Deliverable D300.3

Smart-Logistics Domain-specific Sub-system Specification

WP 300

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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.

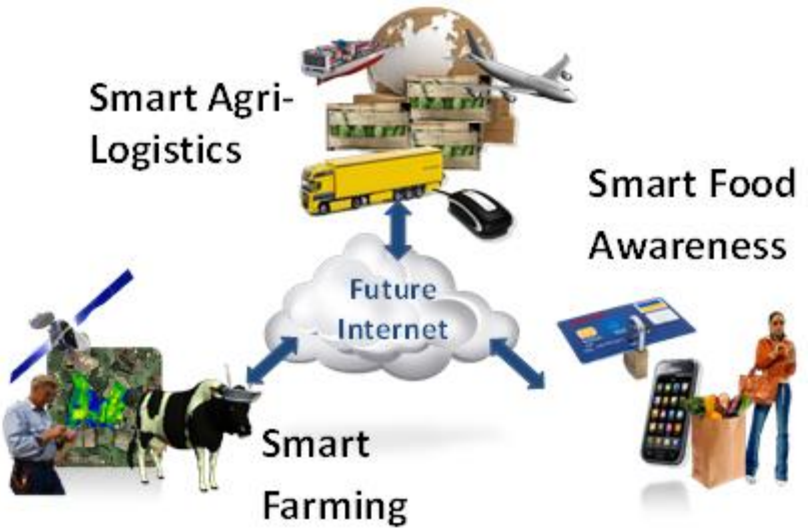
Project Summary

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-logistics-specific capabilities and conceptual prototypes, demonstrating critical technological solutions including the feasibility to further develop them in large scale experimentation and validation,

– Identifying and describing existing experimentation structures and start user community building, resulting in an implementation plan for the next phase in the framework of the FI PPP programme.



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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
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Document Summary

This document can be understood as a continuation of the previous deliverable related to this Work Package, D300.2. It further elaborates in the description of the architecture, presenting a final version of it ready to start the implementation of the pilots.

At this level of definition of the architecture a mature version of the Generic Enablers has just been realised, and therefore our designs only integrate a small number of enablers. A deeper and more extensive integration of Generic Enablers will be available in the D500.5.2, related to the final version of the architecture, used in the development of the pilots associated to the smart agri-logistics sector proposed within the project.

The reader can also find a proposed exercise of integration of the developed architectures of the pilots under a common agri-logistics framework, as a first approach of communication and interaction between them. A further integration of the developments will be done during the Phase II of the FI-PPP, as part of the cSpace project.

This document also makes an evaluation of the Smart Agri-Logistics sector within the project, from both a technical and business point of view. The evaluation covers several aspects: interaction with FI-WARE and the Core platform, relationship with the other Work Packages within the projects, feasibility assessment of the development of the pilots, among others.

Abbreviations

API	Application Programming Interface
B2B	Business to Business
B2C	Business to Customer
BAM	Business Activity Monitoring
CEP	Complex Event Processing
DSE	Domain Specific Enabler
DSL	Domain Specific Language
EC	European Commission
EPC	Electronic Product Code
EPCIS	EPC Information Services
ERP	Enterprise Resource Planning
ESB	Enterprise Service Bus
FFV	Fresh Fruits and Vegetables
FI	Future Internet
GTIN	Global Trade Item Number
GUI	Graphical User Interface
HTML	HyperText Markup Language
ICT	Information and Communication Technology
IoT	Internet of Things
IP	Internet Protocol
IT	Information Technology
LAN	Local Area Network
NFC	Near Field Communication
ONS	Object Name Service
OS	Operating System
P2P	Peer to Peer
PC	Personal Computer
PF	Plants and Flowers
PInfS	Product Information Service
PPP	Public Private Partnership
QM	Quality Management
REST	REpresentational State Transfer
RFID	Radio Frequency Identification
SAF	SmartAgriFood
SCEM	Supply Chain Event Management
SME	Small and Medium Enterprises
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SQL	Structured Query Language
Wi-Fi	Wireless Fidelity
WP	Work Package
XML	eXtensible Markup Language

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1 Introduction

This deliverable is a continuation of the D300.2 deliverable and it is a result of the work done in the Task 330 "Domain-specific Sub-system Specification". The document further elaborates the architecture of the pilots and makes an evaluation of it from both a business and technical point of view. The content of this document is in conjunction with the content of D500.5.2 that reports the second release of the prototypes. The main purpose of this document is twofold:

1. To present the final architectural specifications the system that have been designed for Smart Agri-Logistics;
2. To evaluate the extent to what the architecture and prototypes meet the previously defined requirements.

The deliverable particularly reports the results of both pilots that are conducted in two specific sectors, i.e. the Fresh Fruit and Vegetables (FFV) industry and the Plants and Flowers (PF) industry. The pilots depart from an overall architecture for Smart Agri-Logistics that serves as a common base. Subsequently, the pilots focus on complementary issues that i) on the one hand are considered to be a major business challenge in the sector and that ii) on the other hand are challenging from an information technology perspective. The FFV pilot concentrates on the topics transparency and information exchange between agri-logictics enterprises which includes the management, tracking and tracing of the product and returnable packaging in order to enable the provision of product quality information from actors to actors in a supply network. The PF pilot analyses and demonstrates the possibilities of Future Internet technologies for dynamic Quality Controlled Logistics in floricultural supply chains. In this approach, logistic processes throughout the supply chain are continuously monitored, planned and optimised based on real-time information of the relevant quality parameters (such as temperature, humidity, light, water).

The report is organised as follows:

- After the introduction chapter, the second chapter describes the refined overall architecture for Smart Agri-Logistics that serves as a common base for both pilots. The use of Domain Specific Enablers (DSE) and the related Generic Enablers in this architecture are introduced. The chapter also analyses to what extent the specific challenges on logistics in the food and agribusiness domain as defined in D300.2.
- The third and fourth chapters have the same structure and contents, related to the Fresh Fruits and Vegetables Pilot and to the Quality Controlled Logistics in the Plants and Flowers Pilot, respectively. These chapters provide a global overview of the functionality of the pilots, and present the enhanced architecture of each pilot, that has been implemented. Next the Domain Specific Enablers (DSE) and the related Generic Enablers (GEs) of these pilot architectures are introduced. The chapters also evaluate to what extent the previously defined functionalities are implemented.
- Chapter 5 set outs a first approach to the technical integration of both pilots, defining a scenario and some possible message exchanges between modules of both subsystems. This scenario will be further elaborated during the Phase II of the FI-PPP.
- The final evaluation of the pilots is presented in the chapter 6 of the document, including both an evaluation methodology and an evaluation plan. The results of the valuation are related to business and technical aspects, so the conclusions of stakeholders and developers are detailed.
- The last chapter 7 summarizes the conclusions and defines the expected steps that will be done during Phase II to maturate the pilots.

2 Refined Architecture for Smart Agri-Logistics

2.1 Refined System Architecture

The development of the pilots' architectures was performed in respect to be combinable for an overall architecture for a Smart Agri Logistics system. Both pilots have defined different challenges in the logistics scope, and therefore, developed different solutions independent from each other. Nevertheless, common and generic features of such architecture can be combined and merged to achieve several synergy effects as well as to present both pilots as one final solution.

The Fresh Fruits and Vegetables (FFV) pilot focuses on the communication between actors in the food chain to provide product-based information exchange though the supply chain ("Exception & Event Processing" and "Request Management"). In the Plants and Flowers (PF) pilot the provision of highly dynamic product data like status, location and quality is aimed to assure the product quality, and enables short reaction times or to decrease them ("Quality Monitoring & Rule-Based Expert System" and "Data Management").

In the merged architecture (Figure 2-1) three basic functional blocks have been identified:

- **External Connectivity**: This module connects devices, resources and other systems to the local system for communication and data exchange. By connecting systems a network will be built which will be used to transfer data and messages through the supply chain, called "SAF Network" in the Figure.
- **Web service Layer**: This layer serves as point of user interaction where users get or provide data from and to the system or other users.
- **Request & Data Management**: To enable the correct provision and storage of data a set of compatible data bases as well as interfaces to legacy systems need to be set up.

Additionally to the basic blocks which cover general functionalities, two other abstract blocks (Exception & event handling, and Quality monitoring & rule-based expert system) are needed to integrate the functions and abilities of both pilots.

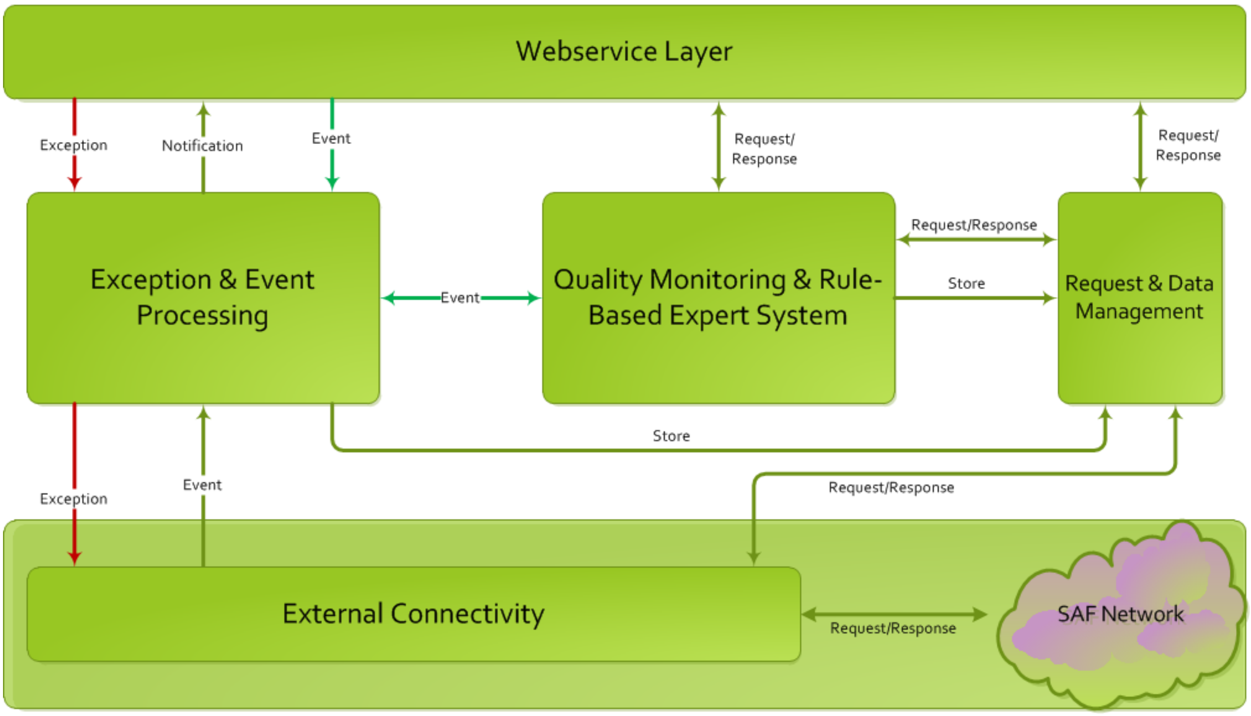


Figure 2-1: Smart Agri-Logistics general architecture, as result of merging both pilots functionalities

In Figure 2-2 the integrated development modules of both the FFV and the PF pilot as well as the communication and interaction between those modules is more specified. The **Web service Layer** was mentioned as point of user interaction before. This user interface includes features like:

- Controlling several system functions
- Creation and receipt of events and messages
- Using product monitoring and receipt of Expert System recommendations
- Request and provide product data/ events

Over the **External Connectivity** each Smart Agri Logistics system will be connected to devices and other instances. These connections enable transfers of events and remote monitoring data between the local instances and devices. The **Request Handler and Data Management** serves as abstraction layer to several kinds of information systems, e.g. legacy and local systems as well as remote databases (for example from other actors).

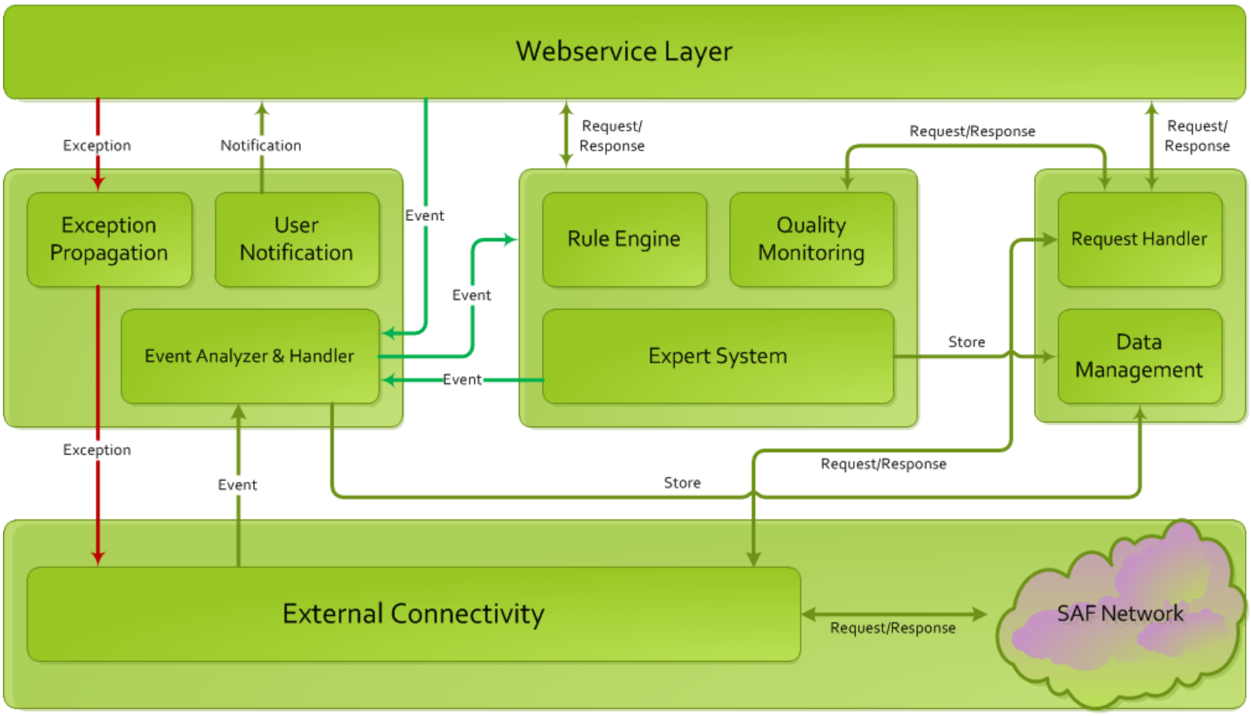


Figure 2-2: Smart Agri Logistics – Overall Architecture and Integrated Pilots' Modules

Figure 2-2 shows the essential parts of both pilots in a more detailed way than in Figure 2-1. The former "Exception & Event Processing" is shown as a composition of:

- The **Event Analyzer & Handler** receives events from both the Web service Layer and the External Connectivity module to analyze and handle them. This process can result in a User Notification and/or an Exception Propagation.
- The **User Notification** receives events to handle by notifying specific users. The resulting notifications will be directed over the Web service Layer to the respective users.
- Similar to the User Notification the **Exception Propagation** receives events but not only from the Event Handler. Exceptions can also be created from users and sent over the Web service Layer. This special kind of event is not intended for notifying users of the local system but rather to notify other actors of the supply chain about the recognized exception.

The "Quality Monitoring & Rule-based Expert System" from Figure 2-1**Fehler! Verweisquelle konnte nicht gefunden werden.** consists of three development modules as well:

- **Rule Engine** contains a set of relevant expert system rules for the products of interest. Currently supported rules are threshold-based and fuzzy logic, and the module is extendable for other types of rules.
- **Quality Monitoring** module is in charge of collecting the necessary information for the expert system. This typically includes measurements of environmental parameters, business steps, location-based information, etc.
- **Expert System** gives prediction results (e.g., product quality decay forecast), recommendations, and alarms. For Phase 2, actuator commands are envisaged.

The reusability of this component in concrete realizations of the WP300 pilots is elaborated in Chapter 5.

The described refined system architecture of the Smart Agri-Logistics combines the solutions of both pilots. The Quality Monitoring of the PF pilot enriches the existing product data by highly dynamic monitoring data about the respective product. In turn the exploit of events and exceptions transferred through the supply chain is extended by using these events as additional input for the Rule Engine and the Expert System.

2.2 Validation of System Architecture

The designed architecture for Smart Agri-Logistics as presented in this report aims to contribute to the specific challenges on logistics in the food and agribusiness domain. Appendix A discusses to what extent these challenges as defined in D300.2 [5] are met by the designed architecture for Smart Agri-Logistics. It can be concluded that the agri-food specific challenges are well addressed.

The further validation of the Smart Agri-Logistics Architecture is reported in chapter 6 of this report.

2.3 Domain Specific Enablers

The Smart Agri-Logistics framework previously described is connected to the other sub-domains of the food chain using several Domain Specific Enablers (DSE) common to the food chain domains, namely Certification service, Product Information Service, Business Relations Service and Identification Service. These DSE are called Generic Services and are fully described in Chapter 3.3 of D500.3 [1] and Chapter 3 of D500.4 [2].

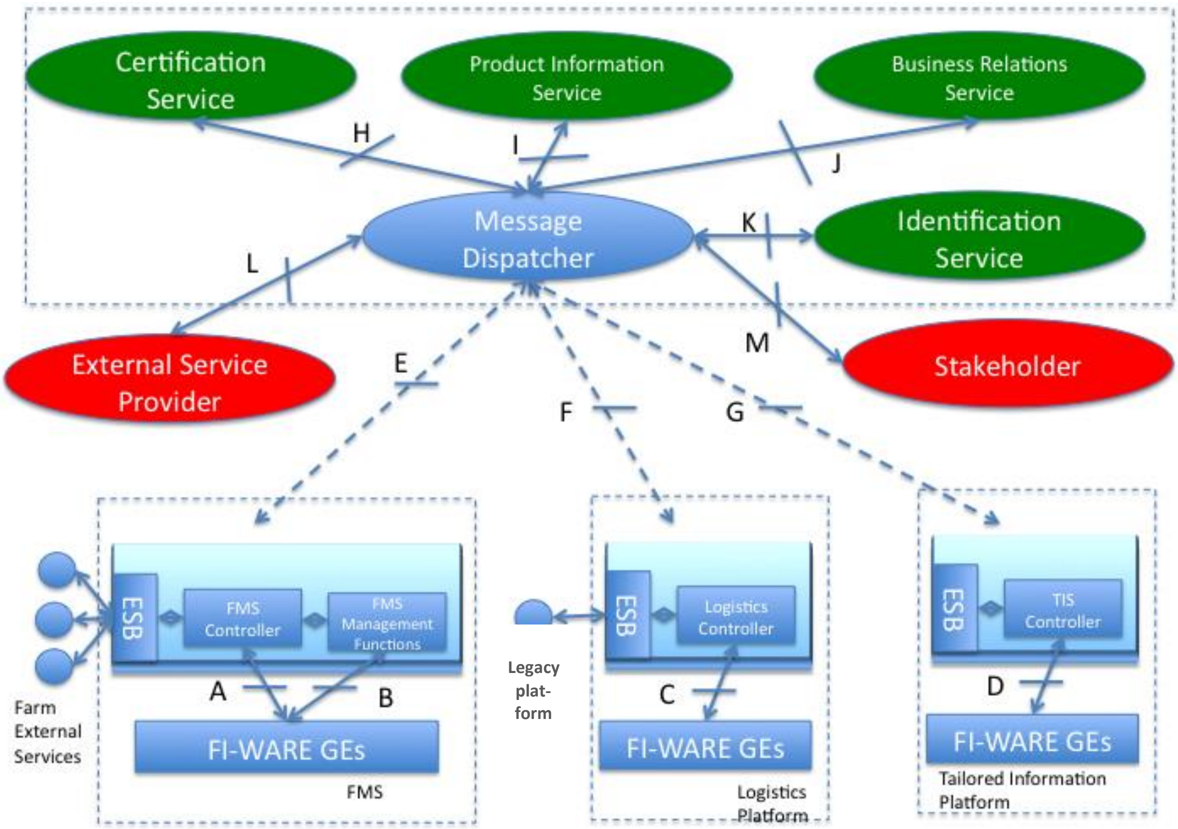


Figure 2-3: The overall architectural picture of SAF

Figure 2-3 illustrates the connections between the sub-domains' frameworks of the food chain and the Generic Services. Each one of these frameworks must contain a "controller" in charge of the communication with the Generic Services, and therefore in charge of managing the bidirectional message exchange between the different systems. In the Smart Agri-Logistics framework the controller role is played by the External Connectivity module, previously explained in Chapter 2.1 of this document.

For reasons of completeness, a brief overview of the usage of these Generic Services in the Smart Agri-Logistics framework is presented in the following paragraphs, while a further explanation can be found in Section 3.1.2 of D500.4.

