environment (e.g. temperature, light, ethylene concentration, etc.), which may lead to a reduced quality of the product and therefore the price.

To promptly react to such changes, the use of sensors is already applied in some parts of agri-logistics, especially in fields where the cool-chain must be unbroken (e.g. fish). Nevertheless it is possible to expand the usage of telematics systems inside the chain. These systems enable automatic monitoring of changes in transport relevant sensor values and communicate critical changes to a logistics management system.

One example is the increase in temperature due to a fault of a cooling system inside a transport vehicle. If this exception is monitored and send to the management system, this system could react by sending a replacement vehicle or instruct the driver to transport the goods to an entrepot to preserve the quality, and therefore the market value, of the product.

Nevertheless telematics systems should not just allow decision making on current information, but also save and forward these data through different actors through the chain.

Additionally telematics system are not only limited to monitor products, but can also be used for fleet management, vehicle tracking and intelligent navigation. This can be used to flexible (re-) deploy transport vehicles based on real-time information.

3.1.3 Tracking and Tracing

Tracking and tracing service are already well known inside logistics processes in general and offered by different companies as a service for their customers (e.g. Deutsche Post, FedEx, etc.). But these services are often limited to an internal level of traceability, which means that it refers to a single step inside the entire supply-chain. To fulfil EU regulation EC/178/2002 inside the agri-logistics sector, traceability should have

«the ability to trace and follow food, feed, and ingredients through all stages of production, processing and distribution.»

This leads to the requirement for "internal traceability" that the company has control and records of how received ingredients and raw materials go into their internal production and finished products. In addition, the company knows from whom it received each raw material unit and to whom it sold/sent each unit of finished goods.

If we increase the level of traceability and focus on the whole supply-chain, the system needs to be able to trace across and through the companies in the chain – a completely different challenge as the one faced by an internal traceability system. Some key requirements of chain traceability are a globally unique identification system and standardization together with agreed best practices between the chain participants.

3.1.4 Autonomous Systems

Most logistics systems available on the market implement a strict centralized approach to represent the management of logistic processes in a top-down way. While the growing complexity of those logistics processes leads to a growing challenge of centralized approaches, decentralized systems are becoming the focal point of different research and innovation projects.

Opposite to centralized systems, decentralized systems are trying to translate the former hierarchy approach into a heterarchy model. To achieve this, each entity inside the logistics processes are able to process information, take decisions autonomously and communicate with other entities.

Similar to the Internet of Things topic, these capabilities implicate the existence of a virtual identity representing the physical one, but encapsulating the intelligence and social abilities.

3.1.5 Business Intelligence

Business Intelligence plays an important role to support companies making strategic and functional decisions. To support these decisions BI systems analyse company-, competitors- and market-relevant electronic accessible data and process models by acquisition, processing and dissemination. While this data is mainly extracted from existing ERP systems, the four preceding functionalities can be used as information sources, as well as information consumers:

- The **Internet of Things** offers a direct communication to all types of entities, which can be used to access a massive amount of information attached to that entity. One possible source of that information can be **telematics system**. In addition, **tracking and tracing** applications can be used to generate even more information to be used for BI.
- **Autonomous Systems** can use the information generated by BI systems to improve its decision making process.

3.1.6 Existing Standards

Telemetric Systems

XTCE (XML Telemetric and Command Exchange) is a standard developed by different space agencies inside the CCSDS (Consultative Committee for Space Data Systems) to define the exchange of sensory data and the exchange of command meta-data. These meta-data include the possibility to define special criterions for packet filtering, data verifiers, prioritisation of commands, etc.

Since this standard is based on XML, it can be easily extended and adapted for different application and research fields.

Tracking and Tracing

The GS1 Global Traceability Standard (GTS, Ryu and Taillard, 2007) describes the traceability process including the minimum requirements for each stakeholder to participate. It also covers different levels of traceability, different types of products (e.g. Shipping Unit, Consumer Unit, Logistic Unit, etc.), information handling, etc. while being independent to the choice of enabling technologies. Five key features of this standard are:

- Efficient exchange of master data
- Unique identification
- Recording and archiving of traceability data
- Interconnection of traceability relevant data
- Continuous flow of information

Autonomous Systems

The architecture of most autonomous systems is based on multi-agent platforms. The Foundation for Intelligent Physical Agents (FIPA) is and IEEE Standard Organisation, which tried to norm agent-based technologies and ensure interoperability with existing technologies. The result is a specification composed of different standards (including 25 final standards).

Important components of the specification are:

- ACL – Agent Communication Language. The message format or language of the agents.
- Various interaction protocols (e.g. English Auction, Dutch Auction)
- The agent architecture
- The architecture of the agent platform
- The transport of messages
- Etc.

RFID in the scope of IoT related applications

There are diverse standards available with respect to the development of RFID based systems. Previous RTD activities as well as in the scope of the IERC cluster and the RACE network RFID, the status of existing standards was analysed. Specifically the GRIFS project (Building the Global RFID Standards Forum) analysed RFID related standards. Moreover, to enable the overall ICT community to understand the different elements with respect to RFID and also for IoT on the longer term, one need to identify the main components of such systems and fields for standardisation. As presented in [5], one could structure the topics directly or indirectly associated with RFID systems, as presented in Figure 11.

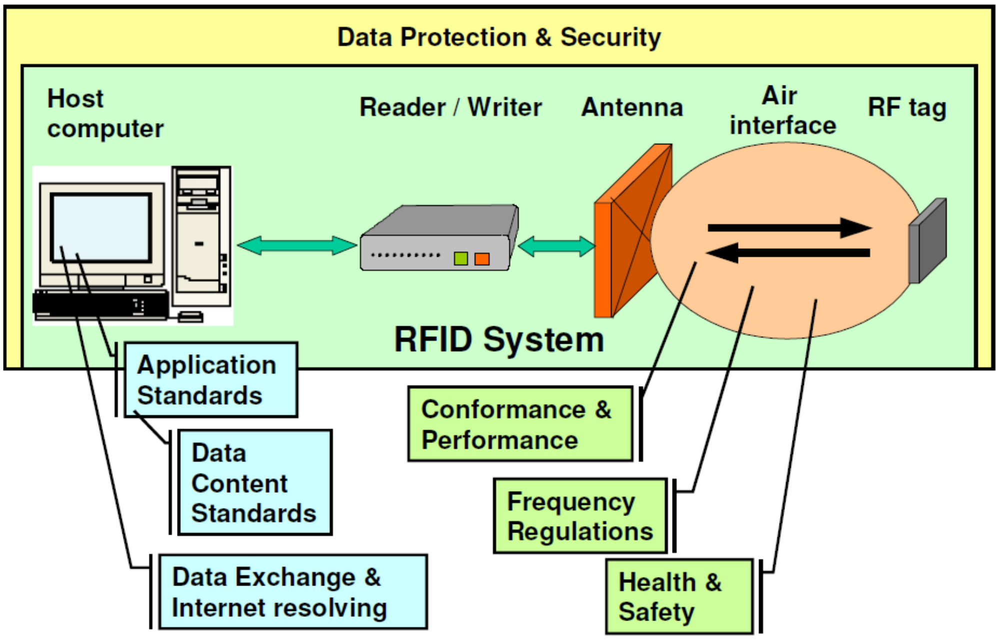

Figure 11: RFID related High Level Standards Map [5].

It can be stated that there are a large amount of standards available when aiming at the realisation of RFID and IoT related solutions. These standards are generally grouped from a technical perspective and their relation to the different architectural elements of an overall RFID/ IoT system. The analysis in the GRIFS project was elaborating such an RFID system architecture overview as presented in the following Figure 12.