Certification service: The service consists of two sub-services, the Certification Validation Service and the Logo Validation Service. The functional requirement implemented by this service is related to the reliability and trustworthiness of the collected and transmitted information, which is a mandatory aspect in the information workflow addressed in the logistics domain. When a stakeholder adds any information to the logistics' chain, the origin of it must be validated before this information becomes being accessible to any other stakeholder. In the same way, when a stakeholder demands any information it must be able to access to the validation data linked to it.

Product Information Service: The Product Information comprises a generic service that can be developed, implemented and provided by ICT services providers. In SmartAgriFood, its main focus is to enable the exchange of product related information and facilitate the control in complex supply networks and, in parallel, to drastically reduce reaction times with respect to quality issues. For the agri-logistics domain this Generic Service is a keystone in the information workflow. This service must provide the information sources where the stakeholders can access any information related to a product. Besides, each time a stakeholder creates any new information related to a product, this must be registered in this service, so others supply actors can access it.

Business Relations Service: This service provides an interoperability infrastructure to maintain interactions of business partners. In other words, it creates long term and quality relationships between partners playing different roles supporting B2B, B2C and C2C relationships and manages the user feedback and distributes it to the appropriate business entity. To make feasible the product information workflow, the stakeholders of the food chain, owners of the information, must create business relationships with the other involved companies to allow the information exchange and allow the other companies access their information. It is also important to remark, that the stakeholders must create relationships with the final user, to get their feedback and improve their own working methodologies.

Identification Service: The Identification Service provides several functionalities related to uniquely identifying an object within a context, such as registration of user, systems, and service provider accounts or self-administration for users. Among them, within the agri-logistics sector, the authentication of a company is of particular importance. In other words, it should be validated whether a stakeholder gathering some data from another company is allowed to do this, and that there are no third parties trying to access the information in the name of this stakeholder.

It is important to realize about the difference of the DSE of the Smart Agri-Logistics subdomain, the Generic Services, with the DSE belonging to each one of the pilots developed within this subdomain, mainly modules, explained in chapter 3 of this document.

2.4 Link with FI-WARE's generic enablers

Table 2-1 summarizes the Generic Enablers of interest for the Smart Agri-Logistics' pilots, with an indication about the integration plans for FI-PPP Phase 1. Further explanation of the planned integration and the components of the pilots which will utilize these Generic Enablers can be found in the respective chapters of each pilot.

Table 2-1: GEs of interest for the pilots in Phases 1 and 2

Generic Enabler	Pilot	Planned Integration in Phase 1
Application Ecosystem and Delivery Framework		
Mediator GE	FFV	N
Mashup GE	PF	N
Data / Context Management Services		
Complex Event Processing GE	FFV, PF	Y
Publish / Subscribe Broker GE	FFV, PF	N
Location GE	FFV, PF	N
Security		
Identity Management GE	FFV	Y
IoT		
Complete IoT Framework	PF	N[1]

[1] Both pilots currently exploit Fosstrak, the open source RFID platform [8] that implements the GS1 EPC Network specifications. Fosstrak is suggested by FI-WARE [3], but it is not present in the catalogue at the moment of writing this deliverable.

3 Fresh Fruits and Vegetables (FFV) Pilot Architecture

3.1 High level view of the FFV Pilot

This section describes the concept and the high level view of the Fresh Fruit and Vegetables pilot, first showing the big picture and specifying improvements of the current situation of the food sector and their requirements, and second describing the technical architecture. The following sections show domain specific (DSEs) and/ or generic enablers (GEs) which will be provided by the SmartAgriFood Project and Future Internet Core Platform [3] and developed or used in the pilot for requirements' and improvements' realization in Phase I, in addition more enablers will be mentioned related to Phase II development. The last sections describe validation methodologies and standardization concepts adopted in the pilot.

Improvements in food networks are based on the responsibility of the food sector towards mankind in delivering food that is safe, affordable, readily available, and of the quality and diversity consumers expect. Assuring food safety and quality requires appropriate controls (e.g., on matching regulatory requirements on the use of pesticides, etc.) but also transparency and the support of trust through the provision of information and of guarantees for its trustworthiness. Additionally, the communication towards the consumer about the production of agricultural products is an important part of increasing awareness for food products.

These high level improvements can be described as two aims, **increasing efficiency in food logistics** and **ensuring food quality and food safety**, which the pilot is regarding.

Increasing efficiency in food logistics:

- Tracking and tracing of products and shipments in order to enable better planning of resources and better enabling of product withdrawal and recall,
- Monitoring of transport processes and conditions by capturing data from transport processes in order to identify critical situations and enable pro-active handling of transports,
- Forecasting of negative influences on product quality in order to enable better distribution of supplies.

Ensuring food quality and food safety:

- Provision of product quality information for specific product batches in order to proof compliance with different legal and private requirements,
- Capturing and provision of process information in order to maintain product quality and reduce negative influences leading to spoilage,
- Gapless tracking and tracing between agricultural production and the point of sale or even beyond in order to identify the path of potentially unsafe products.

The FFV pilot concentrates on the topics transparency and information exchange between agri-logistics enterprises which includes the management, tracking and tracing of the product and returnable packaging in order to enable the provision of product quality information from actors to actors in a supply network. It is based on a dual approach concentrating on the "management of product & information carrier" and the "provision of product quality information". Both use cases are elaborated with European-wide acting business partners from the sector.

Detected issues and corresponding solutions of the FFV pilot addressed by the pilot were envisaged in D500.5.1 [6] Section 2.4.1 and following sections by considering "Information Provision" and "Exception Reporting and Propagation".

The improvement of logistics processes in a supply network includes a close collaboration between supply chain actors in respect to communication and information exchange. To improve planning and re-planning of resources and orders it is required to realize a flexible communication infrastructure and integrate existing information systems (legacy systems) into business processes. This shared information between food chain actors can be used to create awareness of food quality and food safety by providing related information to retail and finally to consumers of the product. This enhancement also requires a smart communication infrastructure and applications for both, chain actors and consumers.

3.1.1 Technical architecture

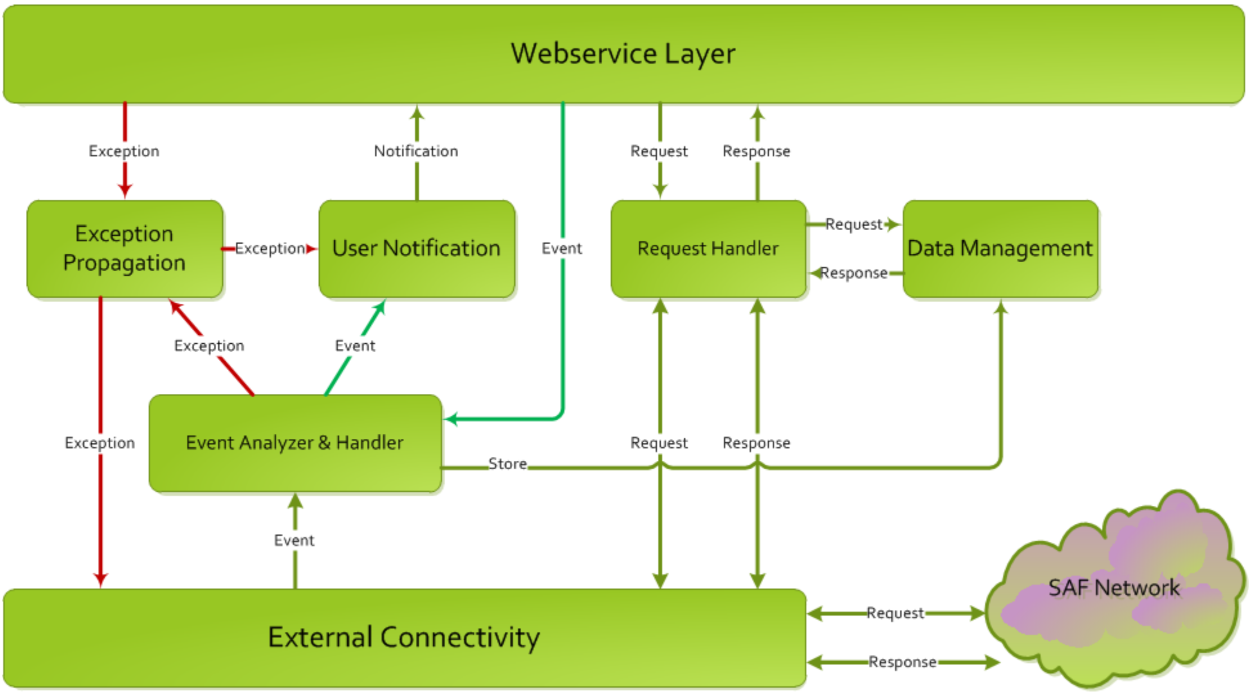


Figure 3-1: FFV Pilot – Development Modules

The key principles and building blocks defined in D300.2 [5] of the FFV architecture remain unchanged in the current development trunk. However these blocks are transferred into development modules. The modules that changed and/or improved in relation to D300.2 and D500.5.1, in Figure 3-1, are described in the following subchapters.

3.1.1.1 Web service Layer

The web service layer propagates the functionality of the backend modules to the different types of GUIs (e.g. smartphone, tablet, workstation, etc.) and offering a central connection point of the SAF platform. On top of that this layer abstracts from the type of the underlying architecture (i.e. local, mobile or central server) and hides the complexity of the different modules to support an easy development of additional applications and the integration with existing systems. This functionality is developed within the following four core services:

- The **Tracking Information Service** offers the possibility to receive tracking information represented as EPCIS events for a given product identified by an EPC. It is important to mention, that this is not only limited to an internal tracking and tracing by also returning these information from external companies.
- The **Product Information Service** works similar to the tracking information service but is more focused on the product information itself. Based on the flexible design of the FFV architecture this may include all kind of data including harvesting information, la-

boratory results, quality result, etc. Although sensor data are out of the scope of this pilot it is also possible to integrate these data.

- The **Notification Service** allows the proactive notification of users about related events and exceptions.
- The **Master Data Service** provides background information for the other core web services. This includes the offering of static information like location data based on GLN, but also product and asset related data based on GTIN. On top master data from existing legacy systems like ERP are also published via the web service.

3.1.1.2 Data Management

The Data Management service provides an abstraction layer to handle different kind of data. This data can be classified into three types:

1. **Product related data:** This includes all possible variants of product information. Because the structure of this data can highly differ depending on the type of the product (e.g. apples, tomatoes, etc.) and the company which handles it (e.g. laboratory, logistic service provider, farmer, etc.), the data model must cope this.
2. **Event Data:** EPCIS based event data are the glue of the FFV pilot, they allow internal and external tracking of product flows and are used as a base to call back hazard product deliveries.
3. **Configuration Data:** On top of the product data the system needs to store configuration data for the different modules. Similar to the product related data this also requires a flexible way to handle these data.

To support these different kinds of data models the data management modules builds upon the following sub-modules:

- Persisting tracking and tracing information and other event based data the data management uses an **EPCIS [7]**. This EPCIS is an industry wide accepted standard and is used is various application and allows the standardized data-exchange between different companies. For the implementation of this module the open source project Fosstrak [8] is used, which is also intended to materialize the IoT Gateway GEs.
- The **Storage Layer** is built upon a NoSQL [9] storage system (i.e. MongoDB [10]), because this type of persistence type is not necessarily bound to a strict object model; instead it is possible to store documents and lists of key-value pairs. On top of that the presentation in a key-value approach of objects allows an easy integration of the CEP GE [11] of FI-WARE, which also expects objects to be serialized in that way.
- The **Legacy Connector** allows the integration of existing applications and systems by offering open interface which can be used to create tailored connectors for the specific APIs of these systems.

3.1.1.3 Exception Propagation

The exception propagation plays a central role in the FFV pilot by improving the reaction time and quality on possible harmful food problems. To achieve this, the exception propagation module accepts as events that were classified as an exception by the event analyser module and propagates it to companies which were or will be in contact with the related product. This is done by using the tracking information of the data management module to calculate the predecessors and successors in the supply chain. If this information is not available it is also possible to create a broadcast inside the SAF platform network to overcome these communication gaps.

3.1.1.4 User Notification

To inform the corresponding user about an exception, the user notification module detects which user is responsible to handle this event. In the scope of the pilot this is done via basic electronic communication channels, including an integrated notification tool in the pilot GUI and e-mail. However the architecture of the module allows the extension of the channels by offering a reusable interface; possible extensions maybe: SMS or integration in other UIs of existing applications.

3.1.2 Refined system functionality

The FFV pilot focuses on two use cases, the **management of objects** that carry products and information and on the **provision of information** of product origin and characteristics (e.g. quality)" through various services. Both use cases are of relevance for all chain-oriented pilots, where product- or process-related information has to be provided from actors in the chain to other actors in the chain or to the final consumers.

The use case **management of objects** that carry products and information concentrates on the management of packaging pools that play an important role in the distribution of fresh produce. The efficient and transparent management of returnable packaging offers the potential to overcome tracking and tracing issues of produce as well as enabling added-value information services for identified crates.

The use case **provision of information** on product origin and characteristics (e.g. quality) is based on tracking and tracing of products packed in crates. The scope of this use case is to enable agri-logistics companies along the supply chain to provide information (static or dynamic) for specific crates.

3.1.2.1 Management of Objects

In the scope of the FFV pilot the objects of interest are the products but in case of a food chain the produces are packaged into crates to transport them. These crates have a unique identification (ID) which represents the crate itself as well as the produces within because those remain in the crate until they are consumed or destroyed.

The Data Management module of the pilot uses this strong relationship between crates and the products within to identify the products by the ID of their crates. This unique product identification is the base to communicate and exchange information about products.

3.1.2.2 Provision of Information

The pilot includes an External Connectivity module which connects the local pilot instances of the chain actors with each other and manages the pilot's connection to the supply chain network. On top of that external devices (e.g. scanners, mobile devices and other systems like databases) and services will be connected and managed by this module. By integrating such devices' functionalities, the local pilot instance will be partially enabled by and extended to connected devices.

By being connected to other devices and users information about products can be gathered by scanners, entered by users and the other way requested from the local pilot instance by a connected system (e.g. other instances from other actors). The central development modules which enable this are the Data Management and the Request Handler modules. The Request Handler serves as abstraction layer module in the pilot's architecture for any connected device to request event or product data from any connected data base from any actor as long as the access is granted.

The following two subsections describe the internal and external information request procedures and the involved development modules.

3.1.2.2.1 Internal Information Request

An internal information request in the scope of the pilot is defined as access to product information only from data sources connected to the local pilot instance and managed by the local actor. Besides integrated data bases like an EPCIS or others which are part of the pilot instance other legacy systems and data bases could serve as data source. All local available sources are wrapped into the data management module, which is considered to implement various standard connectors to use several kinds of data bases and other legacy systems. Figure 3-2 shows the synchronized communication between some development modules which enables the synchronized data access to internal data sources.

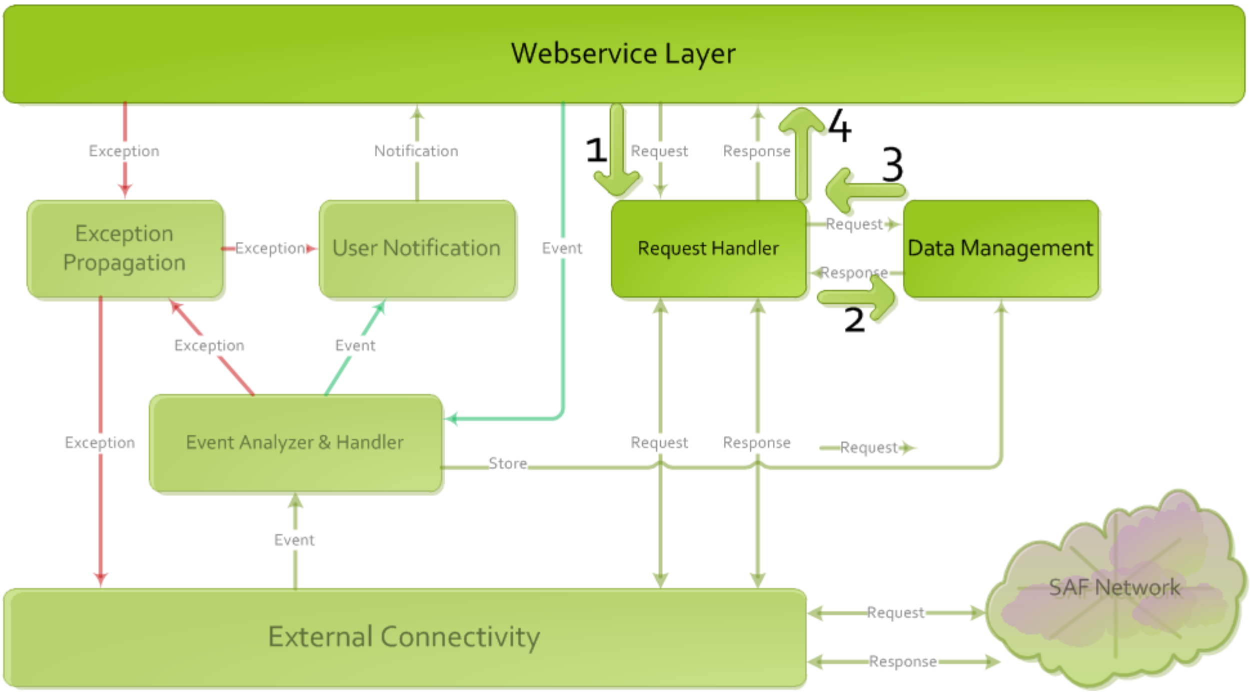


Figure 3-2: FFV Pilot – Internal Information Request

As origin of the data request a user or connected device uses the Request Handler module to forward the request to the Data Management module (Steps 1 and 2). After the requested data was searched the Data Management sends a response including the search result over the Request Handler back to the web service Layer (Steps 3 and 4).

3.1.2.2.2 External Information Request

External requests are defined as request on data sources outside of the pilot instance and managed by another actor like the local one. It is a kind of remote access on foreign data bases and information systems whose access rights of course need to be checked by the requested party.

Figure 3-3 and Figure 3-4 show the local and the remote view of an asynchronous external information request.

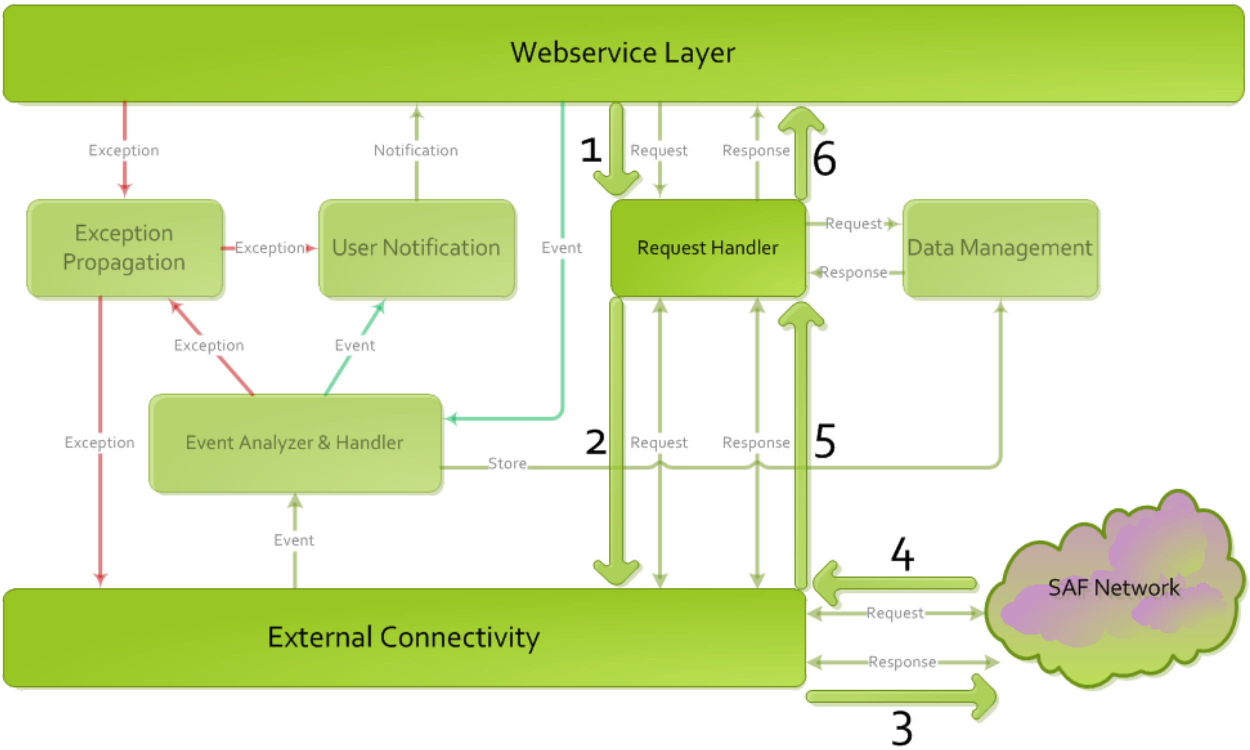


Figure 3-3: FFV Pilot – External Information Request (Local View)

As in the internal request procedure the origin of an external one (see Figure 3-3) is the web service Layer module as well, used by users and/ or devices. Also the Request Handler module is used (Step 1) but in this case the request will be forwarded over the External Connectivity module to another actor providing the requested data within the SAF Network (Steps 2 and 3). After the remote procedure performed within a pilot instance of another actor, the External Connectivity module retrieves the response (Step 4) and directs it over the Request Handler to the web service Layer (Steps 5 and 6).

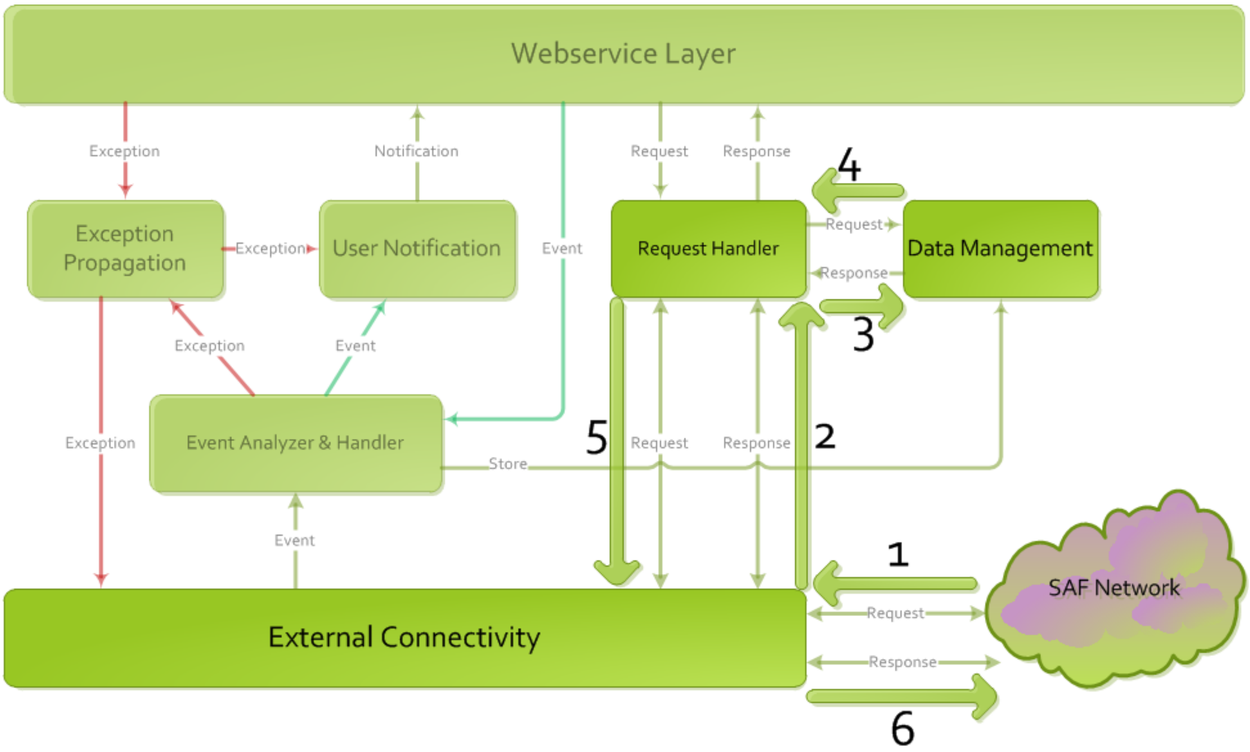


Figure 3-4: FFV Pilot – External Information Request (Remote View)

On the remote side (see Figure 3-4) incoming requests from the SAF Network (Step 1) will be directed to the Request Handler module which checks the access rights of the requesting instance's actor (Step 2) and then, if the access is granted, let the Data Management module search for the requested product information (Step 3). The response of the Data Management returns to the Request Handler (Step 4) and will be sent back over the External Connectivity module in the SAF Network to the requesting pilot instance (Steps 5 and 6).

3.1.2.3 Events and Exceptions

Events are an essential part of gathered product information; they will be generated by chain actors who observe critical information about any deviations (e.g. product quality, delivery delays) related to specific product which will be identified by the crate IDs. This dynamic product information will be provided to other known food chain actors who are involved in producing, handling, selling or consuming the appropriate product. In that way critical information is provided and arrives at relevant actors as soon as possible so that respective measures can be taken.

The term "critical information" is a very generic expression, in the FFV pilot this is concretized as "exception" which is defined in several scopes:

- Logistics: Deviations of shipments following from events like traffic jam, technical malfunctions, etc.
- Deviation of Food Quality: This exception may be raised if the quality (size, color) of the product does not fit the requirements of the customer.
- Food Safety: This type of exception is within the scope of this pilot the most important one. It will be thrown if an imminent danger for the health of the product consumer was detected.

The next section describes the creation, processing and propagation of exceptions considered in the pilot and refers to involved architecture modules.

3.1.2.3.1 Exception Creation

There are two ways to create an exception. The first one is to create an event because of recognized deviation(s) in one or more of logistics, food safety, food quality and other exceptional circumstances. The creating actor gathers all required and available information and adds this to the context of the exception. In addition, involved actors and internal as well as external users, devices or groups need to be entered as receivers. The created exception will be sent to the specified entities to inform them about the included event.

Another way is to receive an existing exception from another actor in the chain and to extract required information to create a new exception with added information and/or changed context. This kind of re-created exception can be used to forward exceptions to special entities, groups or users.

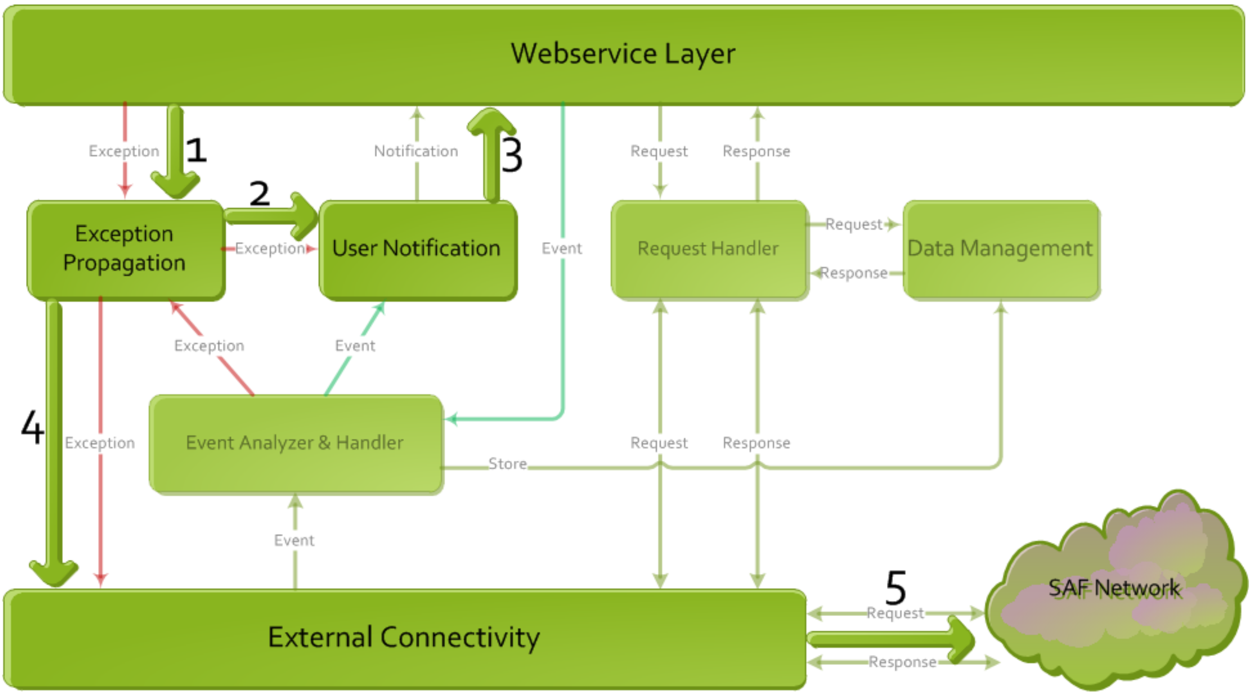


Figure 3-5: FFV Pilot – Creation of Exceptions

Figure 3-5 shows a sample action sequence within the data flow between the development modules is displayed as numbered arrows. The web service Layer serves as interface to users and devices connected to a pilot instance. Required information about the exception is entered here by user and the created exception will be transferred to the Exception Propagation module (Step 1). At this module the data flow forks on the one hand using the User Notification module back to the web service Layer if the actor or at least one of the connected users is involved (Steps 2 and 3). On the other hand the Exception Propagation uses the External Connectivity module to send the exception to other involved and connected actors in the SAF Network (Steps 4 and 5). At the other actors' instances the External Connectivity module receives the sent exception and initiates the Exception Processing, which is described in the next section.

3.1.2.3.2 Exception Processing

The processing of exceptions is necessary to extract the exception's context and so to be aware of possible threats for someone and necessary or proposed preventive or reactive actions to be done. Using the Event Analyzer module all events will be analysed and classified by their context and included information. In the Event Handler module for every kind of classification actors can specify certain actions to be done if an event of a specified type arrives, for example to inform the logistics department about a deviation of a shipment or the warehouseman about harmful goods. Figure 3-6 shows the procedure of exception processing within the FFV pilot architecture and the involved modules.

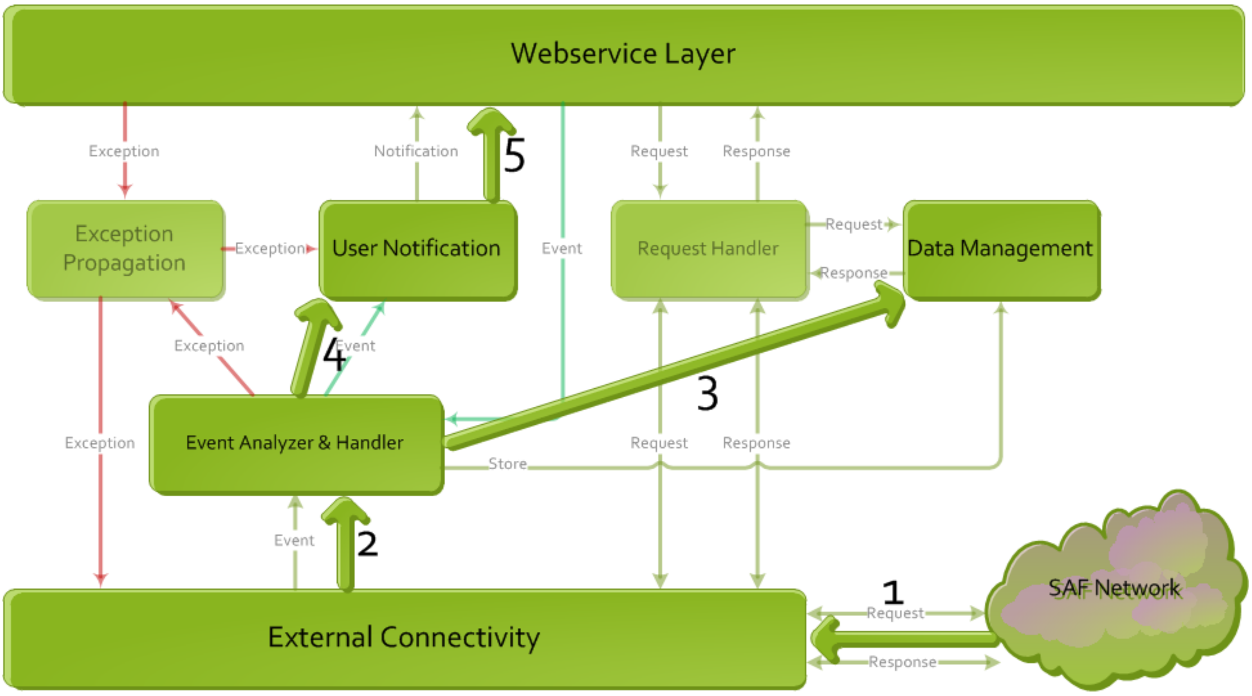


Figure 3-6: FFV Pilot – Processing of Exceptions

Incoming events from the SAF Network arrive at the External Connectivity module (Step 1) and will be transferred to the Event Analyzer & Handler (Step 2). There the incoming event s will be analysed and classified and available information is stored in a data base (Step 3). For each classification type rules can be applied including actions to be done on occurring. According to the event classification and content certain users have to be informed, this will be done by the User Notification module and the message finally arrives the respective users over the web service Layer module (Steps 4 and 5).

3.1.2.3.3 Exception Propagation

The exception propagation is a kind of provision of information. In this case actors do not have direct access to product data of other actors but the actors can decide to provide certain information (e.g. about events) to specific actors by creating an event automatically. In case of exceptions it would be very beneficial to be informed about deviations as soon as possible for being able to re-plan orders, shipments and sales. This kind of critical information will be propagated through the chain, actor by actor, to reach everyone involved in the context of the event. This functionality is very similar to both, just described exception procedures in the previous two sections. Figure 3-7 shows how this procedure will be realized as combination of the both others.

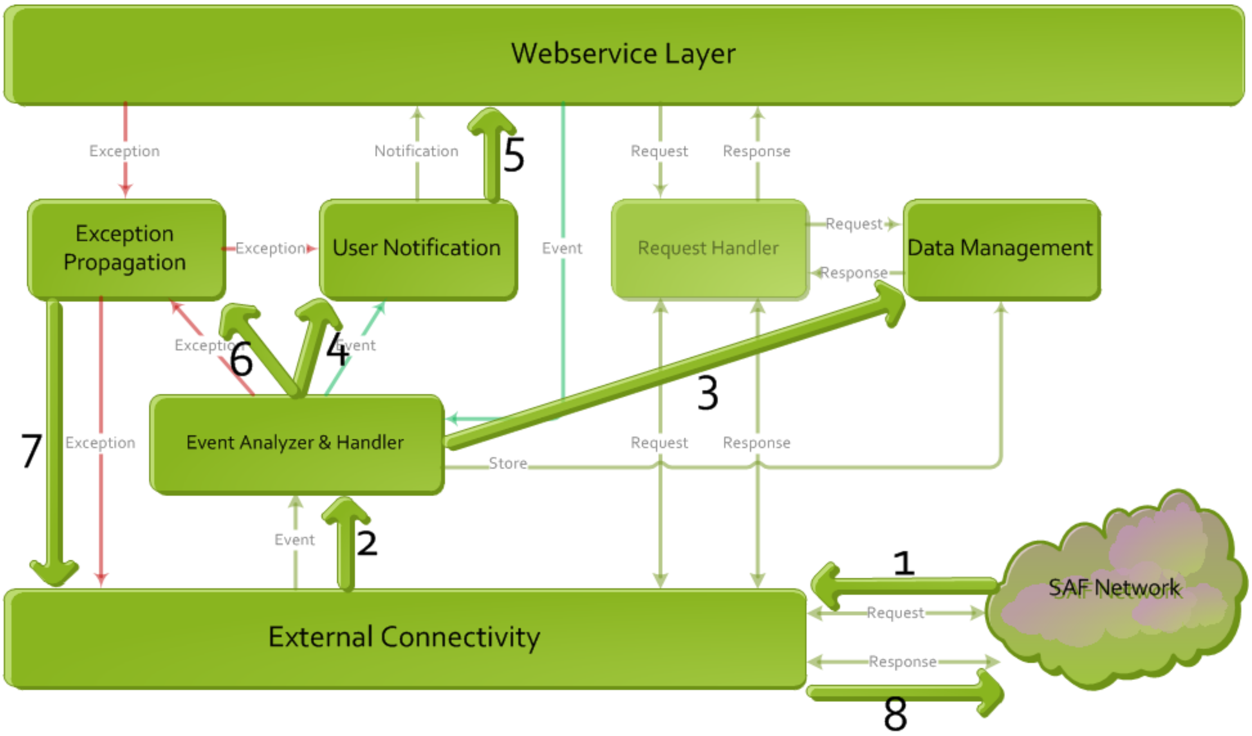


Figure 3-7: FFV Pilot – Propagation of Exceptions

As mentioned before this procedure is very similar to the exception creation and exception processing and could be almost regarded as a sequence of them except for the missing user interaction on creating yet another to be propagated. Until step 5 the actions performed by the development modules are identical with the Exception Processing. After the steps 2 and 3, the analysis, classification and storage of events, the procedure forks to first inform users like described in exception processing (Steps 4 and 5) and second use the Exception Propagation module to create automatically another exception with altered receivers. This altered exception now will be sent to the defined receivers and their pilot instances do the same to propagate the exception through the whole supply chain and reach every involved actor.

3.2 Domain Specific Enablers of the FFV Pilot

In the context of the Fresh Fruits and Vegetables (FFV) pilot the following domain specific enablers have been implemented:

- *Connected Device Handler*
  This domain specific enabler is in charge to manage the connections of the different devices and is implemented as an Enterprise Service Bus (ESB).
- *Data Management*
  Module in charge to abstract the lower layer and composed by a NoSQL storage system in order to be able to manage heterogeneous information based on multiple data formats.
- *Request Handler*
  The responsibilities of this module are handling all requests about product related information. Directly connected to the Identity Management and Security module, it prevents the misuse and unintended disclosure of information.
- *Exception Propagation*
  Its main responsibility is propagating information caused by anomalies in products or processes.

- *User Notification*
  In charge to propagate manual notifications launched directly by users when irregularities are detected in the products.
- *Session Management*
  Closely connected with the Identity Management GE, it is responsible to manage both specific and anonymous sessions.
- *External System Communication Handling*
  Module in charge to connect different systems involved in the FFV Pilot and manage connections among the different providers involved in the Pilot.

The rest of modules composing the architecture are covered by specific GEs. These components are:

- Identity Management and Security
- Event Handler
- Event Analyser

A more detailed description about the implementation, capabilities and functionalities of each one of these components will be available in D500.5.2 [4].

3.3 Related FI-WARE's GEs to the FFV Pilot

Due to the challenge of integrating the GEs in the real implementation of FFV pilot, an accurate identification and selection of the different FIWARE's GEs has been done to assure the interoperability among the different modules involved in the FFV pilot. The real integration with the GEs started in the 1st of October 2012, M19 of the project, as many the GEs were delivered at that time. Therefore, currently, and during Phase I, this pilot only integrates two GEs, the **Complex Event Processing GE** and the **Identity Management GE**.

Table 3-1 reflects both the two GEs integrated in the current FFV pilot and other GEs identified that will be integrated in the near future in the Phase II. The integration as well as the interactions of these GEs with the rest of the modules will be documented in the D500.5.2.

These are the GEs identified for use in the FFV pilot during Phase II:

- **PubSub GE**: To handle dangerous exception if detected (e.g. high amount of deadly bacteria on bananas), this GE can be used to establish a central point to inform subscribed companies about the current situation at some specific moment.
- **Location GE, IoT, I2ND**: During Phase II it is possible having an approach to include real time product information within the FFV pilot, like temperature, management of the sensor data and Location GE, using different devices (I2ND)
- **Mediator**: To allow the access of the REST-based UI Services via SOAP

Table 3-1: Usage of FI-WARE GEs by the FFV pilot modules

Generic Enabler	Integration in FFV Prototype Phase I	Exploited by module
Application Ecosystem and Delivery Framework		
Mediator GE	No	Communication
Data / Context Management Services		

Complex Event Processing GE	Yes	Event Analyser & Event Handler
Publish / Subscribe Broker GE	No	Critical exception Notifier
Location GE	No	Connected Device Handler
Security		
Identity Management GE	Yes	Session Management

3.4 Validation of the FFV Pilot

This section will match previously defined functionalities and requirements within the scope of the pilot with the developed modules and classes. In several deliverables of WP300 (see D300.1 [12] and D300.2 [5]) the FFV pilot has been characterized and its building blocks (modules) as well as basic functional range described. On top of that in some deliverables of WP500 (e.g. D500.3, D500.4) services, FI-Ware GEs and DSEs were specified partially used in modules of the FFV pilot for the first release. A high level view of those architectural modules, which realize the required functionalities to fulfil and enable the functional requirements of the pilot, is given in section 3.1 and further related GEs or DSEs are described as well in the sections 3.2 and 3.3.

In Table 3-2 the functional requirements represented by the building blocks and their realization by the developed modules of the pilot will be compared. The comment column describes the degree of realization and the planning of development in further releases of the pilot.