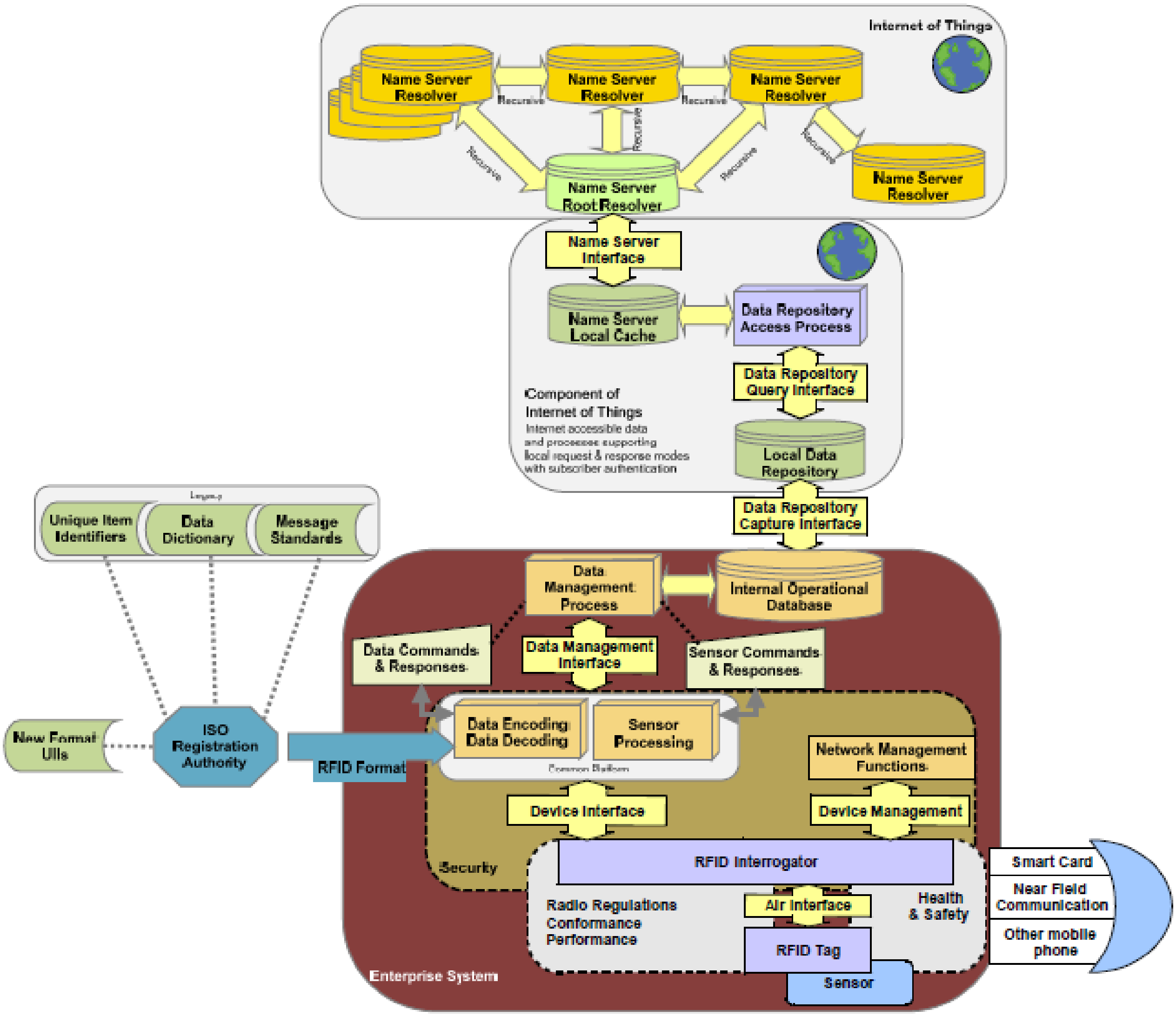

Figure 12: The core RFID system architecture as outlined by GRIFS [45].

Based on this architectural model, GRIFS was structuring the standards with respect to the following areas:

1. Frequency regulations
2. Health and Safety regulations
3. Data protection and privacy regulations
4. Air interface standards
5. Sensor standards
6. Conformance and performance standards
7. Device interface standards
8. Data encoding and protocol standards (often called middleware)
9. Data standards
10. Application standards
11. Data exchange standards and protocols (e.g. DNS, ONS, Handle)
12. Security standards for data and networks
13. Real time location standards
14. The European Harmonisation procedure

15. Mobile RFID

In conclusion, one need to identify that there is a large amount of different standards, which have also different interrelationships between each other and with existing regulations. However, it is not the objective to list the detailed standards in this deliverable, but to highlight the large amount of results that are available for RFID and IoT related implementations and which are providing a basis for further developments towards a Future Internet. Furthermore, a valuable reference presents the standards database (http://grifs-project.eu/db/) hosted by the GRIFS project.

3.2 Possible FI Applications in Agri-Logistics

The next table gives a short overview of the Future Internet enablers defined in the High Level Description of the FI-WARE project. Possible agri-logistics application and their benefit are outlined briefly. Then, these applications are described in more detail.

Table 7: Possible Future Internet Applications in Agri-Logistics.

FI Enabler	Application (brief description)	Main Benefit	Time Frame
Cloud Hosting	Stakeholders can rent or host software inside the cloud. Also virtual hardware can be rent in the cloud (IaaS). Standardized interfaces for access to infrastructure, platform or software.	Reduce resources for IT department; especially in hardware and software maintenance. The computing power can be increased or decreased on demand. Scalability to future storage or processing demands.	Short
Data/context management	Effectively loading, accessing, processing and analysing of large dataset. Simulation Decision support systems. Fault identification. Sensor data integration. Process complex events	Massive amount of data, for instance in Business Intelligence, can be analysed. Simulate action alternatives (if-then) for supply chain events. Monitor the quality of products during transport and conditions during loading, transport and unloading though sensors and react on critical values. Order prediction by analysing available datasets (e.g. stock, sales, quality of the product in the store) React automatically on different events (e.g. critical raise of temperature) to ensure quality of transported goods	Short

FI Enabler	Application (brief description)	Main Benefit	Time Frame
Applications / services eco-system & de-livery	Infrastructure for composition and mashup a various set of logistic applications. Business framework infrastructure and monetization in agri-logistics. Support for variety of communica-tion channels and devices.	Fast orchestration of busi-ness mashups to enhance existing or create new appli-cations. Offer logistic based services on virtual marketplaces. Access services and applica-tions with heterogeneous systems reduce the need to buy special hardware.	1-4 years
Internet of things	Integration of heterogeneous communication technologies on farms Management of device resources on farms Handling of data collected from devices on farms	Unified architecture for com-munication with smart devic-es on farms. Easy management and dis-covery of relevant devices on farms. Collecting and storage of farming data.	2-5 years
Interface to networks and devices	Support heterogeneous access of devices. Intelligent connectivity to the FI. Create/Join/Leave P2P Networks Local routing of messages. Maps real-life communication inside a supply-chain by allowing easily creating, joining and leav-ing P2P networks. Identify available feature and capabilities of connected device	Allows supply chain monitor-ing systems to support differ-ent communication media/ devices. The migration of functionality from the cloud to a mobile device can compensate the lack of an internet connec-tion. The system can compensate disconnects from the internet on mobile devices by using asynchronous communica-tion (i.e. sending data without waiting for an immediately response). Routing of messages through the chain, not requiring a central authority that tracks the latest IP addresses. Orchestrate and find devices with required features (e.g. able to monitor temperature)	2-5 years
Security	Authenticate objects/actors and authorise them for specific tasks Add and/or revoke access rights automatically Security monitoring, fraud and attack detection / prevention.	Stakeholders can control, who can access their data, or if the data is strictly private. Massive amount of actors and objects need an intelli-gent access rights manage-ment. Legal binding contracts and payments are enabled.	Short

3.2.1 Cloud Hosting

3.2.1.1 Cloud Proxy

The cloud proxy acts like an agent between the cloud and the user devices respectively and provides intermediate storage abilities to compensate for disconnection to the cloud itself. This is done by splitting one service into two. One service running on the cloud proxy and one in the cloud.