Table 3-2: – Comparison of Functional Requirements and Developed Modules of the FFV Pilot

Building Blocks (D300.2)	Developed Modules (D300.3)	Comment
Content & Format Provision	Content & Format Provision	The visualisation of data is one of the main functionalities of the UI of the FFV pilot, which is encapsulated in a module, which will be used for the Content & Format provision.
User Notification	User Notification + Event Analyser	For the analysis and compilation of events the Event Analyser module is created. The User Notification module is now only responsible for the pure notification.
User Request Handling	Request Handler + Web Service Layer	The Request Handler module is responsible to contact the needed information resources. The synchronous communication between the backend and the UIs is done in the Web

Building Blocks (D300.2)	Developed Modules (D300.3)	Comment
		Service Layer
Session Management	Session Management + Web Service Layer	The mapping of users and devices, session handling and documentation of user interaction is done by the Session Management module as foreseen, but the asynchronous communication will be enabled by the Web Service Layer.
Local Workflow Control	Web Service Layer + Ext. Communication Handling	The Web Service Layer is responsible for the internal connectivity, while the Ext. Communication Handler takes care of the communication to external devices.
Exception Propagation	Exception Propagation + Event Analyzer	For the analysis and compilation of exceptions the Event Analyzer module is created. The Exception Propagation module is now only responsible for the propagation
Virtualisation & Aggregation of crates	Data Management + EPCIS	The virtualisation of crates will be done by the Data Management module and the EPCIS server. The aggregation of crates will be enabled by the EPCIS Aggregation-Event.
ID processing	Data Management + EPCIS	The processing of GS1 IDs is done by the Data Management module and the EPCIS backend application.
Order/Batch Mapping	Data Management + EPCIS + Legacy Connector	The mapping of batch and crate IDs to existing orders is done by the EPCIS and the Data Management by using the EPCIS TransactionEvent. To allow the linkage the Legacy Connector is responsible to access the existing Order Management System of the company

Building Blocks (D300.2)	Developed Modules (D300.3)	Comment
Ext. System Communication Handling	External Connectivity	The External Connectivity module connects a pilot instance with external devices, services or other instances. It enables the basic communication between an instance and other connected entities.
Encryption Integrity Check	External Connectivity	All messages sent between different stakeholders are signed (optional encrypted) by the private key of each company. The External Connectivity Module checks this signature against the available public key of the corresponding company to validate the integrity.
Access Credential Mgmt.	Session Management	The Credential Mgmt. is handled by the Session Management and the IdM GE.
Storage	EPCIS, MongoDB	In the EPCIS object-related events and data is stored. Another data base is needed to store additional data not included by the EPCIS or not compatible with the EPCIS data structure. MongoDB was selected as light-weight and easy to handle data base instance.
Query/LS Connector	Legacy Connector	The Legacy connector offers a set of interfaces which can be implemented to connect legacy systems to the FFV pilot. Although currently no connection to a real legacy system (e.g. ERP) is implemented.
P2P Connectivity	External Connectivity	The External Connectivity module implements and manages a P2P-based network approach to connect pilot instances with devices, services or other instances.

Building Blocks (D300.2)	Developed Modules (D300.3)	Comment
Cloud Proxy	External Connectivity	For the first release of the pilot this module is regarded as a low priority requirement. In further releases a Cloud Proxy will be developed.

3.5 Standardization of the FFV pilot

Identifying a product is a very important aspect within the fruits and vegetable market and therefore within the fruits and vegetable chain. At this moment there are many different identification codes to identify products and crates. These codes are also used to describe them in more detail. From this variety grows the necessity of elaborating standards to share and harmonize the products and crates data.

A complete standard's classification and roadmap related to the FFV chain has been elaborated within the D300.4. [13]

4 Quality Controlled Logistics in the Plants and Flowers Supply Chain (PF) Pilot Architecture

4.1 High level view of the PF Pilot

This chapter describes the technical architecture of the plants and flowers (PF). It builds on the architecture as described in D300.2 [5], which includes an in-depth definition of the functional architecture. This chapter first explains the technical architecture defined for the pilot, and afterwards elaborates in the relevant architecture-related dimensions concerning the supply chain structure, processes and data processing.

4.1.1 Technical architecture

Figure 4-1 represents the integrated solution architecture. The starting point of this architecture is the identification and sensor devices at the stakeholder locations. These devices can be accessed via Internet of Things services, i.e. the identification device data service and the sensor data service. Next these devices result in events that are stored and processed on the event platform.

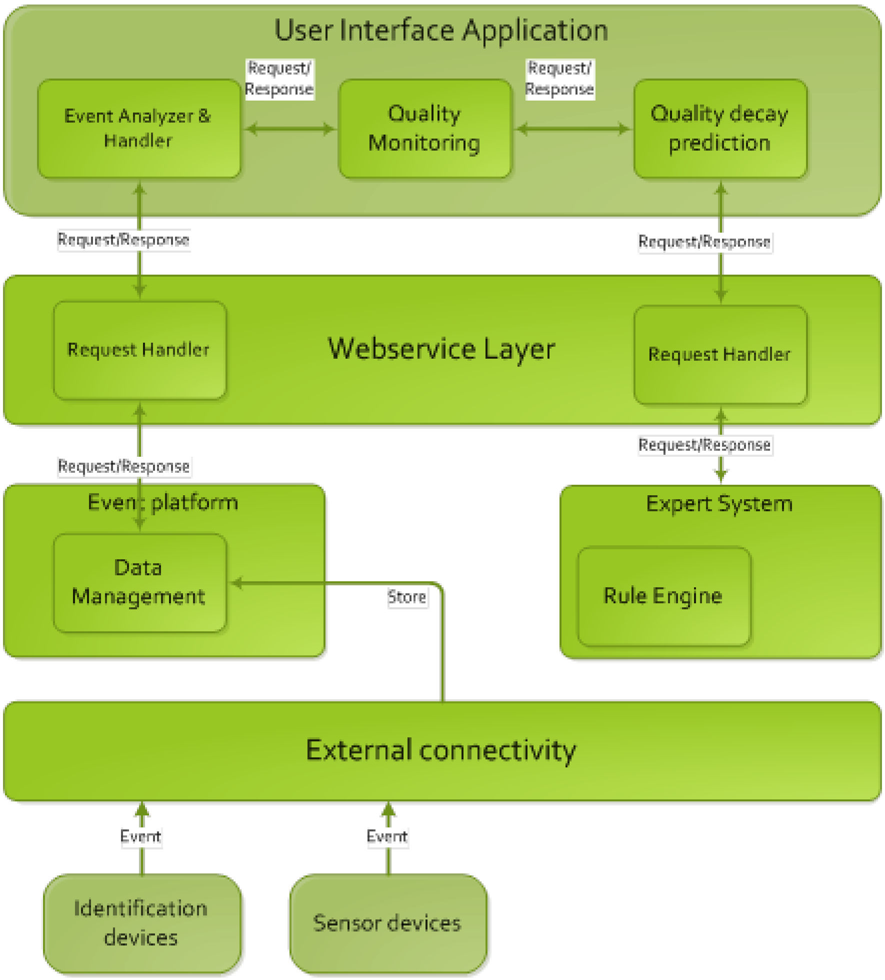


Figure 4-1: Technical Architecture of the PF pilot

The platform is leveraging the currently implemented logistic tracking system, which is based on the ultrahigh-frequency RFID tags that are attached to the complete pool of plant trolleys. The event platform can be accessed via the event data service. Besides this event platform, the architecture includes a quality projection system, which is an expert system that can predict the quality decay of products. The expert system can be accessed via the quality projection service. The last component of the architecture is the User Interface, which is a Cloud Dashboard that integrates the event platform and the expert system.

4.1.2 Refined system functionality

The technical architecture describes how the user interface application is realised. In the following of this section the development process and choices are described that have led to this architecture, starting with the supply chain structure. The supply chain structure describes the actors from the chain who are the potential users of the User Interface Application and the locations in the chain where events are being generated by identification and sensor devices.

4.1.2.1 Supply Chain Structure

These are the locations that are involved in the flower pilot chain:

- Grower’s greenhouse
- Transshipment area at Grower’s
- Inbound transporter’s truck
- Trader’s Warehouse
- Outbound transporter’s truck
- Retail location

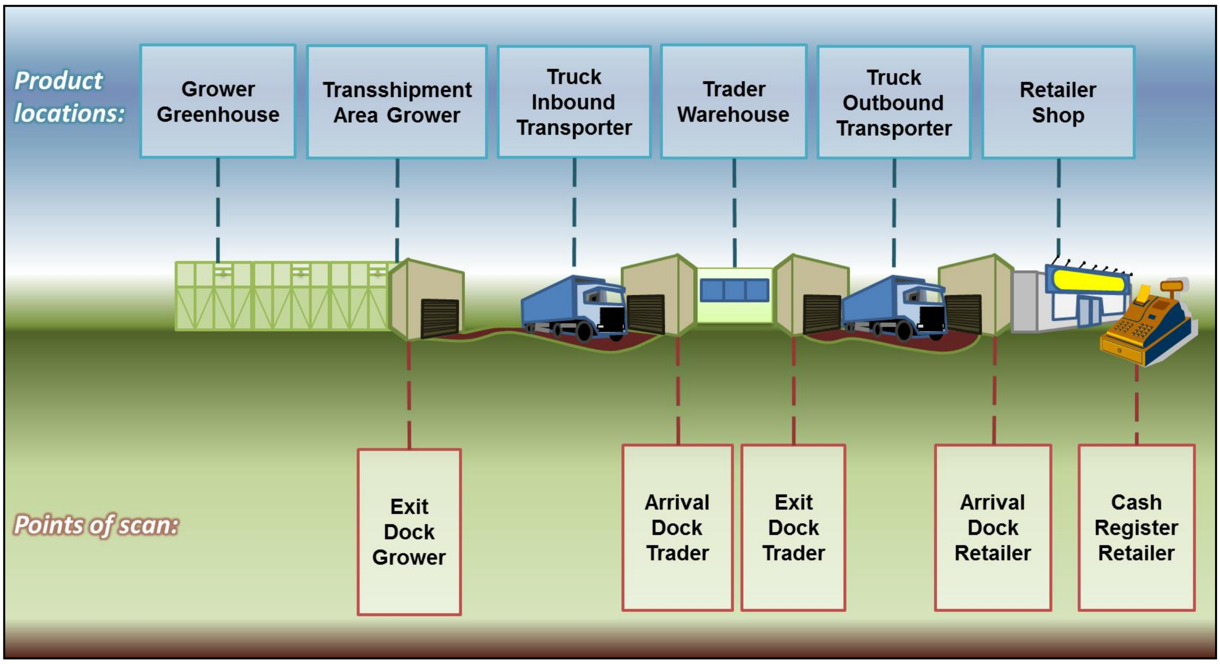


Figure 4-2: Supply chain partners, locations and points of product scans.

Figure 4-2 represents a "simplified" version of the analysed supply chain, which is the basis for the description of the flower & plant pilot. The chain starts at the grower's greenhouse where the flowers and plants are grown. Here, also the initial quality of the products is determined and recorded and the flowers and plants are labelled with a label containing a unique identifier to be able to track and monitor individual products while they are transferred through the supply chain.

Scans

The squares in the lower half of the image resemble points that are passed while the flowers and plants are transferred from one chain partner to the next and to the consumer at the end of the chain. These are the points where identification devices (e.g. RFID scanners) scan the objects that pass by. At the exit docks, this means a scan is made by the party that sends away the products and a scan is made by the party that receives the products. At the arrival docks a scan is made by the delivering and the receiving party. At the cash register at the retailer, the products are scanned for the final time and transferred to the consumer.

Locations

The squares in the upper half of the image resemble locations in which the flowers and plants stay during their greenhouse-to–consumer-life. Because all products are always scanned when entering and exiting a location, the location of a product can always be determined. At these locations data is gathered about the local conditions by continuously measuring temperature, air humidity and luminosity in the area.

Trajectories

Using the data gathered by the identifying devices a location history of an individual plant can be reconstructed during any moment in the greenhouse-to–consumer-life of the flowers and plants. Knowing this location history, the matching environmental data can be filtered out to find the plant specific trajectories for temperature, air humidity and luminosity. Combining these data with the initial quality data of the flower or plant, an expert system is able to calculate the expected quality decay of the flower or plant. This information could help improving product quality by providing suggestions for quality optimization. It would also make it possible for the retailer to provide the consumer not only with a product, but also with a reliable prediction about the expected quality decay of that product.

Location Types

The chain described above is relatively simple, for reasons of convenience, but the described method for monitoring individual plant quality can be extended to different types of chains. For each chain three different types of location can be identified:

- Production location.
- Logistic transfer location.
- Point of sales location.

These location types can be viewed as chain building blocks which can be used to construct all different kinds of chains, for example the Flowers and Plants Pilot chain in Table 4-1.

Table 4-1: – Simple chain parameters

Chain Partner	***Grower***	***Inbound Trans-porter***	***Trader***	***Outbound Transporter***	***Retail Shop***

Type of Location	Production Location	Logistic Transfer Location	Logistic Transfer Location	Logistic Transfer Location	Point of Sales Location

But also more complex chains can be built up from these building blocks, for example chains in which there is also an auction involved in Table 4-2.

Table 4-2: – Complex chain parameters

Chain Partner	***Grower***	***Inbound Transporter***	***Trader***	***Outbound Transporter***	**Auction**	**Retail transporter**	***Retail Shop***
Type of Location	Production Location	Logistic Transfer Location	Logistic Transfer Location	Logistic Transfer Location	Logistic Transfer Location	Logistic Transfer Location	Point of Sales Location

Each location type has its own specific processes which are explored in the next chapter.

4.1.2.2 Processes at chain partner locations

Of course each chain partner has its own unique processes, but the processes that generate relevant data for the pilot are essentially the same for all logistic transfer locations. These processes are identified in this chapter.

The production location

The production location is where the product comes to life, both physically and virtually. Here the initial quality is determined and recorded at harvest and the products are individually labelled to enable continuous monitoring. After harvest the environmental parameters that influence the quality of flowers or plants are measured until they are shipped at the dock. At that point they are scanned which also represents a transfer in responsibility for the product from the grower to the trader, as represented in Figure 4-3.

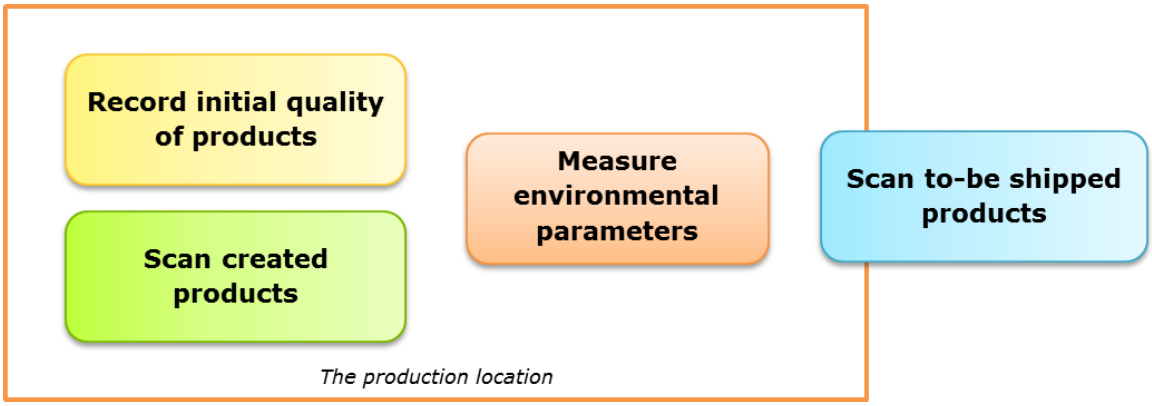


Figure 4-3: Relevant data gathering processes at the production location.

The logistic transfer location

A logistic transfer location is any location in the chain where the flowers or plants stay for a certain period of time, which is not the start/production location or the end/point of sales location. This can be any location, for example the container of a lorry, the operation facility of a trader, or an auction. This location can also be composed of different sub locations. Before entering a location the flowers and plants are scanned to establish their whereabouts. Accordingly the quality influencing environmental parameters are measured continuously during the stay of the products. At leaving the location the flowers and plants are scanned again to close off the trajectory build-up of parameters and to indicate transfer of responsibility, as represented in Figure 4-4.

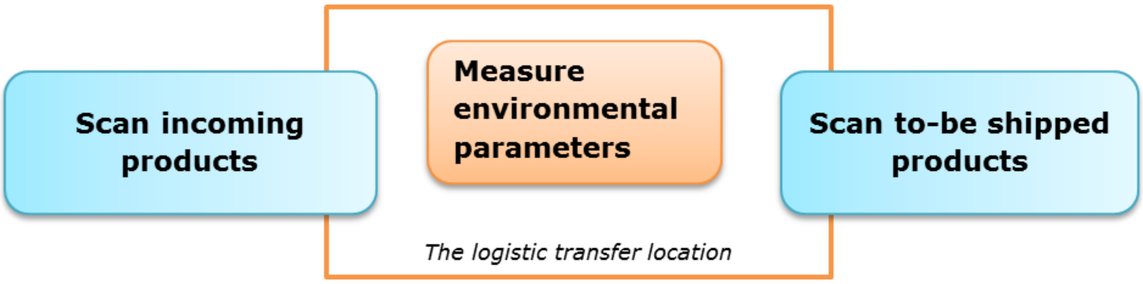


Figure 4-4: Relevant data gathering processes at the logistic transfer location.

The point of sales location

The point of sales location is the final location in the chain where the flowers and plants are sold to the end-consumer, e.g. a retail shop. The flowers and plants are stored here until they are sold to the end-consumer. During their life on the shelf, quality parameters are monitored, as represented in Figure 4-5.

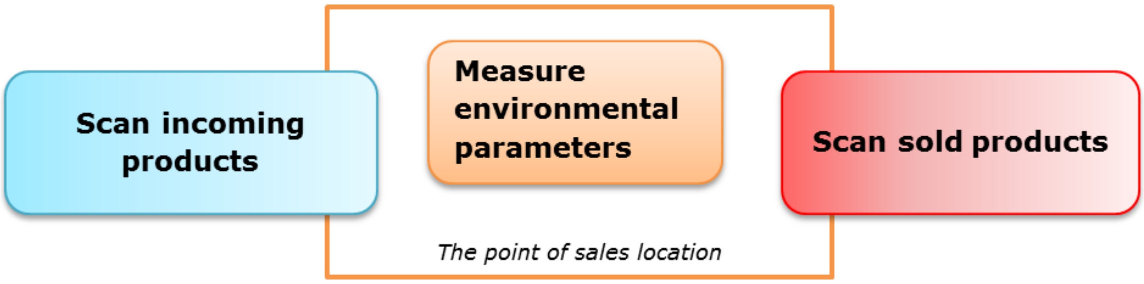


Figure 4-5: Relevant data gathering processes at the points of sales location.

All the above explained processes that are carried out at the different locations generate data. The contents of the data are further explained in the next paragraph.

Data processing

In the Table 4-3 the relevant processes are identified and linked to the corresponding data objects.

Table 4-3: Overview of processes and data objects.

Process	Data object
Record initial quality	**Initial quality data** • Number of flowers • Surface diameter • Colour intensity • Flower distribution • Height of plant • Density of foliage
Scan created cultivars	**Cultivar creation scan data** • Object ID • Time • Greenhouse location • Meaning = Cultivar created • Initial quality
Measure environmental parameters	**Environmental parameter measurement data** • Continuously measurement of value * time (humidity, luminosity and temperature) • Measurement Location • Sensor ID
Scan to-be-shipped cultivars	**To-be shipped cultivar scan data** • Object ID • Time • Location • Meaning = Cultivar handed over
Scan incoming cultivars	**Incoming cultivar scan data** • Object ID • Time • Location • Meaning = Cultivar received
Scan sold cultivars	**Sold cultivar scan data** • Object ID • Time • Location • Meaning = Cultivar sold

Exchanging generated data

This pilot focuses on cloud functionality. Therefore the data gathered during the operations has to be transferred to the cloud in order to be processed. There are two methods for local-to-cloud data synchronization that are considered for this pilot. The first is real-time cloud synchronization and the second is event-based synchronization.

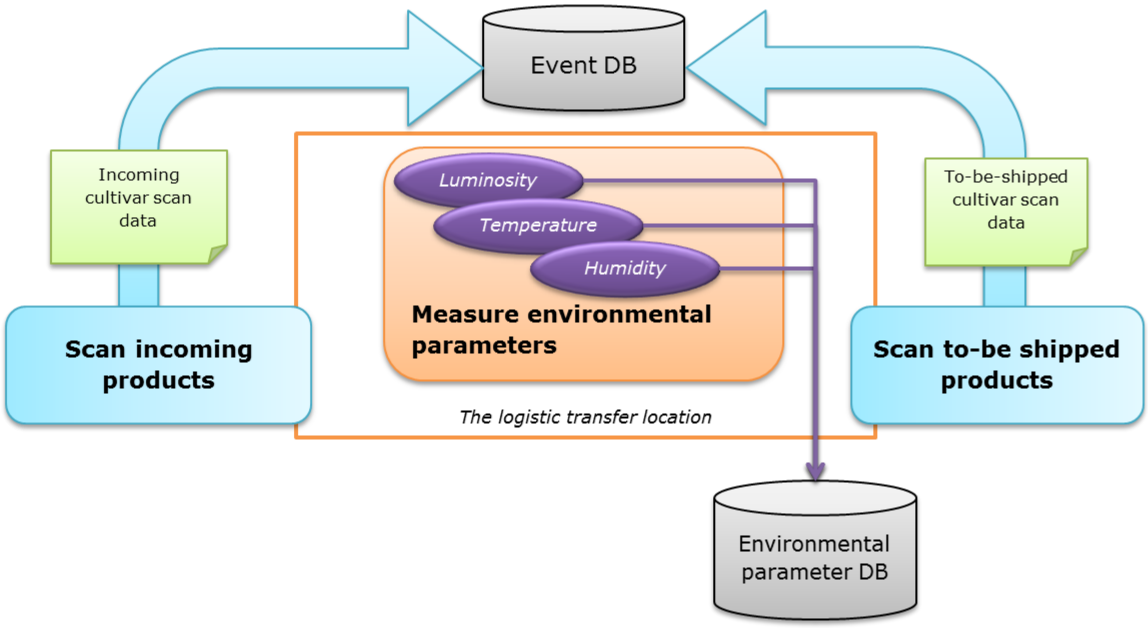


Figure 4-6: Storing data generated in processes at the logistic transfer location (option 1).

In real-time cloud synchronization the environmental parameter measurement data is transferred to the cloud, as the title says, in real-time, as visualized in Figure 4-6. This means that continuously data is exchanged about the environment of relevant locations from location to a dedicated cloud database. Because of this characteristic, the data is continuously accessible and the cultivar's quality profile can be determined real-time. This provides possibilities for immediate process optimization, which is the ultimate goal for the future of this pilot.

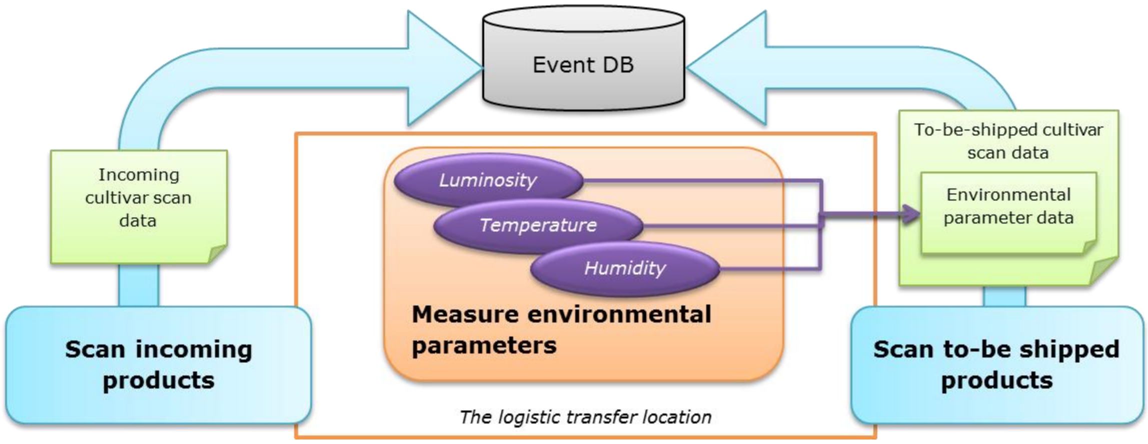


Figure 4-7: Storing data generated in processes at the logistic transfer location (option 2).

However, for practical reasons, the setting of the proof of principle is a bit simpler, as shown in Figure 4-7. The data about the location's environment could also be transferred to the cloud with the event data. In that case the infrastructure will be less complex than in the previous example, making it easier to realise. The disadvantage is that data about the environment in a location where the cultivar has been can be accessed only afterwards once the cultivar leaves the location.

This limits to a certain extent the possibilities for immediate process optimization, but should still be sufficient to point out the benefits of the pilot.

For the pilot demonstration the choice is made for the latter option, because it the software basis will consist of a combination of the platform of Mieloo & Alexander and an adapted Expert System that has been developed for WP200. Working with the Mieloo & Alexander platform will require fewer resources to develop option 2 than it will be for option 1. The environmental conditions data can then easily be stored with the scan data while using the existing infrastructure from the current system. The resulting solution will act as a proof of concept and function as a demonstrator of the desired situation.

The image below (Figure 4-8) visualizes the overview of processes and data-exchange when the solution is mapped to the production location described earlier.

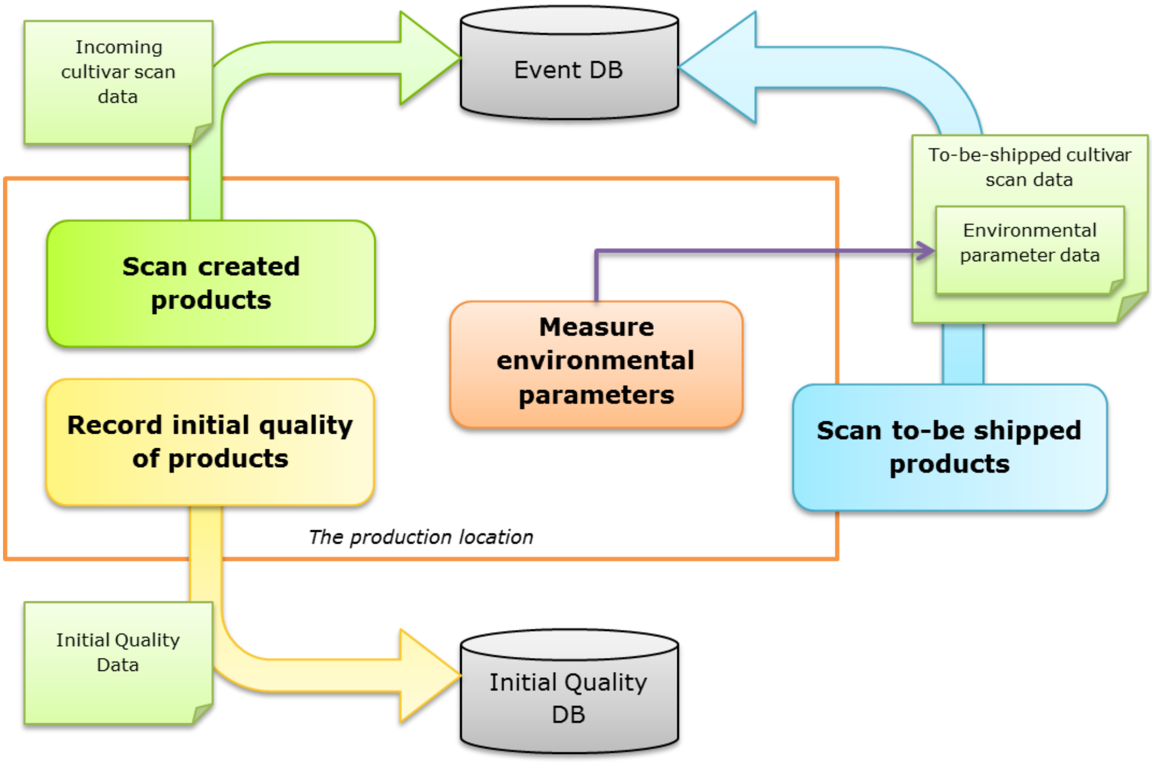


Figure 4-8: Storing data generated in processes at the production location.

For the point-of-sales location, the resulting data storage is very similar to the logistic transfer location, as can be seen in the image below, Figure 4-9.

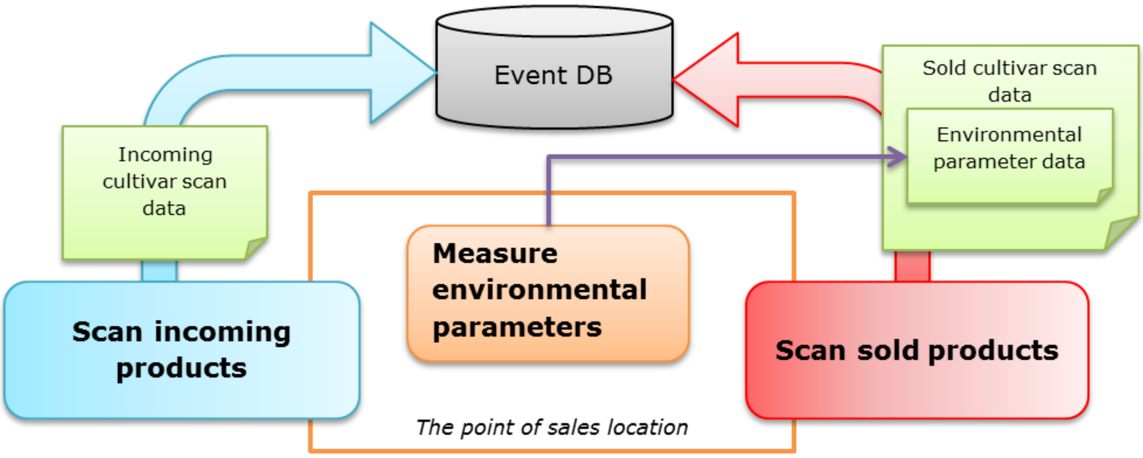


Figure 4-9: Storing data generated in processes at the point of sales location.

After gathering and storing data from the processes, it should also be processed to be able to actually predict the cultivar's quality decay. This processing is further described in the next chapter.

Processing cloud located data

The expert system calculates quality decay predictions based on the data from the Initial Quality DB and the Event DB. The results are stored on the Quality Decay Prediction DB as depicted in the figure below, Figure 4-10. The databases in the image are all cloud based to optimize accessibility to the data throughout the supply chain.

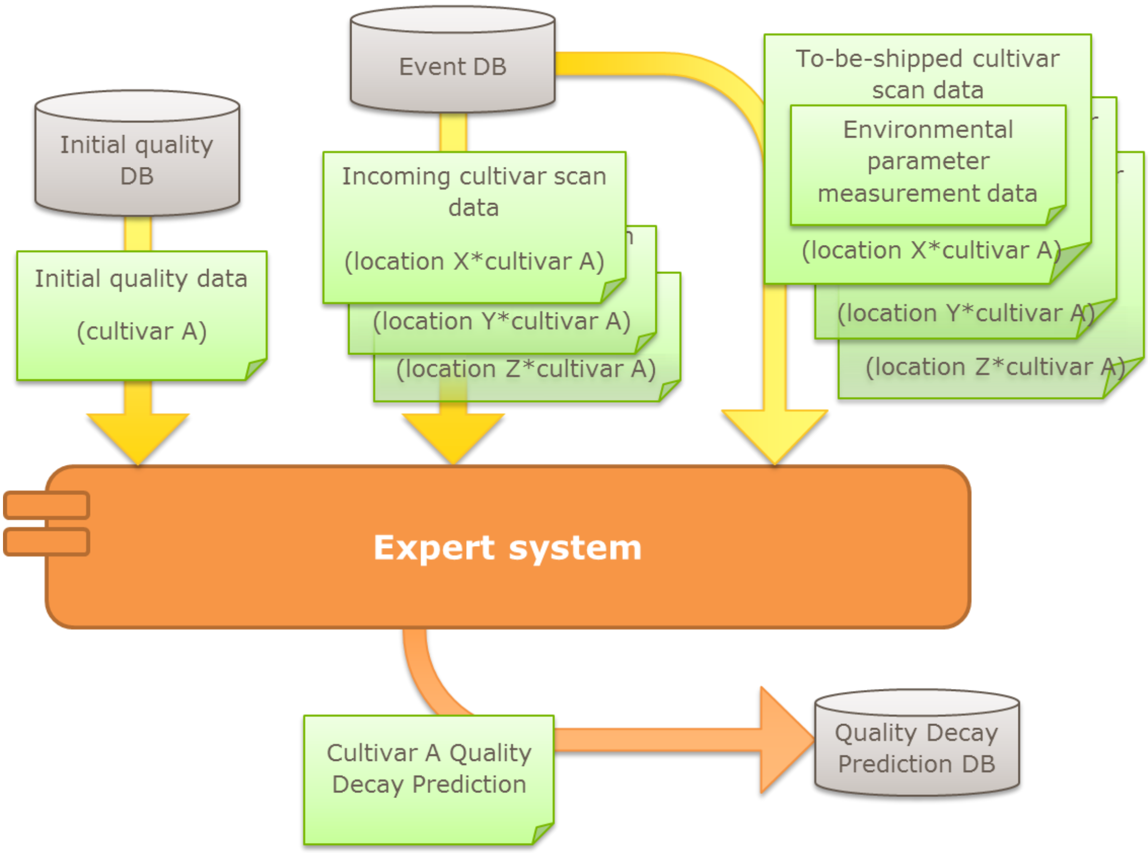


Figure 4-10: Processing cloud-based data by the expert system.

With the basic architecture of the system explained, the next chapter looks at how to realize it practically.

4.2 Domain Specific Enablers of the PF Pilot

In the context of the Plants and Flowers pilot the following domain specific enablers have been implemented:

- Cloud Dashboard:
  - Initial Quality Service
  - Plant Quality Service
  - Location Environment Service
- Event Platform
  - Event Data Service
- Expert System for Quality Prediction
  - Quality Prediction Service

The Cloud Dashboard and the Event Platform are fully explained in the D500.5.1 [6], chapter 2.3.2 and 2.3.3. The Expert System and the Event Platform are based on specific GEs, which are described in the section 4.3.

Although a brief explanation of the Expert System can be found in the mentioned deliverable, further details related to it are provided in the next section.

Expert System - Prediction Web Service

The expert system predicts the quality decay of a plant of interest based on the history of its environment. With this, higher levels of intelligence in food logistics information processing (cf. [14]) can be reached. The prediction functionality is realized as a web service, which communicates with the main dashboard application, as illustrated in Figure 4-11. The requests of the dashboard application contain parameters necessary for the quality prediction, the latter being contained in the corresponding response message. For the purpose of demonstration, Simple Object Access Protocol (SOAP) [15] request and response messages, relying on eXtensible Markup Language (XML) [16], are generated following the agreement defined using Web Services Description Language (WSDL) [17]. In the proof of concept of FI-PPP Phase 1, no specific web service discovery mechanisms are used, but such services will be of importance for large scale expansion in future FI-PPP phases.

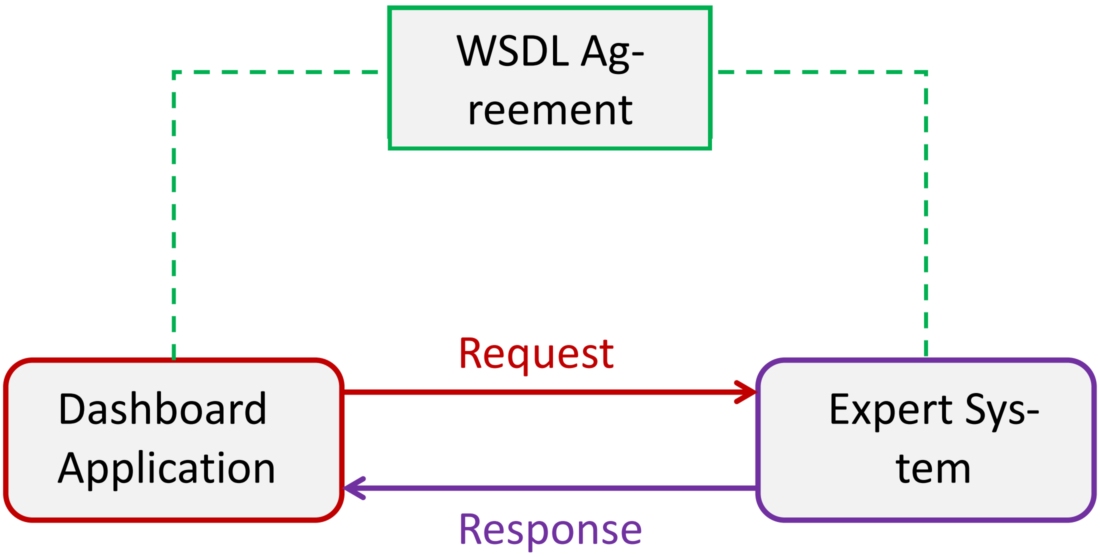


Figure 4-11: Communication between the expert system and the dashboard application

Request Message

In the current implementation, the request message contains:

- Type of product
    - Name and kind of product. The products can include various types of plants, such as pot plants, cut flowers, etc.
- Initial quality parameters
    - The initial quality parameters can be, e.g., the vase life of a non-stored flowers of interest at room temperature, but other product dependent parameters as well, which are necessary for the corresponding algorithm. The algorithms

implemented in Phase 1 mainly predict the relative quality decay with respect to the initial quality of the flower entering the chain.

- Environmental parameters with time stamps
  - Regarding the time stamps, it should be noted that in many applications, the average daily temperatures are taken.
  - In general, the prediction algorithms are based on historical data about the plant temperature, humidity, luminosity, and photo synthetically active radiation. In Phase 1, for the proof-of-concept purpose, the measurements of the environmental parameters are (realistically) mocked-up, by extending the EPCIS (logistics) data model. The integration of actual sensors is planned for FI-PPP Phase 2.
- Desired prediction algorithm
  - The code for the desired prediction algorithm can be specified. Note that a particular algorithm assumes always a specific set of parameters (product, initial quality, and environment). Combination which is not allowed generates appropriate alarms and error messages.

An illustration of a simple request message structure is given in Figure 4-12 (real examples will be available in the D500.5.2 [4]). Note that the currently used WDSL file structure allows a number of other parameters to be entered, and it is very flexible, so that it can be further modified in the future according to the stakeholders needs.

Product	*ROSES (Cut Roses Red Naomi)*				
Initial Quality	Vase Life on a Referent Temperature [days]			Referent Temperature [°C]	
	7			*20*	
Environmental Parameters	Temperature [°C]	Value	*18*	*17*	*22*
		Time [days]	*1*	*2*	*2*
Algorithm	*SAF01 (TTS -Time Temperature Sum)*				

Figure 4-12: Illustration of request message parameters.

Response Message

The expert system response gives the predicted plant quality. Depending on the product at hand, this can be, e.g., the vase-life (for cut flowers) with a time-stamp, or a percentage of initial quality in a more general case. In the simplest realization, the response gives just a snapshot of the quality, while the complete answer can contain an array of quality parameters in the future and the corresponding time-stamps. Further, results for various algorithms can be given. As some algorithms from the literature underestimate and the other overestimate the quality in a certain range of environmental parameters, the dashboard application can finally be equipped with the possibility to show an uncertainty region for the prediction. Finally, the response message contains also a description of a possible error. Currently, the system will display an error if the supplied environmental parameters do not match the requested prediction algorithms or the corresponding products (e.g., the data provided in the request is insufficient to make a desired prediction for the specified product). The error field is used also to generate basic alarms (e.g., temperature above a predefined threshold for the specified product, etc.).

An illustration of one of the possible response messages is given in Figure 4-13.

Product	*ROSES (Cut Roses Red Naomi)*			
Quality Prediction	Referent Temperature [°C]	Minimum Vase Life [d]	Maximum Vase Life [d]	Time Stamp
	20	*4*	*5*	*2012-19-09 22:20 UTC*
Algorithm	*SAF01 (TTS -Time Temperature Sum)*			
Errors	*No Error*			

Figure 4-13: Illustration of a response message.

Prediction Algorithms

Two types of prediction algorithms have been implemented: the time-temperature sum algorithm and the first order Arhenius (FOA) algorithm (cf. [14] for an overview of these algorithms).

Time-Temperature Sum Algorithm

The time-temperature sum algorithm is rather simple. Besides the initial parameters (the vase life on a reference temperature), it is based only on the temperature measurements with the time-stamps.

The estimated plant life can be calculated as:

$$EPF = VLNSP\ [d] - \frac{1}{TNSP}\left(\sum_{i=1}^{N} TI_i\ [d]\ \times\ TEMP_i[°C]\right),$$

EPF is the estimated plant life,

VLNSP is vase life of the non-stored plant in days [d],

TNSP is the temperature of the non-stored plant,

i is the time index for measurements,

N is the total number of measurements,

$TEMP_i$ is the temperature in Celsius [°C] for the measurement with index *i*,

TI_i is the length of the time interval the plant spent on temperature $TEMP_i$ in days [d].

A drawback of the time-temperature sum algorithms is its inaccuracy on low temperatures, where it can overestimate the plant life. For this reason, in the developed web-prediction service a modification of this algorithm is also implemented, which takes the prediction at a certain (low) threshold temperature (e.g., 2 °C) as a lower boundary for prediction.

FOA Algorithm

The FOA algorithm assumes an exponential plant quality decay model $q(t) = q_0\, e^{-k_T t}$, where $q(t)$ is the plant quality at time t, q_0 is the initial plant quality, and k_T is the quality decay rate, which depends on the temperature T, but some other product-related parameters, as well (cf. [14]). While the FOA model is more reliable (particularly at low temperatures), the lack of knowledge of these product-related parameters, might prevent it from widespread application. The developed expert system supports the prediction based on the FOA model, in case when all necessary parameters are provided.