Since it is not guaranteed to have a stable internet connection, connection to the cloud can be lost and loss of functionality would be the consequence. This can be fatal when a proactive monitoring system loses its functionality while transporting products in areas without an adequate internet connection. To overcome this issue a Cloud Proxy can be installed on the user's system to host part of the virtualised resources, applications and data.

3.2.2 Data/context management

The generic enablers of the data/context management have the potential to address various challenges in the field of agri-logistics. Applicable enabler inside the field of smart-agri-logistics are presented in the following subsections

3.2.2.1 Exchange information on events (Publish/Subscribe Broker)

The Publish/Subscribe Broker allows an easy way to push and pull events inside the future internet. While the publisher and subscriber can be either a human or a piece of software, it is for instance possible to let a monitoring agent watch quality relevant sensor data (e.g. temperature) and publish this information to the broker. That information can be accessed by other enablers, software to analyse critical changes or a user.

Since it is also possible to pull new information, it doesn't depend on a continuous connection to the internet, which cannot be guaranteed on the road or in rural areas.

3.2.2.2 Real-time interpreting, processing and handling events (Complex Event Processing)

While the preceding enabler doesn't support a strong intelligence or filtering capabilities, this enabler fills the gap when event processing is needed and allows "event-based routing, observation, monitoring and event correlation" [7]. Possible events on different stages of a simple fruit supply chain can be:

- At the grower:
  - Diseases (anthracnose, powdery mildew, bacteria)
  - Pests (mango seed weevils, fruit fly)
  - Force majeure/ extreme weather conditions (thunderstorm, hail, heat, etc.)
  - Incorrect use of pesticides
  - Contamination of organic fruits by nearby non-organic ones
  - Contamination by genetically modified fruits
  - Delay in delivery
  - Delivery failure
  - Missing optimal harvesting time
- At the forwarder (grower → packer)
  - Damages in transit (tipping of loads, e.g.)

  - Incorrect cooling
  - Delay in customs clearance
  - Delay in delivery (due to traffic jams, etc.)
  - Mixed transport with non-foods material/scrap (one-way pallets, waste, etc.)
- At the packager:
  - Contamination of untreated products (e.g. on packing conveyor belt)
  - Incorrect cooling
  - Delay in delivery
  - Delivery failure
  - Incorrect packaging
  - Contaminated packaging material

3.2.2.3 Big Data Analysis

This enabler allows the processing and analysis of big amounts of data. The generated knowledge can be used for simulation and forecasting.

The conditions for transport and storage of products can be used by this analyser that should be available, to forecast the consequences of detected changes by the time the product reaches destination (e.g. best-before date simulation). Based on this outcome, it can be decided in real-time to adapt the logistics chain accordingly or make better/other decisions for future transport/storage in order to improve these conditions.

3.2.2.4 Localization Platform

The localization platform allows applications to take the geographical position into account and can be used in manifold logistics applications, like::

- Tracking and Tracing
- Fleet management

3.2.2.5 Mediation and Multi-Channel/Device Access

The software ecosystem of agri-logistics is heterogeneous, different types of ERP systems are used, handling data and information in different ways. Also the variety of hardware and operating system is increasing, especially for mobile devices (e.g. Android OS, iOS, etc.).

To have applications to be executable, irrespectively of the interface, at the end-user side is eligible, this also applies for the access of different data formats, created and/or distributed by legacy systems. This seems feasible, because legacy systems are often offering semantically similar but technical incompatible interfaces. Moreover it is crucial that important information and events and their corresponding actions must be monitored via various different communication media and devices, such as mobile apps/devices, fixed back-office apps/systems and internet-based apps/services.

3.2.2.6 Internet of things

The current internet consists of an interconnected network of computers or at least electronic devices. Opposite to this idea, the internet of things (IoT) takes all physical objects into account. As a prerequisite it is mandatory for each “thing” to be uniquely identifiable, which is often linked to the usage of RFID tags. This uniquely identification allows a linkage of the object with a virtual representation or identity, which is be used to communicate with other entities inside the IoT.

In addition to this “weak” description the IoT topic, it is often linked to research fields such as Ubiquitous, Pervasive Computing, Ambient Intelligence, etc. This extends the capabilities of entities to process information autonomously, react proactively and context sensitive to their current environment.

3.2.3 Applications / Services Ecosystem and Delivery Framework

Throughout the supply chain there are several functionalities of the FI Application/Services Ecosystem, which can be exploited as a crucial support to offer, use and mash-up services. One central part of this functionality is the marketplace. In contrast to a service- or software store it allows different actors to offer their products to a broader audience, by which consumers and service creator/provider can benefit:

- The **consumer** can search and compare similar services based on various criteria (e.g. price, rating, SLA, etc.)
- The **provider** is able to offer its product to a broader audience, while reducing the efforts to establish a distribution and pricing system.

3.2.4 Interface to networks and devices

3.2.4.1 Connected Devices Interface (CDI)

To monitor a various amount of different quality parameters on heterogeneous systems it is eligible to have a generic layer to access all monitoring devices and sensors in the same way. This functionality is provided by the connected devices interface layer. Additionally this enabler can be used to discover capabilities of available devices.

These features play a key role when orchestrating multiple monitoring devices to gather the parameters necessary to achieve a proper quality control.

3.2.4.2 The Network Information and Control (NetIC)

One interesting feature of this enabler is to create virtual network providers. This can be used to represent real-life connections between different stakeholders inside the supply chain. This can be achieved by the ability easily create, join and leave P2P networks. This includes centralized, hybrid and pure P2P networks. Additionally problems like routing of messages through the chain, not requiring a central authority that tracks the latest IP can be addressed, while taking care for routing, prioritisation, message handling and storage.

Another feature is that this GE is able to optimize the network and adds additional feature such as QoS to ensure that service-level agreement are satisfied and that crucial information, which are needed i.e. in real-time, will be transported prioritised.

3.2.5 Security

Security and trust are essential prerequisite for stakeholders in the agri-logistic sector to share information with each other. This leads to a few requirements:

- The system shall enable the user/object to authenticate and/or authorise each other (i.e. in a client server, as well as p2p environment) based on decentralised certificate scheme.

- The system should support authentication and authorisation mechanism for all types of entities (e.g. actors, objects, etc.) - also enabling a decentralised security approach for issuing certificates not requiring a central root.
- Automatically adding and/or revoking access rights, based on the changes in the physical as well as in the virtual world. This may include ownership, location, etc.

4 Smart Food Awareness

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 build. Transparency is not meant to know everything but to create awareness on the issues consumers are interested in, involving information on the safety and quality of products and processes, and increasingly on issues around environmental, social, and ethical aspects. Smart food awareness focuses on this context.