4.3 Related FI-WARE's GEs to the PF Pilot

First analysis of the application of FI-WARE GEs in the PF pilot was performed in [5][18], based on the FI-WARE documentation. In the meantime, the first modules developed by the FI-WARE project, became available to the SmartAgriFood project. The actual testing of these and the attended webinars have influenced slightly the priorities defined in [5], w.r.t. the integration plans. In Table 4-4, we give the current work plan for GE integration in the PF pilot in FI-PPP Phases 1 and 2.

Table 4-4: GEs of interest for the PF Pilot

Generic Enabler	**Integration in PF Prototype Phase I**	**Exploited by module**
Application Ecosystem and Delivery Framework		
Mashup GE	No	Cloud Dashboard
Data / Context Management Services		
Complex Event Processing GE	Yes	Expert System
Publish / Subscribe Broker GE	No	Cloud Dashboard
Location GE	No	Cloud Dashboard
Security		
Identity Management GE	*No*	Cloud Dashboard
IoT		
Other IoT GEs	No	Event Platform, Cloud Dashboard

The ultimate envisaged application of CEP is illustrated in Figure 4-14. In this ideal case each actor in the transport of the flowers and fruits (the whole logistics chain) is a producer. The events that are produced the environment the plant is exposed to at various stages. These events are processed by the CEP web instance to modify the values of the resource (plant for the PF pilot, but could be also fruit, meat, etc. for other pilots) thereby implementing an expert system.

All consumers can sign up to the various alerts delivered by the system they are interested in. In that way, e.g., the shop owners can refuse the delivery of a plant mentioning insufficient expected life, if it was exposed to incorrect environmental conditions.

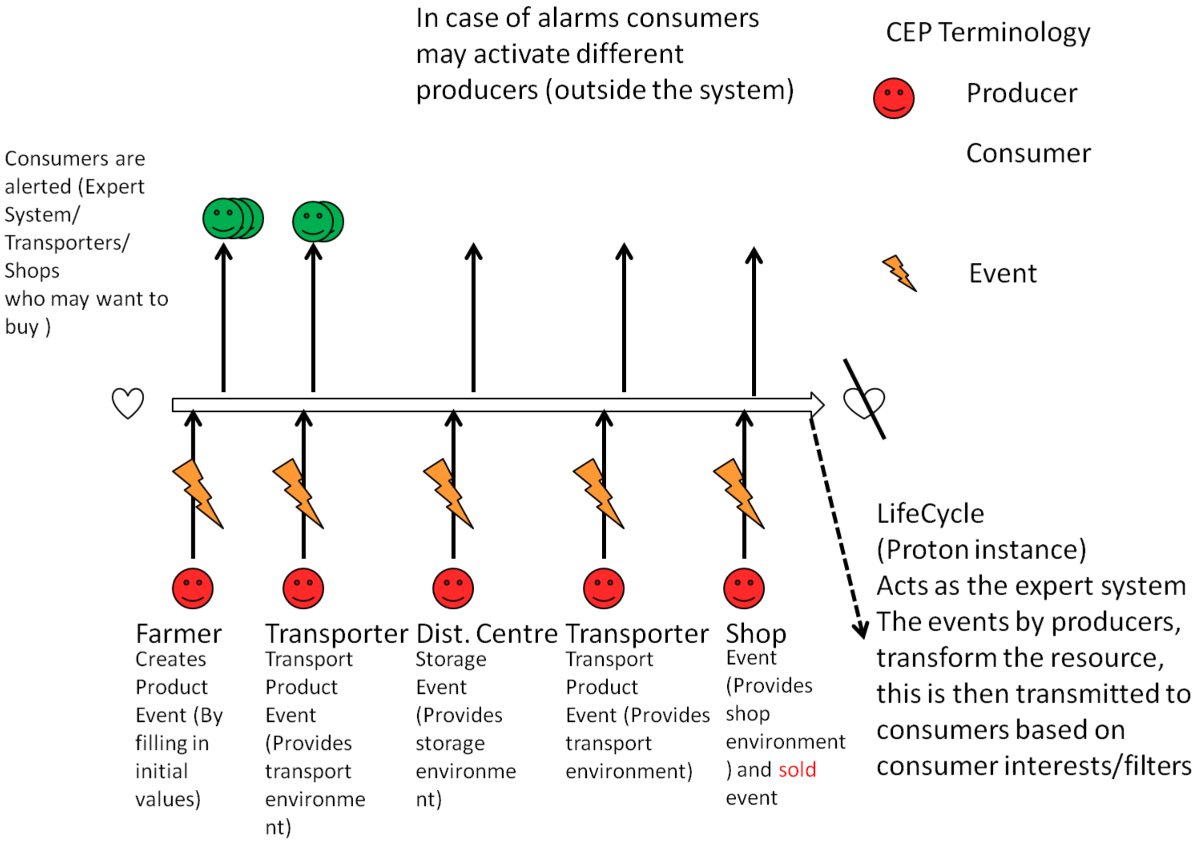


Figure 4-14: Envisaged, ultimate implementation of CEP in the PF Pilot.

In order to adapt the CEP to the already existing infrastructure, for the work in Phase 1, the architecture shown in Figure 4-15 is followed. The cloud dashboard application internally relays the updates to the proton web instance acting as both producer and consumer. In the case of successful implementation of certain rules, some parts of the expert system described 0, could be completely implemented in the CEP, which allows this possibility. Finally, the complete rule engine of the developed expert system (assuming also rules for decision making) might supplement the CEP GE instance provided by the FI-WARE, realizing the intelligent processing of information in this supply chain.

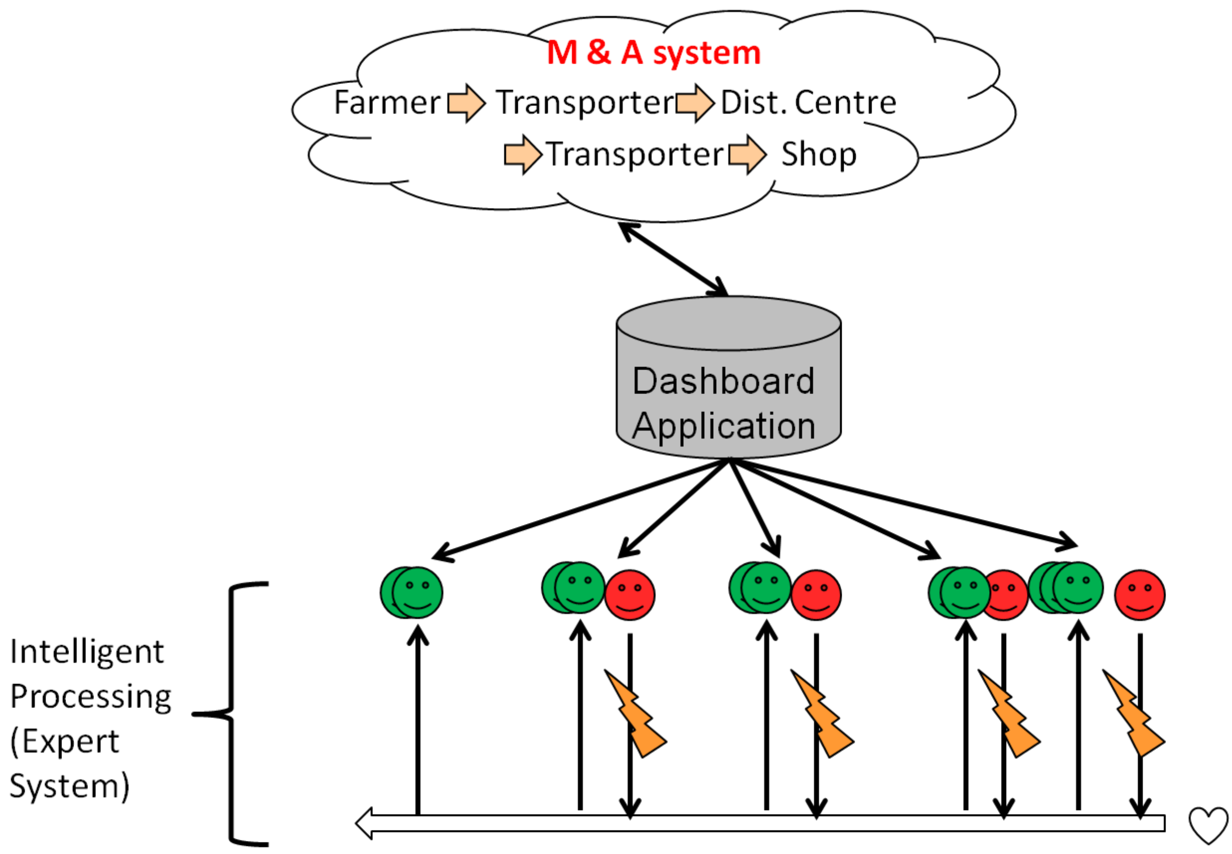


Figure 4-15: Integration of CEP into the existing PF architecture.

4.4 Validation of the PF Pilot

In Table 4-5 we give the description of the main classes implementing the functionalities of the architectural blocks of from the previous sections.

Table 4-5 – Main Classes of the Expert System – Prediction Web Service

Building Blocks	Developed Modules	Comment
Label flowers and plants	n/a	Currently the RFID tag on the CC-trolley is used and no additional activities and systems are required. In the next phase of the pilot also tags will be placed on tray level and on individual plant level.
Record initial quality of flowers and plants	Cloud Dashboard (Initial Quality Service)	Currently the initial quality of the plants that come from the growers are assumed to be of perfect quality (100%). In the next phase of the project an additional module will be developed that is able to give a more nuanced view on initial quali-

Building Blocks	Developed Modules	Comment
		ty of cultivars based on the assessments of quality experts.
Control environments of flowers and plants	Cloud Dashboard (Location Environnent Service)	The grower, trader and logistic service provider all use systems of their own to control conditions at their locations. In the future a harmonized approach should be developed to send condition alarms to these systems so they can respond appropriately. For now data about the environment conditions are incorporated in the event message that is send locally to the event platform. In the future this data could be gathered in a separate database.
Track and trace flowers and plants	Event Platform (Event Data Service)	Objects that are now tracked and traced through the supply chain on trolley level. At the trader the trolleys are rebuild for the retail shop. It is a problem to track and trace which products are exactly on the trolley. Therefore in the future trays and also individual plants will be equipped with a RFID tag to realise tracking and tracing of cultivars from grower to retailer.
Monitor supply of flowers and plants	n/a	The supply of flowers and plants is based on the planning of the growers. In the future a link to the ERP systems of them is to be realised so that detailed information on the supply of cultivars can be shared with the trader.
Monitor quality of flowers and plants	Cloud Dashboard (Plant Quality Service) Expert System (Quality Prediction Service)	Quality decay is calculated based on the temperature trajectory of the selected cultivar based on the quality decay model of cut roses. In the future the module is to be enriched with specific quality decay models of more cultivars.
Create orders for flowers, plants and transportation	n/a	In the future the order communication will be further standardized according to florecom standards.
Confirm orders	n/a	See previous comment

Building Blocks	Developed Modules	Comment
Schedule transport	n/a	The logistic service providers from the selected chain use systems of their own to schedule transport. In the future links to these systems are to be established so that information about driving routes can be taken into account in the optimization analyses.
Signal 'ready to be shipped'	Event Platform (Event Data Service)	This signal helps logistic service providers to optimize their routing.
Build up retailer trolleys	n/a	Not yet implemented.
Monitor inventory of flowers and plants	n/a	Link to inventory/replenishment system of retailer to be realised in the future.
Sell plants	n/a	In the future a link to the sales module of the retailer is to be established so that additional consumer information on plant lifecycle can be gathered and expected quality decay developments can be shared with consumers.
Update strategy retailer	n/a	In the future an experimental module is to be developed that gives the retailer the opportunity to dynamically update their store replenishment/category management to the trader.
Expert quality assessments	n/a	Module to be developed that gathers expert quality assessment information of cultivars to be able to automatically calibrate the quality assessment module and to intelligently improve the quality decay algorithms

4.5 Standardization of the PF pilot

Identifying a product is a very important aspect within the flower market and therefore within the flower chain. At this moment there are many different identification codes to identify products and describe them in more detail. From this variety grows the necessity of elaborating standards to share and harmonize the flower data.

A complete standard's classification and roadmap related to the flower chain has been elaborated within the D300.4. [13]

5 Integration of FFV Pilot and Plant and Flowers Pilot

As it can be seen from [5], [6], the intention of the two Smart Agri-Logistics pilots was to focus on different scenarios in Phase 1. The PF pilot initially assumes a centralized, cloud-based scenario with measurements of environmental parameters playing a major role in quality controlled logistics. The accent in the FFV pilot is on designing a novel distributed information exchange scheme for the agri-logistics supply chain. The selection of partially non-overlapping topics for Phase 1 was deliberately done in this way, so that the pilots cover versatile aspects of complex supply chains in the food sector, and to enable integration of the pilot in future FI-PPP phases. Namely, one should note that distributed information exchange scheme from the FFV pilot can ultimately also be utilized in the flower supply chain, while on the other hand the measurement of environmental parameters certainly plays an important role in the FFV chain too. It is the second aspect that will present the first integration example of the two pilots and it will be elaborated in this chapter.

5.1 High Level Scenario

The expert system service, described in Section 4.1.2 (cf. also Figure 2-1 and Figure 2-2 which explain the integrated smart agri-logistics architecture), can be utilized for extending the scope of the FFV pilot in the direction of quality driven logistics in the FFV supply chain. Namely, FFV quality control based on measuring environmental parameters has recently gained a lot of attention in the scientific community [22]. In fact, many of the quality decay models from the flower chain have counterparts in the FFV chain (with different product-dependent parameters, of course). For example, the time-temperature model sum, described in Section 4.1.2 for the flower chain, has an interpretation in determining physiological maturity and colour of tomatoes [19]. For this case, the rule engine of the flower pilot is simply extended by the formulas for the colour stage, which can be found in [19]. Further parallels can be found in modelling the respiration rates [20], where the temperature influence is modelled also by the Arrhenius equation. However, even in the cases when completely new models are needed (e.g., influence of gas composition, ethylene, etc. [20], [21]) the modularity of the developed expert system (cf. the classes in Table 4-5) allows quick extension of the rules with prediction models for new products, different parameter and measurement data, etc.

An illustration of the envisaged module reusability is given in

Figure 5-1. From an architectural point of view, the expert system, realized as a web-service, is deployed in a local server, and matches well to the decentralized architecture of the FFV pilot. In fact, such prediction services can be offered from external parties, as well (cf.[5]). The service itself does not violate security constraints, which motivated the P2P architecture behind the FFV pilot, as the exchange of information with the expert system is already organized in a P2P way. For calculations following various quality decay models, only basic product parameters and measurement data is needed from the interested side (farmer, trader, retailer, etc.). No logistics data revealing the trace of a product or business transactions would have to be delivered. Finally, it should be mentioned that the reuse of the expert system module could go beyond SAF WP300, as the same framework can be utilized in smart farming and at the retailer side. As an example for this utilization, one can already consider the Advisory Service described in [18].

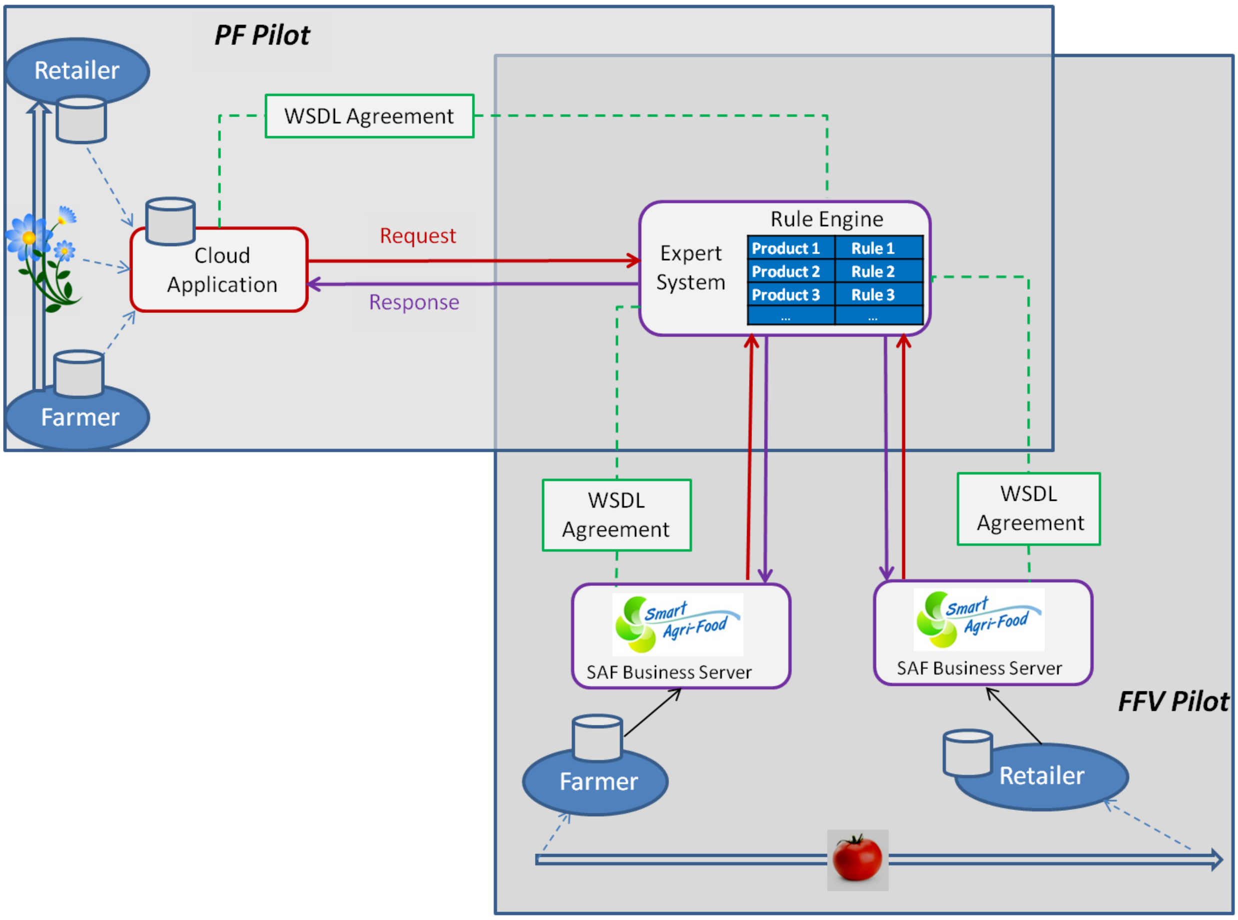


Figure 5-1: Reusable Expert System Module in the two Smart Agri-Logistics Pilots.

5.2 Message Exchanges

The message exchange between the local SAF business servers will be organized in a similar way as described in Section 4.1.2. For the purpose of fast prototyping in FI-PPP Phase I, the set of web-service agreements is currently defined using WSDL. However, other (e.g., REST) technologies might be utilized in future releases, as well.

As far as the modelling of environmental data is concerned, both pilots, having the same basis in the EPCIS, can follow the add-on approach. This means extending the standard EPCIS-compatible logistics data, with the environmental data. In this case, the request and response messages are organized as already described in Section 4.1.2. The expert system service operates with part of the overall product data, necessary for the prediction/recommendation calculations.

6 Evaluation

6.1 Evaluation methodology

The Work Package has used a design-oriented methodology to develop the Future Internet based architecture for smart agri-logistics. The design took place in two pilots: the Fresh Fruit and Vegetables (FFV) and the Plants and Flowers (PF) supply chain. These pilots draw on the same technological base that has been described in the D300.2 [5] and in chapter 2 of the present report.

Both pilots have been designed from a user-driven perspective. This means that end-users' needs in logistics activities were identified and user requirements were formulated as central design goals. Recurrent design workshops and repeated end-user evaluations during the entire development process were also undertaken. The process of a user-driven design and evaluation process was conceptualised by a model that was labelled V7 model in D100.2 [24]. The model defines seven steps via which research and design efforts are combined to deliver a gradually maturing design output. These steps portray two types of efforts, i.e., expert-based design tasks and different design and evaluation – oriented interactions with end-users. In the sequence of steps these two types of tasks alternate systematically (see Figure 6-1).