The scope of this scenario includes the last step on the food supply chain and the final consumer, playing a new and active role, in a user centric approach. With this new paradigm, the final consumer could be seen as an additional link in the chain. On the other hand, retailers plays the current role of last step, however, other less obvious stakeholders could be found as restaurants and other catering options.

In this environment, there have been several initiatives to answer the questions of the consumers related to food transparency– origin, composition, allergenic, quality, safety, etc. Some technologies are available currently in order to answer many of these questions (image recognition, smartphones, proximity communication technologies, etc.). However, there are some obstacles that do not allow a full deployment of this new approach: specific solutions for a small set of products or for a local product; lack of standards; difficulty in retrieve information from the previous steps in the chain; crowd sourcing initiatives based on social networking which may produce information with low level of trust; etc.

It is necessary to answer these questions on an open approach, with coordinate actions and using a common infrastructure in order to succeed. The capabilities expected in the FI initiative could really help on the development and deployment of such an infrastructure, based on the management of massive and heterogeneous sources of information which allows open accessibility from different channels, adaptability to consumer profiles and trust and information reliability.

4.1 Non-Exploited available Internet functionalities which could be used for Smart Food Awareness

4.1.1 Social networking

The application of social networking concepts could be of benefit for the scenario, especially when the participants are able to provide guarantees or approve participation of "friends". With this approach, evaluation of performance and reliability is done by the process of participation in the network.

4.1.2 Infrastructure as a network of heterogeneous components

Based in concepts related to Cloud computing (with storage and computing services) and agent platforms (with ubiquitous computing based on smart objects), there are many issues related to Smart Food Awareness that could be improved:

- Tracking and tracing, this is a baseline for food products. Intelligent cargo combined with the support of a cloud of services to monitors the checkpoints in the food supply chain, could boost the information exchange between stakeholders in the chain. This is important in order to gather all the information of the food items that may be of interest for the final consumer.

- In addition, the agent approach could give flexibility (and sustainability) to generic tracking and tracing functionalities, so easing the adoption for the food sectors and information scenarios.
- Distributed access platform. Given the atomised structure of the food sector, allowing easy access to these infrastructures to SMEs and others stakeholders (as clusters or associations) is of the major importance. Again, Cloud Computing may ease this issue by reducing the initial investments to access these services
- Specialized services. The interaction between the different components of the network (products, stakeholders, information systems) could depend on the interaction abilities of smart dynamic services, with advanced interface and exchange capabilities.

4.1.3 Data Management

Another important issue in the food awareness scenario is about the management of big collection of information coming from several sources, using different system references, standards or specific one-to-one information protocols.

On the one hand, the provision of standardized data containers containing data from different formats could facilitate the information exchange. In this case, the use of tools to facilitate the integration, storage and communication of these sets of information, linked to the freight by some AIDC technologies (RFID, for instance), could complement the tracking and tracing base.

On the other hand, the application of big data analysis together with semantics-based homogenization of the information could facilitate the interaction of the information across the supply chain.

4.1.4 Accessibility and ubiquity

The wide use of smartphone and other mobile devices creates an interesting direct and dynamic communication channel with consumer that could expand the range of information services offered to them, from just basic information requests, compatibility to user profiles to the adoption of the already explained social networking approaches.

Augmented reality concepts are possible using the smartphone as an access device, combining several of their capabilities (camera, location, short-range communication, etc.) in a single direction

4.1.5 Location based services

A core support of some location technologies (both in outdoors scenarios – GPS, Galileo, or indoors, RFID-WIFI, NFC, Bluetooth, etc.) could boost the adoption of additional location based services (LBS) in the normal experience of both retailers and consumers.

- Identification of location, origin and path, which is becoming a demand from a wider range of consumers
- Geofencing techniques, in order to trigger events depending on the position of different parts of the network (from freight to consumers)
- Smart shelves concept, with information about its products and the different events related to these products (“consumer has fetched an item”, “consumer has returned an item”, etc.)

4.1.6 Consumer privacy and trust

Finally, together with new services using the wide range of information available, there could be the fear of losing consumer privacy; for the stakeholders in the supply chain, especially the retailers could be very easy to create detailed consumer profiles based on their behaviour. For the own sake of the adoption of the scenario by the consumers, transparency about the use of such information is of major importance.

In this approach, the smartphone combined with the cloud computing approach could give an opportunity by storing the profile of the consumer in the smartphone itself, so the consumer is owner/responsible for the information: she/he can accept/deny access to certain data by certain stakeholder in certain situation.

4.1.7 Existing Standards

Concerning communication between enterprises for tracking and tracing activities, for the identification of trade units (product batches), solution proposals have been formulated by the universal standard committee GS1 ('General Standard One'; www.gs1.org) with its specification of:

- Global Location Numbers (GLN),
- a universal trade unit identification scheme with the Global Trade Item Number (GTIN),
- the development of Electronic Product Codes (EPC) that facilitate the use of electronic identification devices like RFIDs and others.

Concerning social and ethical concerns, a number of certification schemes for food products presently exist that are sought to address social and ethical concerns around food. Certification schemes operate in business-to-business as well as in business-to-consumer relationships and are perceived a means to facilitate transparency.

- Ethical Trading Initiative (ETI), Suppliers take responsibility for improving the working conditions of the people who make the products they sell.
- Fair trade certification schemes.
- Rainforest Alliance, The Rainforest Alliance Certified seal is awarded to farmers who meet the standards for responsible farm management of the Sustainable Agriculture Network (SAN), a coalition of environmental and conservation groups.
- GlobalGAP sets voluntary standards for the certification of production processes of agricultural products.
- Recommended by Animal Welfare Association (Denmark), Danish animal welfare scheme established by the Danish Animal Protection Association (APA) covering, a.o., animal welfare requirements under production, transport and slaughtering.
- KIR Kosher Food Certification.
- HMC (Halal Monitoring Committee) Certification Scheme.

4.2 Possible FI Applications in Smart Food Awareness

Table 8: Possible Future Internet Applications in Smart Food Awareness.

FI Enabler	Application (brief description)	Main Benefit	Time Frame
Cloud Hosting	The creation of services platform to support the distributed access platform, with several of the components like the tracing/tracking backbone, data containers access, multi-agent platform.	Lower access investments, so SME can be involved. Flexibility in the managing of the component network (food items, SC, IT systems)	Medium
	Use augmented reality functionalities or pattern recognition software of smartphones to scan the products packaging and identify quality signs, logos and text (e.g. production codes) to enable the provision of hidden background information for these labelling elements to the consumer. This includes e.g. logos and quality signs, which already include important food quality, safety and integrity information.	Due to its non-product specific character, the application works for all product ranges right away and can be supplemented with additional SaaS or IaaS concepts from agri-food enterprises. The reduction of additionally required barcode elements.	Short
Data/context management	Homogenization and management of big volumes of information Support to the data container concept	Combination of several sources of data, creating new and extended information profile for the food products Improvement in the interoperability between stakeholder in the SC New opportunities based in the range of information available and the quick access	Medium
Applications / Services Ecosystem & Delivery	Support to the creation of several IT frameworks to facilitate the construction of services for different aspects: - Tools for Food transparency and information flow - Consumer pull scenario framework - Retail push scenario framework	For IT services providers, improvement in the application development lifecycle. So, costs reduction is feasible	Long
Internet of Things	Support to the concepts of data container, smart shelf, mobile consumer	Creation of new services and information products, improvement in the business procedures and managing of the information across the SC	Long

FI Enabler	Application (brief description)	Main Benefit	Time Frame
Interface to Networks and Devices	Common access to different terminal devices, or to different identification infrastructure	Homogenization and simplification of the access and retrieval of food information	Medium
Security	Support to privacy and trust issues	Improve the early adoption by the consumers	Short

4.2.1 Cloud Hosting

This chapter of the FI-WARE architecture provides an opportunity to deploy and manage an infrastructure able to offer the final consumer with specific information services able to gather the food information from a variety of sources and apply them to the specific interest, in an efficient, scalable and economical way. This is especially important when taking into account the potential figures of different food products (just a medium-size supermarket can handle some thousand references) and the potential users of the system (from thousands to millions, depending on the deployment area).