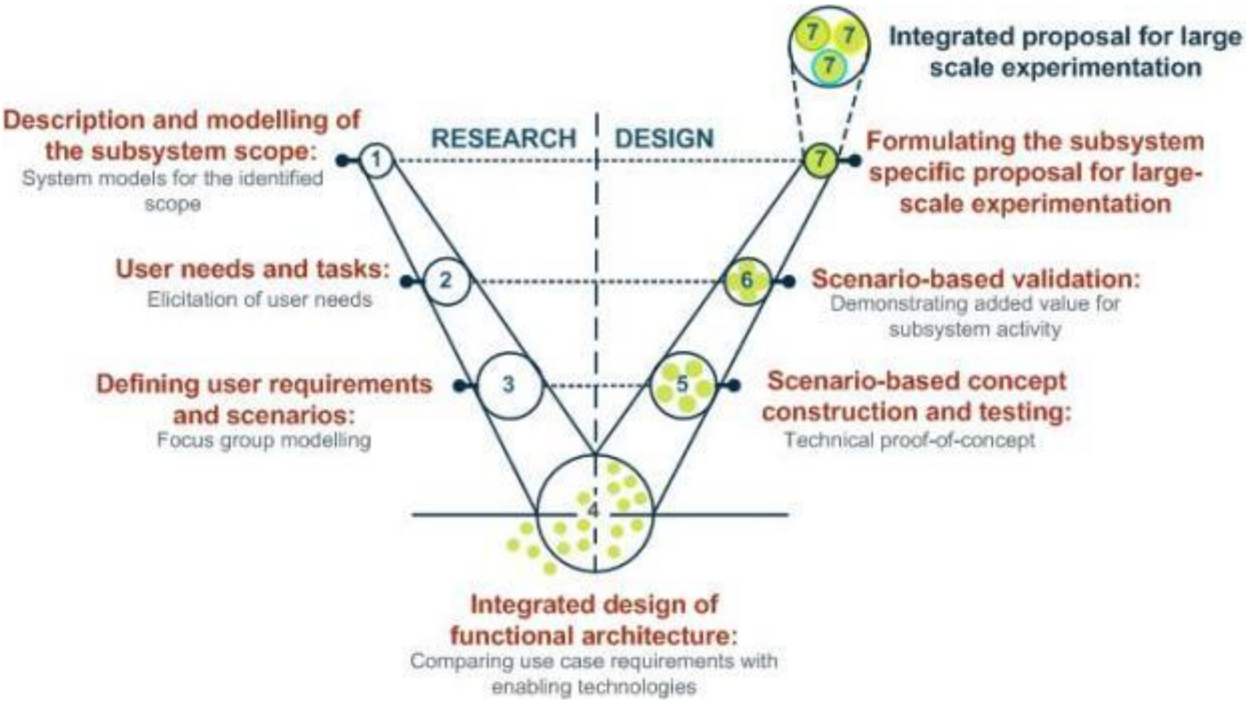


Figure 6-1: The usage-driven design and evaluation model, the V7 model

The deliverable D300.1 and D300.2 have reported the results of step 1, 2 and 3. The previous chapters have presented the integrated design (step 4) and the scenario-based concept construction and testing (pilot architectures). This chapter describes the results of the scenario-based validation, i.e. the evaluation of the developed architectures.

The evaluation was threefold.

First, the functional requirements as defined in D300.2 are verified. This analyses to what extent the requirements are addressed in the design and finally implemented in the conceptual prototypes.

Second, the developed conceptual prototypes are validated technically with respect to:

- The development of new Specific Domain Enablers
- The interoperability between pilot-specific components and GEs
- The FFV and PF pilot management strategies
- The User Accessibility (ease of use, adaptability to diverse user profiles) without losing the support for safe, secure, maintainable, reliable, cost efficient and timely system services.

To make this possible, we will use functional testing (i.e. assessing the functional behaviour of a system under test conditions against the functional requirements) and complement this with white-box techniques (which allow using internal knowledge of the software to guide the selection of test data; this is also known as structural testing).

The tests will be performed in the following order:

- Unit/Component Testing: Unit testing verifies that the separate pieces of software are functioning properly. Depending on the context, these could be the individual subprograms or a larger component made of tightly related units.
- Integration Testing: Integration testing is the process of verifying the interaction between software components.
- System Testing: System testing is concerned with the behaviour of a whole system, the FFV and the PF pilots in this case.

Third, the pilot results are evaluated by the stakeholders of both pilots. This evaluation has focussed on the conceptual and face validity of the designed pilot architectures and the developed prototypes. Conceptual validation evaluates whether the model concepts that have been used correspond to the concepts recognizable in the system that is being studied in reality [25]. In the pilots, this was done by asking key representatives of the involved companies to compare the developed design with their company's situation. Face validation judges whether the design appears to be reasonable to people knowledgeable about the system, for example by confronting experts with the model outcomes and asking them if they are reasonable [26]. In the pilots, this was done by the key representatives of the involved companies.

The stakeholder evaluation was setup systematically based on a structured questionnaire (see Appendix C), which consists of six parts:

1. Stakeholder objectives and requirements: stakeholder diagrams that define their drivers and goals concerning the pilot and the functional requirements for the to-be-developed system;
2. Desired situation and process design: models of the desired situation that define the relevant actors, business processes and information flows;
3. System architecture: the technical design of the solution to be developed;
4. Prototype: demonstration of the developed prototype system;
5. Impact and adoption: questions about the value, impact on the business processes and the expected adoption of the presented solutions.

The remainder of this chapter describes the results of these different evaluations.

6.2 Requirements verification

A crucial part in system validation is the verification of the initial user requirements. Towards this end, in Appendix B we describe to what extent the functional requirements as defined in

D300.2 have been encapsulated in the architecture design and finally implemented in the pilots. Table 6-1 summarises to what extent the defined functional requirements are addressed by design and implemented in the prototypes.

Table 6-1: Number of functional requirements that are addressed by design and implemented in the prototypes

	Addressed by design	**Implemented**
Yes	53	18
Partly	1	14
No	1	23
Total	*55*	*55*

The analysis shows that most functional requirements are addressed in the design. Exceptions are:

- The requirement "Configuration possibilities for a wide range of supply chains (no 'one size fits all')" (# 2) is only partly addressed. Although the pilots include different supply chain configurations, obviously the supply chain variety is still limited because of the focus on specific cases which is inherent to a pilot approach. However, configuration capabilities are considered as essential for scaling-up the pilots to broad implementation.
- The requirement "Calculate the most appropriate routes based on real-time information" (#28) is route optimization is a complicated issue that is concerned with the shipping unit level. As motivated in D300.1 [12], in this Work Package the management of the management of shipments is taken as a constraint because the focus is on agri-logistics specific challenges, which are most apparent beyond the Shipping Unit level. As a consequence we have not elaborated this requirement.

Regarding the implementation it should be noticed that this phase of the FI-PPP programme is concerned with requirements definition and specification. The implemented conceptual prototypes are used to demonstrate key functionalities and consequently the requirements have been implemented only on a limited scale.

6.3 Technical validation

A detailed explanation of the technical validation will be described in the D500.6 [27]. Nevertheless, this section makes a brief explanation in order to provide a complete evaluation in this document.

As previously explained, in the two WP300 pilots have been developed, i.e. the FFV and the PF pilots. Within these pilots different partners with different roles have been involved in their development, as business experts, architecture developers, programmers, etc. These actors have found several aspects during working along the Phase 1 of the FI-PPP, described as follows:

Positive aspects

- The FI-PPP program is very interesting, involving important projects and partners all around Europe, creating a full iteration ecosystem, providing the possibility of developing new partnerships with different partners.
- The Core Platform provides a full set of Generic Enablers, providing a complete bunch of functionalities ready to be used within our developments.
- The FI-WARE webinars and educational sessions have been very helpful to understand the behavior of the GEs.
- The catalogue is very useful, user-friendly and it is very well documented.

Aspects to be improved for Phase 2

- The FI-PPP program is complex, and sometimes is difficult to understand it and to know who is in charge of something.
- Due to the delay in the first release of the GEs, and the unclear information of the available GEs finally implemented during Phase 1, we have had to modify several times our designs to adjust them to the functionalities provided by FI-WARE, provoking delays in our developments.
- The communication between the projects composing the program has been complex, and the interaction between the Use Cases has not been sufficiently promoted
- A better use of the Fusion Forge tool could have been done, mainly improving the ticket threads to dialogue with the GE's owners

6.4 Stakeholders evaluation FFV pilot

The stakeholder evaluation took place at four different occasions with different key stakeholders of the pilot consortium, science (at the International Forum on Food Dynamics 2013 [29]) and food sector specialists where we presented a video with our vision of the pilot and the prototypes. The evaluation followed the questionnaire presented in Appendix C.

6.4.1 Stakeholder Objectives and Requirements

The discussion about the completeness and alignment of the drivers, goals and requirements was very positive. The stakeholders involved in the definition of the pilot participated in the development of the pilot since the beginning of SmartAgriFood. In the discussion with experts from science (a.o. Food Chain Management, Food Logistics, Business Management) the drivers, goals and requirements have been discussed including recent crisis (horse meat and organic eggs). All requirements and services defined in the project possibly gain even more importance than we expected two years ago.

The defined drivers, goals and requirements match the business needs regarding the pilot scope are fully covered by the pilot. The defined business requirements are fully covered by the pilot description. Additionally, the pilot description and pilot scope offer flexibility concerning the identification standards that could be applied for using the pilot prototype. The majority of interview partners stated that the flexibility of using different batch sizes (boxes, pallets, dollies) is one of most important requirement for transfer into real-world business processes.

6.4.2 Desired situation, process design and functionalities

The presented process design for implementing the prototypes into existing business processes was discussed for the different prototypes [5] separately, due to the different viewpoints on the application from business perspective.

The process design for implementing the RTI Traceability Management prototype was aligned with the view of Euro Pool System International, the leading European Pool Company for Reusable Trade Items (RTI). The prototype has already been tested in productive use and the implementation of it in different existing processes:

- In the Depots for capturing the traceability data at the good inward and goods outward,
- In the Asset Management Department for analyzing the captured data,
- In the Logistic Department using an aggregated set of data from the prototype for inventory control

The process design for the Product Information Service has been discussed positively on a theoretical basis. The prototype was presented for the different stages of the PInfS (Product Information Service) process [1] starting from the preparation of a product information service publication down to the capturing of a RTI identification and the provision of product quality information for the product in the RTI. The process design covered all required process steps. However, the used technology (barcodes on single crates) in the pilot has been considered as inefficient in a real-world process, Serial Shipping Codes (SSCC) on pallet level is considered as more realistic. RFID technology would tremendously reduce the effort of RTI scanning and increase the adoption potential, which we proofed by the workshop in the European EPCglobal Competence Center (EECC) [28] in the beginning of January. The presented results from this workshop were discussed very positively, but always with the remark, that it would need sectorial coverage of RFID technology at least for the key stakeholders (Traders and Retailers).

The process design for the exception notification prototype was discussed using the prototype. The process design is complete and aligned with the stakeholder views. Especially, following the current crisis, exception reporting would have an enormous potential to help companies to investigate their supplies and if theses supplies are somehow connected to specific companies dealing with undeclared horsemeat products.

The defined to-be processes for utilizing the prototype are matching the expectations. The current process model defines the access to product information at different steps in the distribution process. Additionally, the access to product information from the quality management department should be possible and should be considered for further development. The quality management department is sometimes at a different place then the distribution.

6.4.3 System architecture

The system architecture was discussed with the stakeholders using a presentation based on a slide set.

The local server was rated as very good concept to extend the existing IT infrastructure of the interviewed stakeholders without large investments. However, for smaller enterprises with less IT infrastructure a cloud-based service could be helpful, especially focusing on farmers. This could also be hosted by traders or retailers to provide their suppliers an additional service. The facilitation of GS1 standards has been rated very positively and has been described as a minimum requirement for success, because the large companies in the sector already use different GS1 standards on a regular basis. The functionality of the User Interfaces was rated clear and understandable.

Every single interview partner stated that they want to manage the access rights for their data on their own. It is not thinkable to leave the data at a neutral party for further distribution. Such solutions failed in the past. The pilot's concept considers these aspects, but has to proof to be feasible for a large number of business contracts. A recommendation from the stakeholders was to have different pre-defined levels of access and the possibility to assign business contacts to these levels.

6.4.4 General questions

The final general questions regarding the potential impact and a potential adoption decision of the presented prototypes was discussed at the end of the evaluation meetings. Both discussions took the most time in the complete evaluation process and delivered interesting insights on the current situation in the sector.

The anticipated value of the different prototypes varied between the stakeholders and science experts. While for the RTI Pool Management Company, the value was already clear thus the prototype has been implemented and actively used in the past month. The solution had a direct impact on the quality of available data, which created a positive change for all involved departments. The extension of the prototype solution, which was only a test of one GE, is currently discussed and further investments will be made in the future.

For the other stakeholders, mostly interested in the topic PInfS and Exception Reporting [1], the adoption decision is strongly dependent on the decision of the involved retail group (note: their largest customer) and on the participation of other companies in the agri-logistics sector. The anticipated change in the way they run their daily business has been rated medium:

- The PInfS has the potential to create extra value for the quality management department by improving data quality on delivered products and satisfy customer information needs,
- The exception notification as such has the potential of establishing a rapid warning system for unsafe products, but the potential is depending on the number of participants, which decreased the rating.

The solution, architecture and the approach in general was rated very positive; however the success of the prototype is depending on the perception in the fresh fruit and vegetable market.

For all directly involved stakeholders, the involvement in the project was a good chance to start thinking about new ways of value creation for their customers and improve data quality and collaboration by sharing product information with chain partners. The pilot as such was a very interesting platform for discussion between stakeholders of different stages, science experts and IT companies. Therefore the participants are looking forward to future discussions and the large-scale experimentation.

6.5 Stakeholders evaluation PF pilot

In the pilot 'Quality Controlled Logistics in the Floricultural Supply Chain' a structured method for the stakeholder evaluation was carried out by combining a physical meeting with an elaborated and structured questionnaire. All involved participants of the pilot supply chain were present (see Figure 6-2).

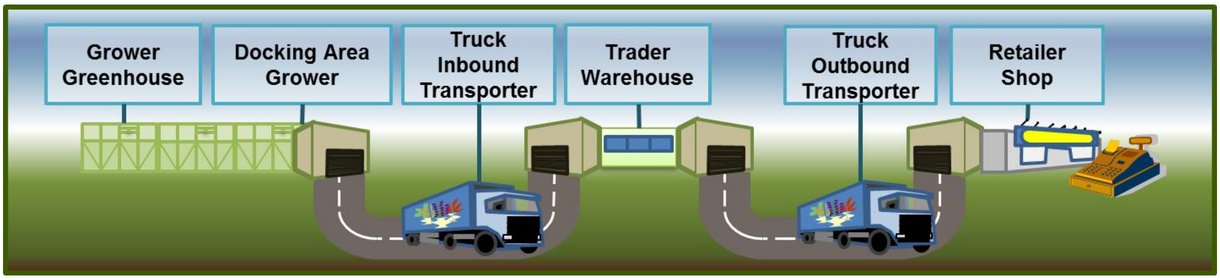


Figure 6-2: The stakeholders from the floricultural supply chain from the pilot.

The involved *trader* is Baas Plantenservice, an innovative Dutch trader that implemented a large-scale tracking system based on the RFID tags that attached to the 3.84 million plant trolleys put into circulation across Europe in 2011. This trader was selected because to the best of our knowledge, Baas Plantenservice was the only company in Europe who is actively taking advantage of this unique RFID infrastructure. The tracking and tracing system of Baas Plantenservice has served as an important basis of the pilot. As a consequence, the trader also served as a pivot in the pilot community building.

The involved *grower* is Van der Salm, an important supplier of Baas Plantenservice, who produces lavender plants mainly in greenhouses.

The involved *transporter* is Speksnijder, an important Logistic Service Provider of Baas Plantenservice, who is specialised in cooled logistics.

Additionally three sector experts were participating in the evaluation:

- A quality expert from FloraHolland, the biggest flower/plants auction in the world, which has a lot of knowledge and expertise in the field of quality monitoring, tracking and tracing and RFID. FloraHolland is a front runner in the implementation and has an important role in many related projects;
- The project manager of 'Together 4 Better', a consortium of traders, growers, auction and logistic service providers that collaborates in the application of eBusiness standards to improve supply chain logistics.
- A standardization expert from Florecom, an active industry association for chain information in the Dutch plants and flowers sector.

The evaluation was carried out by combining a physical meeting with an elaborated and structured questionnaire (see appendix C). In the 4-hours meeting the different pilots components were presented and intensively discussed. After the meeting, all respondents (6 in total) have filled in the detailed questionnaire. In the remainder of this section the evaluation results are presented, component by component.

6.5.1 Stakeholder Objectives and Requirements

On average, the involved stakeholders from the chain tend to respond positively in reply to the question if they agree with the presented drivers, objectives and requirements. They also consider the presented components of the stakeholder analysis to be complete. The most important additional comment to this subject was about the margins in the sector: these are extremely low. Some products are sold by the retail for prices below the cost price, because they function as a customer-pulling sales object. Margins for traders are often lower than 1% and maybe even lower for the logistic services providers. In these days of economic recession many growers have difficulties to survive, with many going bankrupt. Therefore one must keep in mind that the room for investment in innovation is extremely limited in this sector. New inventions only have a chance to be adopted if the business case is undisputedly positive.

Figure 6-3, Figure 6-4, and Figure 6-5 present how recognizable and complete the in the stakeholder diagram identified drivers, objectives, and requirements are, according to the stakeholders.

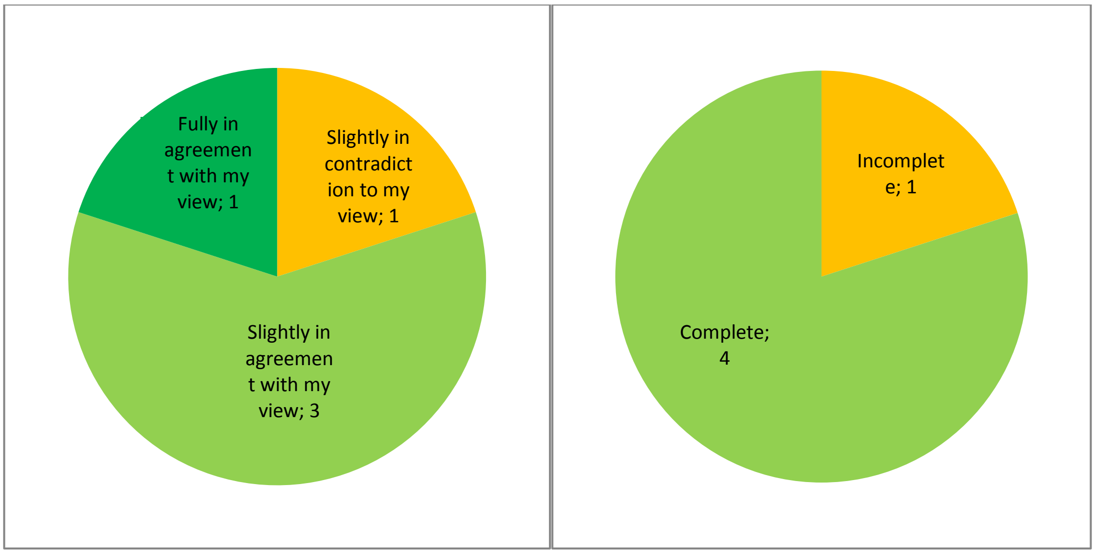


Figure 6-3: The results of the questions that assess how recognisable and complete the defined *drivers* are to the stakeholders.

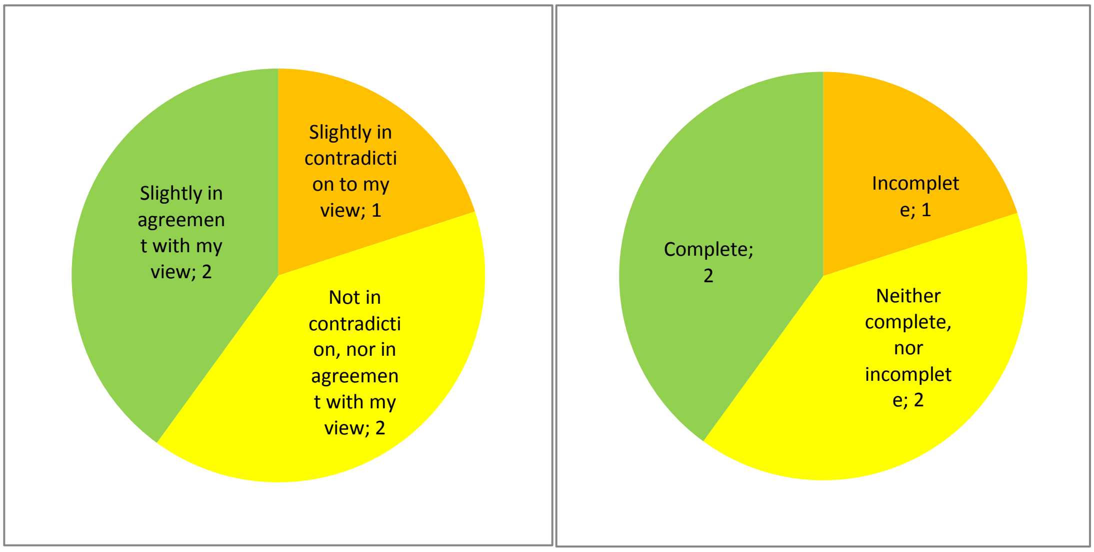


Figure 6-4: The results of the questions that assess how recognisable and complete the defined *objectives* are to the stakeholders.