For instance, the IaaS Service Management GE could facilitate the creation and managing of a service infrastructure; or the Storage Hosting GE, which stores items as units of both opaque data and meta-data, could provide common infrastructures for the use and storage of the information related to the food products – this is especially important to allow flexibility in the movement of the goods within the supply chain.

4.2.2 Data/context management

Some of the specific needs of the scenario refer to the provision of information coming from a variety of sources, origin, formats, structured or not, etc., stakeholders in the supply chain; external repositories of general information (Carbon Footprint, certifications characteristics); etc. So some of the Generic Enablers included in the Data/Context management chapter may support the management of these sources of information.

For instance, the Unstructured data analysis GE, which enables the extraction of meta-data based on the analysis of unstructured information obtained from web resources, could support the integration of unstructured information in system's data model, of interest for the management of certification features or labelling identification.

Then, Semantic related Generic Enablers, which can enrich information with semantic meta-data tags, can be used to homogenize the different kind of information, especially those coming from the supply chain stakeholders, that could use different formats, even giving specific meaning to similar values.

Also, the Location GE, which provides geo-location information as context information obtained from devices, can be used to give context information to the consumer.

Finally, the Big Data Analysis enabler "plug-ins", defined as "Intelligent Services" in FI-WARE, gives support to several issues like a) Social Network Analysis, b) Mobility Analysis, c) Real-Time Recommendations, d) Behavioural and Web Profiling, and e) Opinion Mining. These features can be used to answer some of the requirements related to the scenario concerning the consumer behaviour and the social networking around the reputation of the branding.

4.2.3 Applications / services ecosystem & delivery

One concept that is being discussed is about the prosumer, this means, a user that both consumes and provides information and services. In this context, such a prosumer requires a suitable environment for creating services and service components. At the same time, Service Execution should be supported locally combining user terminal and environment in order to provide a fully adapted service execution.

The application of these concepts could allow the creation of a service ecosystem based on third party tools but allow the final user to generate additional functionalities tailored for specific situations (for instance, finding of food free of specific allergenic) with the potential sharing with other interested consumers .

The use of a repository of commonly structured services that operate in the system is required in order to prepare service descriptions or parts of it to appear at a store, marketplace and other components of the business framework. A location for storage (centrally or distributed and replicated), for reference and/or safety. Furthermore, the registry, a universal directory of information is used for the maintenance, administration, deployment and retrieval of services in the service delivery framework environments. Existing (running) service endpoints as well as information to create an actual service instance and endpoint are registered. The USDL Registry links USDL descriptions in the USDL repository with technical information about instances available in the platform. Similar to UDDI Registry for web services, it is a place to find information for technical integration. Only if the service endpoint is registered it actually can be used for service composition and coordination by the FI-Ware platform.

4.2.4 Internet of Things

One of the applications of IoT technologies in the scenario is about the deployment of infrastructure for the identification of food products, to support the consumer during the search/selection/inspection of the items. A variety of technologies could be applied, from wireless communication (NFC, RFID, and Bluetooth) to imaging analysis and augmented reality support.

In any case, it is necessary to support to the deployment, management and maintenance of a network of different sensors and communication devices so IoT chapter may answer these requirements.

An abstraction layer will provide technologies developers with a common API to communicate with different devices that use different communication protocols and interfaces. *IoT communications* will provide common and generic access to every kind of things regardless of any technological constraint on communications, typically integrating several protocols and manage discontinuity of connectivity for nomadic devices. Additionally, it is necessary a service and device description repository. In this repository should be identified, described and published the capabilities, characteristics and properties of IoT enabled devices and services. *IoT Resources Management* will propose unified service and operational support management functions enabling the different IoT applications and end users to discover, utilise and activate small or large groups of IoT resources and manage their properties.

The Data Handling GE, in order to manage the collection, filtering and distribution of data generated by sensors, will support the system component that will gather all the raw data incoming from the sensors, filter it in a way that all the not usable information is deleted, combine it into usable information, and deliver it to the next component in the information flow chain. All based on the concept of 'sticking' a data usage policy to the data to which it applies.

To establish mechanisms to automatically trigger actions involving IoT components, it is necessary to support an unified model for the description of domain specific rules;

IoT Process Automation will propose to Application/Services Providers generic capabilities enabling to use subscription and rules templates that will ease programming of automatic processes involving IoT resources. In this way, it is possible a more autonomous management and operation of IoT resources.

4.2.5 Interface to the network

It is expected that a wide variety of terminal devices will be used to access the food information. At the same time, input from several devices will be used, especially to support the identification of the food items.

In addition, the services created by the prosumers should interact with these devices using transparent and standard mechanisms in order to fully deploy the potential to the consumer while not requiring special knowledge for their use.

In this way, some GE of this chapter can help with these features. So, the Connected Devices Interface (CDI) Generic Enabler (GE) will provide the means to detect and to optimally exploit capabilities and aspects about the status of devices, through the implementation of interfaces and application program interfaces (APIs) towards device features.

The Service, Capability, Connectivity, and Control (S3C) Generic Enabler is the manifestation of an adaption layer between the targeted network control layer for Fixed-Mobile-Convergence: Evolved Packet Core (EPC) and all possible applications and services.

4.2.6 Security

Finally, about the Security chapter will support some basic requirements, fundamental in a context of food awareness and food transparency, when it is necessary to trust and rely on the information provision.

Especially, the information related to the profile of the consumer has to be handled with maximum care, ensuring at any time the ownership of this information. So, the services and applications that could need to use this information should be granted to access specific rights by the consumer to the selected parts of the profile. Moreover, an anonymization process support will be necessary in order to protect the user about his/her shopping behaviour

Moreover, it is necessary to handle the reputation of the food brands, retailers as well as the consumers that interact in social networks.

The Identity Management Generic Enabler may give support to obtain reliable identification and authorisation of the user to the system's services: it is necessary support to the externalization of the identification and authorization processing and data storage and communicating with those identification services through open protocols. In this way, it is possible to provide applications for the end users to manage their privacy policies.

5 Conclusion

The first objective of this document was to collect advanced functions of the internet for which the technical possibilities are already available but the functions have not been developed yet. As described in the introduction, lots of advanced applications are already applied in the three sub-use cases Farming, Logistics and Food Awareness; however there is a lack of interoperability and standards leading to a manifold of isolated solutions. In addition there is a strong user requirement for affordable low-cost solutions with no administrative ICT overhead for small companies.

Common to all three sub-use cases, existing cloud technologies with their potential to “rent” infrastructure or software as a service is already available for being applied. Further, solutions for data mining and business intelligence are available on the market from several data warehouse providers. In addition, the available internet functions relevant for the sub use cases are in principle sufficient to build a solution for the smart agri-food use case. However, this solution would again be proprietary, thus not leading to a envisaged future agri-food internet, providing a market place of for agri-food services, seamlessly interworking and aggregating services to the individual’s needs.

The second objective of this document was to review the future internet functionalities in order to identify potential applications in agriculture applications. Also, the very technical description of FI-WARE enablers has been translated into a more comprehensible explanation for non-ICT experts. As a conclusion, FI-WARE technically considers all relevant building blocks for advanced future applications in the agri-food area. However, specification of privacy and security features are currently not finalized in FI-WARE. The success of agri-food FI-WARE solutions will strongly depend on the trust of the community into the implementation policies for security, resilience, privacy and storage.

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7 Annex: Description of expected applications

This section contains the description of expected applications from the deliverable D700.1, as available by December 2011. Contents of this section will not be updated and synchronized with D700.1. For the latest version, please refer to D700.1 directly.

7.1 Smart Farming

1) Advisory system for selecting the cultivated plants based on a database

A large database about different cultivation methods should be available in order to inform every farmer about his cultivated crops or about the ones that he would like to sow in the future. The system will compare the data given by the farmers with the results of soil studies and standards and should make recommendations for plants which could be grown successfully on the specific area and possibly some recommendations, hints about them.

2) Monitoring environment for farms and plants – advisory system

The farmers and specifically the young ones are interested of taking care of their plants' or animals' health by having access to a reliable and regularly updated monitoring / advisory system. The farmer should provide data that may include sensors' data, real and non-real time video, (high definition) pictures, actions taken (e.g. spraying, fertilization) etc. The monitoring system should activate an alarm when some thresholds have been violated; proper recommendations could be sent to the respective farmer in order to take further actions. For example if the temperature is too high and the humidity is too low, a recommendation can find a contractor for spraying, or a fertilizer contractor since those conditions are dangerous for the plants to be infected by a disease.

3) Barcode/RFID system -Traceability system facilities

The farmer has the need to print a basic barcode label for his final product before its storage or shipment. This barcode label should contain information such as the name of the company- farm, the region that it is from, the name of the product, the date of the production, etc. An internet based system could be useful for farmers who have small scale production and they cannot invest a lot of money to have local software for creating and printing the necessary barcode labels. This automation should offer online barcode generator and RFID services, fault tolerant without the burden of managing hardware, deploying patches and upgrades, or monitoring performance.

4) Improvement of the daily work of the farmer/breeder – Task Plan Analyser

A task plan analyser service should organize farmers' daily work with the assistance of a number of specialists. For example, the advisory system has advised the farmer to spray his fields. A spraying contractor could organize his machinery located at a specific point in time in different fields in order to fulfil that contract.

5) Shared infrastructure

A producer, the owner of a small farm can't invest a big amount of money to buy automatic and new sensors for his cultivation. The most crucial information for him is the knowledge of the weather conditions for the specific area. Another issue can be a serious disease that may affect his farms. The agricultural community will be reinforced providing each other inexpensive knowledge and information that are aware of.

6) Yield information system

The professional users explained that the existing yield measurement systems require some development, because the information and results are often inaccurate and unreliable, so organization of production is more difficult. For the same reason there are not reliable and accessible regional and national estimations.

The yield measurement system in the future should ensure appropriate data for the organisation and distribution, should collect information on variation of yield from all points of the area, and should prepare a yield map and a database based on the collected information.

There should be a large database about the information, which is available for all participants. The information collected by different technologies is about:

- the expected yield,
- the development of crops, fruits and vegetables
- the damages of crops
- etc.

This system might be used for planning of the production, for sales forecast, for scheduling harvesting, for irrigation network and for nutrient management.

The collected individual data should be a part of a large national database from which accurate and reliable estimations should be prepared for larger areas (countries, regions, counties). The individual data should be collected through a coding system, summarized into amalgamated data for a major area, without the name of the farmers to ensure their anonymity, privacy and data security.

7) Monitoring environment for animal welfare, sensors in barn/stable

The monitoring of different conditions in barn/stable is very important in animal breeding. The different types and different methods of rearing require different housing conditions. Currently there are just few sensors available which can measure the conditions such as temperature and humidity. The farmers would like to measure and monitor every housing condition which is necessary to keep animals in appropriate health, feeding and rearing conditions.

In the expected system several sensors should be located in the barn which can measure the housing conditions (e.g. temperature, humidity, illumination intensity, air velocity, etc.). If the housing conditions reach the maximum permissible value the sensors will make an alarm signal to farmers and/or the system will correct the options automatically.

8) Risk assessment

There will be several large databases about crop protection, irrigation, cultivation and production information in the future. The individual data should be collected through a coding system, summarized into amalgamated data for a major area, without the name of the farmers to ensure their anonymity, privacy and data security. The collected individual data should be a part of a large and national database from which accurate and reliable estimations should be prepared for larger areas (countries, regions, counties).

9) System for extraneous and foreign body identification

Several foreign bodies can occur and cause hazards during the production and processing of arable crops, vegetables and fruits. Foreign material can be: glass, splint, flinders, plastic, metal, stone, etc. The presence of foreign bodies affects the food safety and the quality of the products adversely therefore it is necessary to identify and eliminate the foreign bodies before the food processing. Foreign bodies can cause injuries for customers/consumers and result in complaints. Reliable removal of foreign bodies coming with raw materials is not always possible during the food processing. It is better to prevent foreign body contamination from raw materials. Currently there are not appropriate devices or applications available which can identify the foreign bodies in raw materials in fields.

Identification might be realized with new technologies on the machines, on the fields and around the fields.

When agricultural machines (tractors, harvesting machines, etc.) are working on the field camera systems should be mounted on them, which are connected to a foreign body identification database on the Web to identify the foreign bodies and their location and to provide a map for guiding their subsequently removal. The images found by camera should be compared with the reference standards of formerly found foreign bodies in the database.

Identification should be very exact and the information should be collected in a large database of pictures, videos, images, data and characteristics about formerly identified foreign bodies. The system should communicate with this database (upload and download information).

Benefits of the expected system:

- Rapid and exact identification of foreign bodies.
- Reducing the number of food safety incidents and customer/consumer complaints, compensation costs and negative effects.
- Improving of food safety and quality.
- Increasing cost effectiveness (non-manual separation, remote control of fields).
- Large database about foreign bodies, which can be used in processing and manufacturing too.

7.2 Smart Agri-Logistics

1) Road monitoring application

The scope of this example is to share online monitoring information from trucks during the transport of cargo. Current practice allows monitoring trucks during transport with individual software applications and collects the monitoring data with available telematics systems. However, the access to such monitoring data is not organised on standards, which makes the exchange of data a complex task. Due to a divers spectrum of possible events disturbing the transport process (e.g. traffic jams or technical malfunctions) information needs arise from uncertainties about arrival times and complications for further distribution planning as well as warehouse dock organisation.

The example shows an idealistic aggregation of information from different systems (order management system, online monitoring and event management system). This application can be opened for customers contracting a specific logistic service provider and enable a real-time event management in order to support decisions and planning.

2) Dock reservation system

Present organization schemes of cross-docks are focusing on first-come-first-serve principles.

Online applications for dock reservation are just implemented for a short time. These applications allow booking of dock spaces for a specific time in advance, but often require the registration up to 24 hours before transport arrival.

A flexible solution for this is required by the logistic service providers and would enable benefits for all participating enterprises.

The process presented in this example is based on the identification of trucks and their task in a specific geographic area (geo-fence) based on GPS coordinates around the warehouse / cross-dock. The communication between truck and warehouse organisation requires the exchange of information on the truck (identification information based on license plate) and its task (loading cargo, unloading cargo) as well as the registration and communication of a dock space and time windows for the truck driver approaching the warehouse.

3) Integrated freight and fleet management for vending machines and small retail outlets

Users expect an integrated management system which can help them to optimize the use of logistics resources and to improve the stock control and production planning.
A software and/or internet supported stockholding and storage system - which helps the company to optimize its stock, and the stock recording and the stocktaking are automatic - is a common demand by the users, however, it is used already at some companies. Moreover this system should handle the necessary interactions (alarming, re-ordering etc.) automatically as well.

- In the case of small sales units where there are not larger reserves in stock (vending machines, containers and tanks of liquids/gases in manufacturing, independent/small retail shops), it is expected that at the decrease of the stock to a set level an alarm signal should be sent to the supplier of the products or an automatic re-order should be generated and sent to the supplier. Since in the case of vending machines the problem is that the supplier has to deliver smaller amounts of different products to several locations, the automatic orders contain as much information as possible (what type of product is needed, in what amount and how many portions can be served from the remained stock). Thus the delivery route can be programmed after collecting and processing the information from the different vending machines.
  Improving the stock control is an expectation of the producers, retailers and logistic service providers as well, since they could benefit
  - by the better forecast and prediction (production plan, delivery routes),
  - by the reduction of delivery and production costs.

  For this, beyond a GPS system, the system requires a direct, real-time and long-range communication and data transfer among the single units, the supplier and the single vehicles of the supplier. A single vending machine should have the ability to broadcast its information.
- This automatic alarming and re-ordering system may be used in smart households for improving the stock control in the larder or in the refrigerator, and for providing input for the preparation of the actual shopping list.

4) Secure banking system

More secure network systems especially for banking systems are necessary to provide people with more confidence to undertake transactions exclusively through internet based technologies. A more secure and easier system would allow there buyers to purchase goods online reducing the work load.

5) Flexible parking system for delivery to shops

In larger cities (e.g. in Budapest) to find a legal parking place near to the shops for loading/reloading is a basic and common problem – parking on a prohibited place often results in fines. Some of the businesses deliver relatively smaller amount of food to smaller urban shops which do not have a designated parking place for food deliveries. The proposed system should organize possible emergency parking for loading for a short period for an increased extra charge at a prohibited place when a free legal parking place is not available. The parking company and the logistics service provider sign an agreement in advance, where the extra charge rate, the maximum duration of the emergency parking described together with the identification of the authorized user and the method and channels, details of desired communication between the two partners and the police. If there is not any free place near to the target, and the vehicle stops and parks to reload on a prohibited place, the driver of the /vehicle could inform (e.g. via SMS) the parking company. The parking company – based on the previously signed agreement - could make a surcharge automatically for short term emergency parking. The employees of the parking company or the policeman, working on the streets get the information about this specific payment via mobile devices, thus the transport company can avoid to pay fines. Instead of that they pay surcharges.

6) Smart household storage

Food storage is both a traditional domestic skill and is also important industrially. Food storage is becoming more important as we see how much waste originates in food industry and in households. The different kinds of food require different conditions of storage (temperature, humidity, etc.). Foods remain longer consumable in appropriate conditions. Fruits and vegetables are often harvested unripe or green. In this case maturation is a necessary step.

Food storage system should contain a storage device with different and separated boxes and control software. The system ensures appropriate conditions for different kinds of food; the users can select the kind of food (e.g. tomato) and the system determines the present condition of food with sensors and after that determines the storage parameters (temperature, humidity, etc.) of the separated box. The system communicates with a large database of storage standards. According to standards the system ensures the appropriate conditions or starts the post-maturation. There are different conditions and processes in all separated boxes in accordance with storage standards and settings. In the separated boxes several sensors are located which can measure the storage conditions (e.g. temperature, humidity, etc.). If the conditions reach the maximum permissible value the sensors will make an alarm signal to users. The system continuously monitors the processes and signals the condition of stored food and forecasts the date of maturing and spoilage.

7) "Service-halls" in the basement of apartment buildings

These halls should be used in logistics as the pick-up point for consumers. In these halls the company can monitor if the product is cool enough and picked up soon enough (monitoring with sensor technology). With an internet food shop, they have no need to store food: they transfer the ordered food straight away from the farm to these „service-halls". This makes it possible to avoid the use additives.

8) Small depots for personalized supply of perishable foods

Consumers, producers and also retailers raised the idea of an improved access to food supply. Access to quality fresh foods, particularly fruits and vegetables needs more frequent shopping then the weekly shopping. Properly ripen fresh fruits and some of the vegetables have to be eaten

within a few days after harvesting. The consumers could buy the selected fresh products daily and collect them on the way home, if a better logistic service is established.
Benefits of the expected system:

- Combination the benefits of the traditional markets and the planned and organized food supply,
- Large choice and flexibility of time of shopping,
- Ensuring of the superior sensorial quality.

After a personalized web-based ordering, the ordered products would be delivered to a selected retail outlet point which is located closely to the route which is used by the consumer giving this order. On the way home the consumer can collect the pack of food prepared for him. Alternatively the personalized food pack can be delivered to his home.

This system could help to reduce costs and time of delivery.

For this, beyond the collecting-trucks or collecting-depots, the users need:

- a central database which collects, organizes and synchronizes the inputs, including data about details of the orders, consumers, target locations, fleets, optional delivery routes,
- simple access and availability to the data,
  - for consumers to personalize the orders
  - for retailers or transport companies to get the details of orders
- a direct, real-time connection between the parties,
- and a system of the future internet which helps.

7.3 Smart Food Awareness

1) Connected automatic system

If systems and devices in different companies and households are connected to each other via the Internet the information flow between them may work automatically, thus the transfer of information will be accurate, quick, and efficient. The electronic devices such as RFID or EPC might transfer information to smart refrigerators in households. This system can handle ordering/reordering functions e.g. monitor the stocks internally and externally too.

Smart refrigerators can collect information about the consumer habits of the specific user (including usual amount, brands, price, preferred shop or a diet), can record the information of product labels e.g. the relevant ingredients (allergenic), the Guideline Daily Amounts (GDA), the nutritional content of the products by sensors inside the refrigerator. Through communication between the smart refrigerator and the smart phones consumers can make informed decisions. With the ability of broadcasting or transferring information the refrigerator can send specific orders directly.

2) Monitoring of food quality

Monitoring of the time-temperature conditions during storage and delivery of perishable foods is an important requirement by the respondents. The most important requirements of this monitoring were to have identification for the smallest packaging unit of the products as possible, and to know the actual (real-time) position with the highest accuracy. By monitoring time-temperature history of the product in the cold chain, items which were out of the control can be identified-e.g. those which may result in a food safety problem. This can also to reduce the cost of a possible recall.

The currently available data loggers and RFIDs have a relatively high price; therefore they can be applied at feasible costs only for larger volumes of products, such as pallets, boxes containing several retail packs. If low cost data loggers, long range RFIDs and accurate GPS systems are available, and long-range and real-time communication between the product (the RFID) and the stock record of the retail shop are available the expired individual retail packs on the shelves of the retail shops can be identified and collected back. Thus consumer complaints and fines from food control authorities can be avoided and the labour costs to achieve full recovery of expired products can be reduced. Home refrigerators can send warnings to the users if some of the foods stored in them are getting out of their use by date and should be consumed urgently.

3) Improved awareness information system based on traceability

Future traceability system may work with sensors and application of RFID (Radio Frequency Identification) or EPC (Electronic Product Code). This system delivers tailor made information (including content, physiological and health aspects, origin etc.) following individually determined selection criteria set by the consumers. Traceability data can be provided to the customer by a code which can be seen on the products. Consumers can obtain information about these products based on their code.

4) Foreign material identification

When a detector finds a foreign body object, which is not similar to any other foreign body which has been identified by it formerly, it communicates with the 'Cloud' - which is a network of thousands of servers - by sending the characteristics and the picture of the foreign material. The 'Cloud' identifies the material and if it hasn't appeared before in any system, the data about the unidentified object are stored automatically in the 'Cloud' database. Thus the 'Cloud' works as a database, which always updates itself.

5) Profile specific newsletters and dissemination of information

The information can be more specific or profile specific, and companies should get only relevant information, which fits in their profile. The news about the changes of the regulations or legislations can be handled by a system, and personalised information can be purchased, which can accelerate the flow of information.

The indicators used for benchmarking might be calculated automatically if the data are collected also automatically, the system might transfer information to the calculator, and update it, thus the dissemination of the indicators can be continuous and up-to-date.

6) Informed decisions of consumers based on tailor made information selected according to their criteria

Informed decisions of consumers can be supported by screening of information if customers can set their individual profile in advance by giving their criteria and individual preferences. Many criteria in a profile like price, preferences can be set, and then offers, recommendations given by the system could help their quick decisions in real shopping situations. This way, consumers can get a route plan for purchasing in the store based on the shopping list, or they can also receive some special offers of products which fit their profile. This information can reach the consumers through their smart phones or through an intelligent shopping trolley.

When consumers enter the food store, give their profile ID to the system, which recognizes the ID and the personal profile. Then the intelligent trolley or smart phone communicates with the shelf sides (radio frequency interaction with the tags on the products), which food match best to the profile requirements, and by accepting and sending information through the screen of trolley or smart phone the customer can choose. This system also provides information on the real-time accumulated price of the content of the shopping trolley, making also paying at the counter faster and easier.

7) Improved diet and health through personalised nutrition

Consumers should pay regular attention to their health and weight. However a large proportion of the population has a tendency of neglecting diet, health and weight management issues and not taking preventative measures unless the first signs of overweight and/ or diseases are not visible. If the food consumption of the individual is properly recorded, monitored and compared to the recommended daily allowance significant improvements may be achieved. Typical examples include the monitoring of energy intake, for elderly people the amount of specific nutrients they need on their diet, for allergic patients the avoidance of specific products which contain ingredients for which they are sensitive, etc.

The system can monitor consumers' purchasing and the quantity of the reduction of stocks in the households, the needed specific nutrients, dietary advice, and provide the amount of the consumed food and compare it to the Guideline Daily Amounts (GDA). When the food is used the energy, nutrient content etc. is recorded (corrected by the number of portions and persons) and the daily consumption is calculated and compared to the targeted, recommended value. It will warn the consumer if the product is getting close to or is going beyond the indicated shelf-life date. The system can provide advice with different levels of stringency from recommendations through gentle warning till strong warning.

This system is important because in this rapid life prevention has increasing significance. That is why this system can help our life.

8) Virtual shops and virtual visits

The consumers require more information about the products e.g. about the origin or about the production process. Therefore communication of product-related information towards the consumer is an important issue for the companies in food sector, and achieving this well-functioning communication, audio-visual solutions should be used more, as virtual visits of factories or stores. Companies can increase the consumers' confidence in their products if they have videos on their web-sites, where consumers can look into some production processes or can see the ambient parameters of the processes.

9) Exchange of product-related information between agri-food enterprises

The exchange of product-related information is often organized individually via specific software interfaces between agri-food enterprises. The expected system is a Future Internet Platform, which would allow a decentralized organization scheme that can be easily adapted according to current business relationships without spending funds for developing individual interfaces as it is common today.

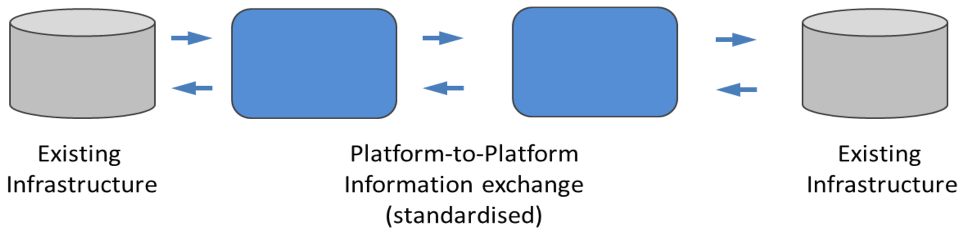

Figure 13: Exchange of product

Due to the highly individual character of systems in place, a platform infrastructure is required for establishing standardized information exchange between the enterprises. Between these platform information can be exchanged in a standardized way including standardized interfaces and data description standards. The integration of these platforms requires the transformation of data to comply with the provided standards. This reduces the number of complexities, because all enterprises can adapt to these standards and don't have to adapt to each and every system the partner offers for information exchange.

10) Communication of product-related information towards the consumer

A standardized communication infrastructure based on information standards describing product characteristic is established. At the point of sale products and product-related information can be accessed by the consumer via a networked device either brought by the consumer himself or provided by the store e.g. at the shopping cart or a terminal in the store.

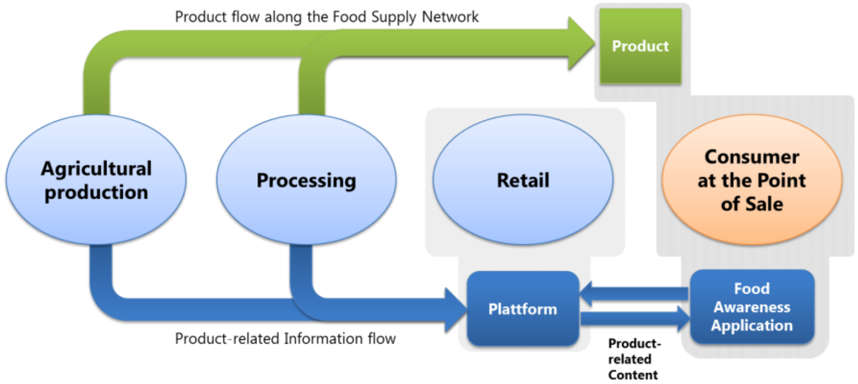

Figure 14: Communication of product

The system includes both above mentioned communication schemes. The product-related information e.g. on the origin of a product, product treatment or other social and ecological aspects of the product are provided regularly or on demand from agricultural production or the processing stage to retail and provided to the consumer at the point of sale. Due to the short timeframe consumers spend in retail outlets, the application has to provide information in a way that is directly accessible and useable in order to support the buying decision. Additional features, such as check-in at the supermarket and reception of individualised product offers available in this particular supermarket or upcoming events at the supermarket are ideas stated during the interviews.

8 Annex: Partner contributions to the interviews and focus group discussions

The interviews were supported by a short presentation from HWDU and CBHU.

In six countries the interviews were performed and summarized by:

- Hungary: CBHU
- Finland: MTT
- Germany: Centma + KTBL
- Greece: OPEKEPE + NKUA
- Spain: ASI
- UK: AST

The focus group discussions were performed and reported by:

- Hungary: CBHU
- Finland: MTT
- Germany: Centma + KTBL
- Greece: OPEKEPE + NKUA
- UK: AST

Questionnaires for the interviews and preparation of the focus group guide was performed by: CBHU with contribution of CENTMA, KTBL, MTT, OPEKEPE, ATOS, HWDU, DLO, ASI

The summary report and work package lead was in responsibility of CBHU.