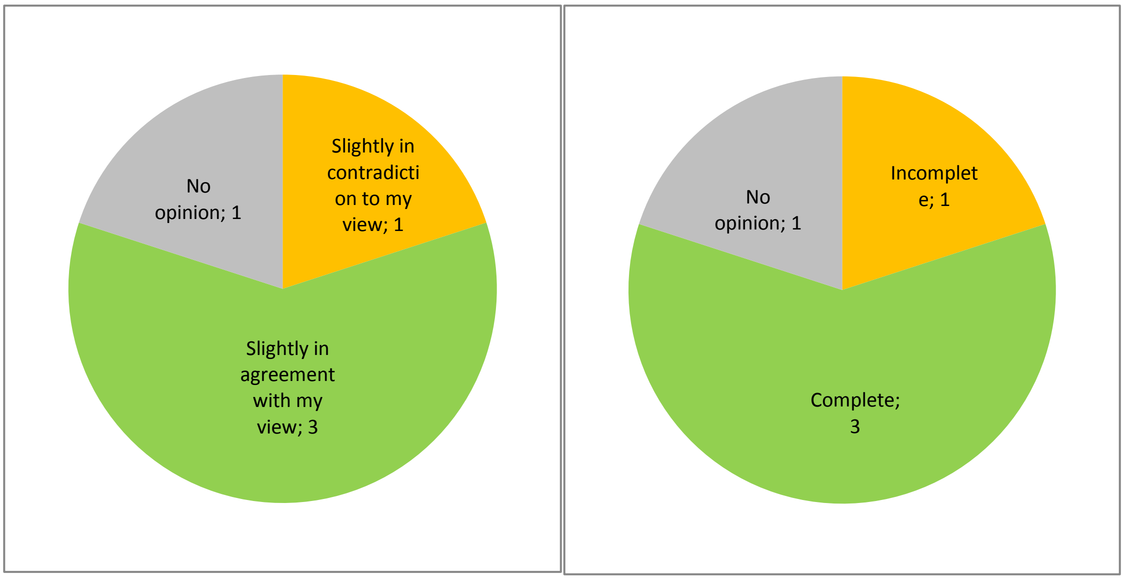


Figure 6-5: The results of the questions that assess how recognisable and complete the presented *requirements* are to the stakeholders.

6.5.2 Desired situation and process design

In general the stakeholders responded positively to the described target situation in terms of agreement. On a more detailed level feedback was provided about the completeness. This mainly impacted the order of business processes and the messages that will be exchanged. The feedback provided has resulted in a reformulation that mainly redesigns the interaction between grower, trader and Quality Control Company.

Figure 6-6 presents how recognizable and complete the in the target process design identified process sequences and information flows are, according to the stakeholders.

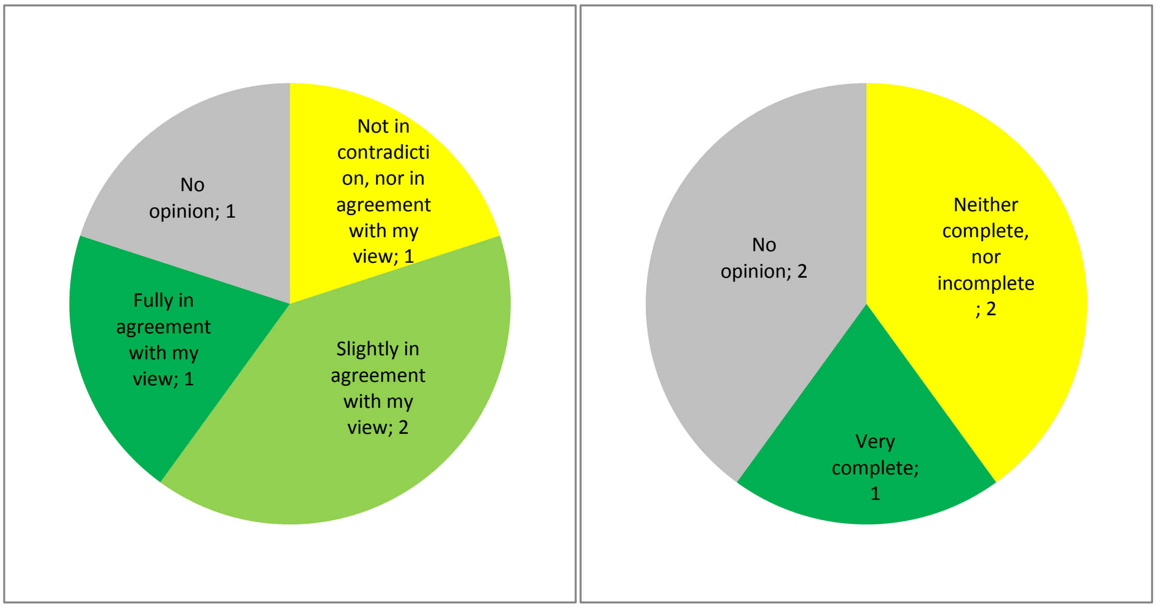


Figure 6-6: The results of the questions that assess how recognisable and complete the description of the target situation and its process design is to the stakeholders.

6.5.3 System architecture

The backgrounds of the audience present during the evaluation were mainly business oriented. Therefore actually evaluating the build-up of the system's architecture may have been too much to ask. Consequently many 'in between' scores were provided on suitability of the design.

Most respondents, however, do seem to trust cloud-based solutions provided that authorisation is covered. They also indicate that a chain wide platform would be a suitable approach. The maintenance via a neutral party, but with authorisation controlled by the data source seems to be a viable future solution which will be further explored in the next phase. However, flexibility should be kept in mind as an important condition to be met, because supply chains in the flori-cultural sector are changing.

The opinions on the quality predicting module are less positive. In Section 5.2 the bottlenecks that stakeholders foresee are further discussed.

In the figures below, the results of the system architecture evaluation are presented. All results reflect the opinions of the stakeholders.

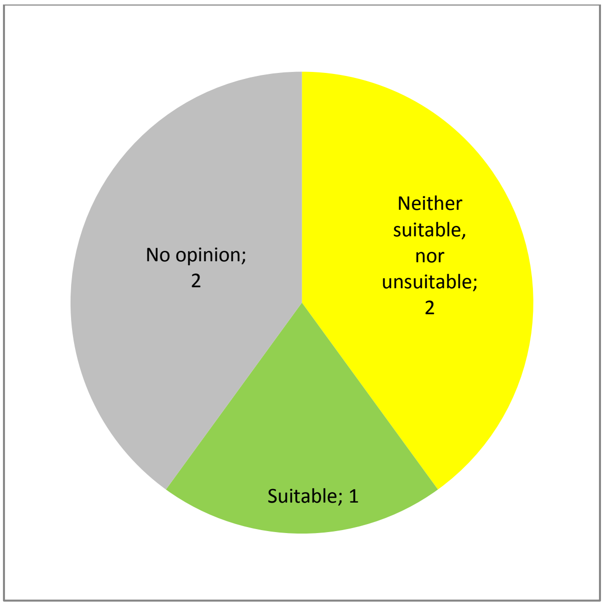


Figure 6-7: The result of the question that assesses the suitability of the described architecture design

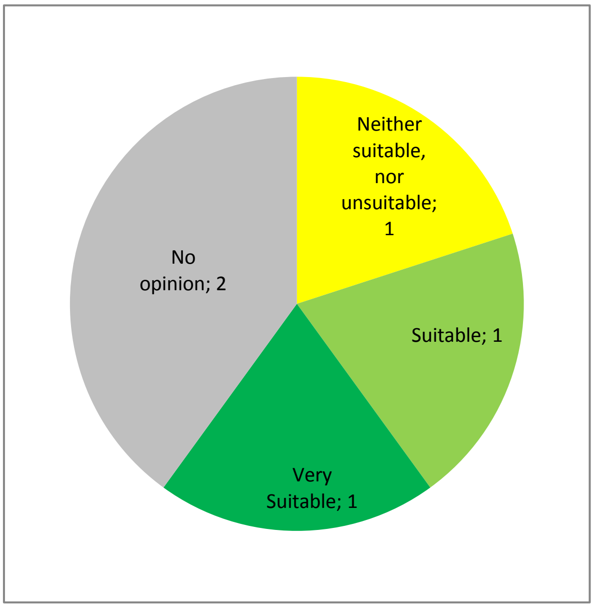


Figure 6-8: The result of the question that assesses the suitability of the functionality that the user interface application provides with (initial quality module, environment condition module and plant quality module)

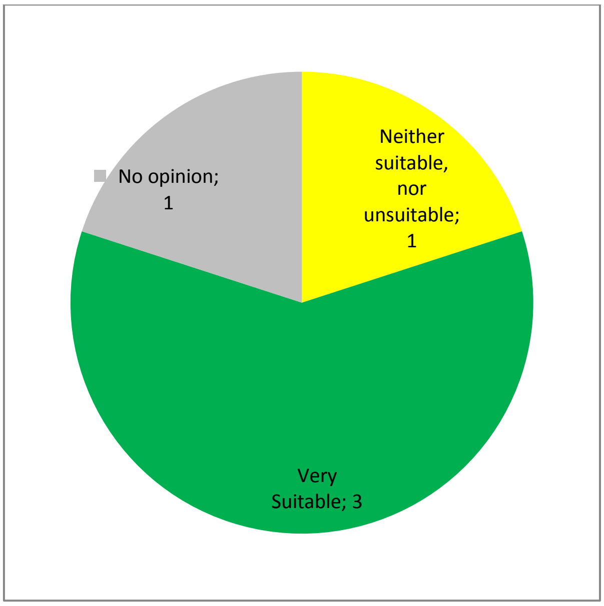


Figure 6-9: The result of the question that assesses the suitability of collecting identification and sensor data via a chain wide event platform

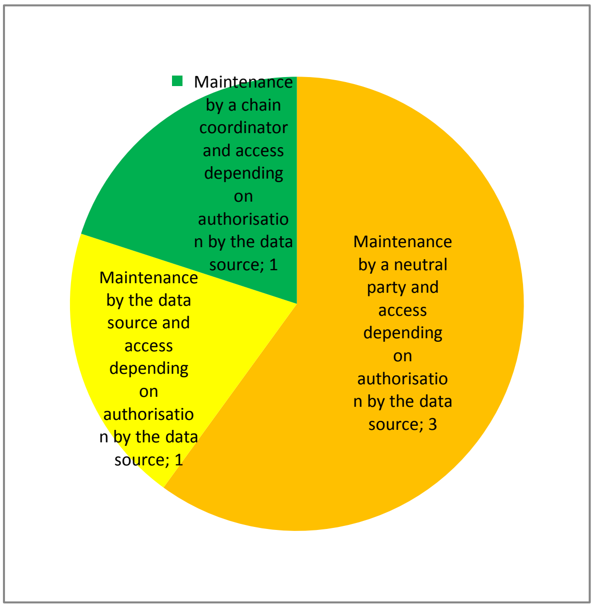


Figure 6-10: The result of the question that assesses the organisation of the data, collected in the event platform

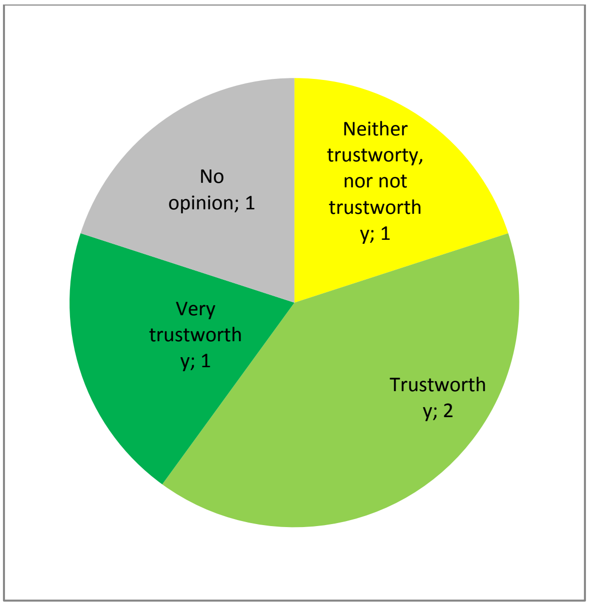


Figure 6-11: The result of the question that assesses the trustworthiness of databases and application that runs “in the cloud”

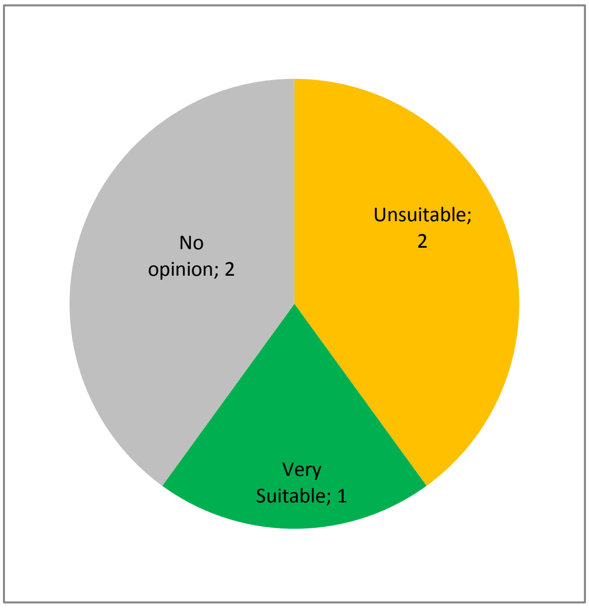


Figure 6-12: The result of the question that assesses the suitability of the quality prediction module.

6.5.4 Demonstrative software

The overall response to the demonstrated software was positive and enthusiastic. The audience indicated that they agreed with the design of the screens and that the current design is comprehensible. Some minor comments were provided on location of information and frames, but in general the audience found the presented information useful. One stakeholder literally said “this exactly corresponds with what I had in mind myself but did not manage to put on paper”.

The first component ‘product orders’ seemed to be a bit unclear. One major comment was provided. It had to do with the enormous quantities of plants that go through the chain in relatively short lead times. Consequently, showing all scanned items would result in loss of overview. A suggestion was provided to group the plants in a smart way to concise the list. Also a suggestion was given to only show the items that in some way were confronted with violations of the norms.

The stakeholders indicated that the items that have no problems need no attention and therefore need not to be shown.

Component two and three (”Item Location” and “Location Environmental Conditions”) seemed to be sufficiently in line with the expectations of the stakeholders, but component four (“Representative item photograph” still needs some attention. Because of the limited lead times in the chain, one can hardly speak of supplies at the chain locations. Representative reference pictures of the products are generally considered to be valuable here. The grower indicated that it is not the supply information that is interesting to him, but it did trigger him. Currently the grower has contracts with the trader about season specific purchase obligations. The grower would like to be provided about the insights in the contractual agreements and the actual delivered plants. In the next phase of the project this frame may be filled in differently for each stakeholder group.

The fifth component “Item History Environmental Conditions” was positively reviewed, but the last component about the quality prediction of the plant’s quality decay led to discussions. This has several causes.

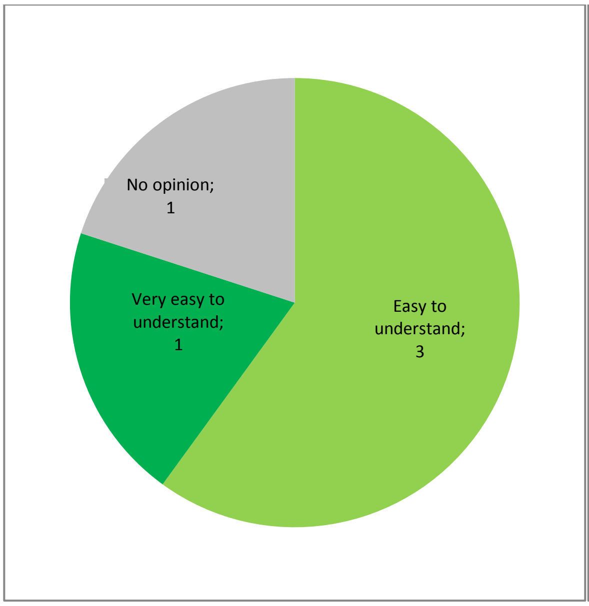
Firstly, the algorithm used to predict the quality decay was developed for cut roses. In this software it serves its demonstrative function well, but the stakeholders have their doubts on the development of enough and matching algorithms that cover their entire product portfolio.

Secondly, the number of variables that influence plant quality makes the functioning of a quality prediction module very complex. The stakeholders have their doubts if decay algorithms that are developed under controlled research conditions will also work in practice. Some variables that are essential for plant quality cannot be measured in reality.

An extensive discussion was held on this subject. Several suggestions for future development and improvement of the quality decay module were presented. The quality expert of the auction suggested to focus less on the predicting of quality since that would be too complex, and focus more on involvement of the quality control and certification companies. Also the option was discussed to make the system self-learning, which means that it would gather all date on plant conditions and properties that are collected in the chain (this may increase over time) and feed it to a to-be-designed module that is capable of correlating this data to quality scores. In that way a pragmatic system is developed that will improve over time. For the next phase an extensive exploration of the available options and combinations of options to improve this module should be made.

In general there should be more emphasis on the alerts. Stakeholders are interested to be informed when norms are violated and to be informed about possible interventions. This is in line with the ideas of the development team that is already looking at incorporating alert information in the next release. It is however a subject that should be explored further, also in the next phase of the pilot.

In the figures below, the results of the demonstration software evaluation are presented. All results reflect the opinions of the stakeholders.



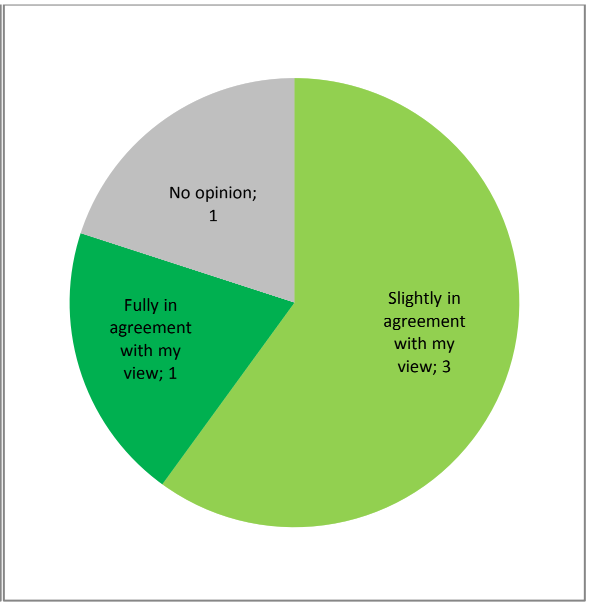


Figure 6-13: The result of the question that assesses the design of the demonstration software

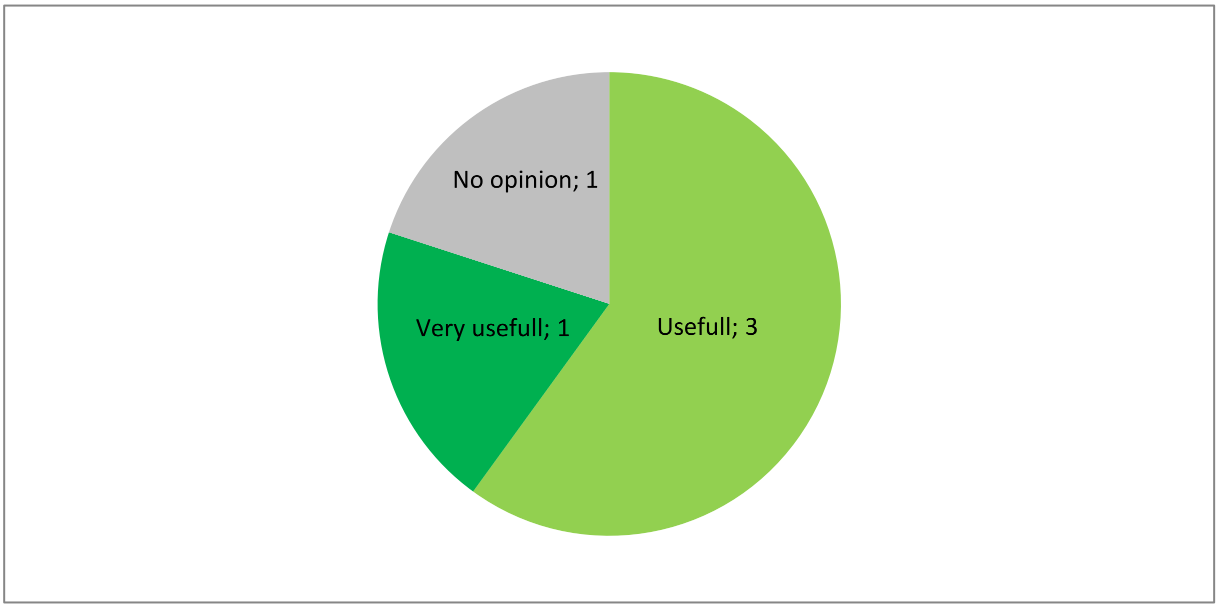


Figure 6-14: The result of the question that assesses the usefulness of the information that is presented in the proposed system

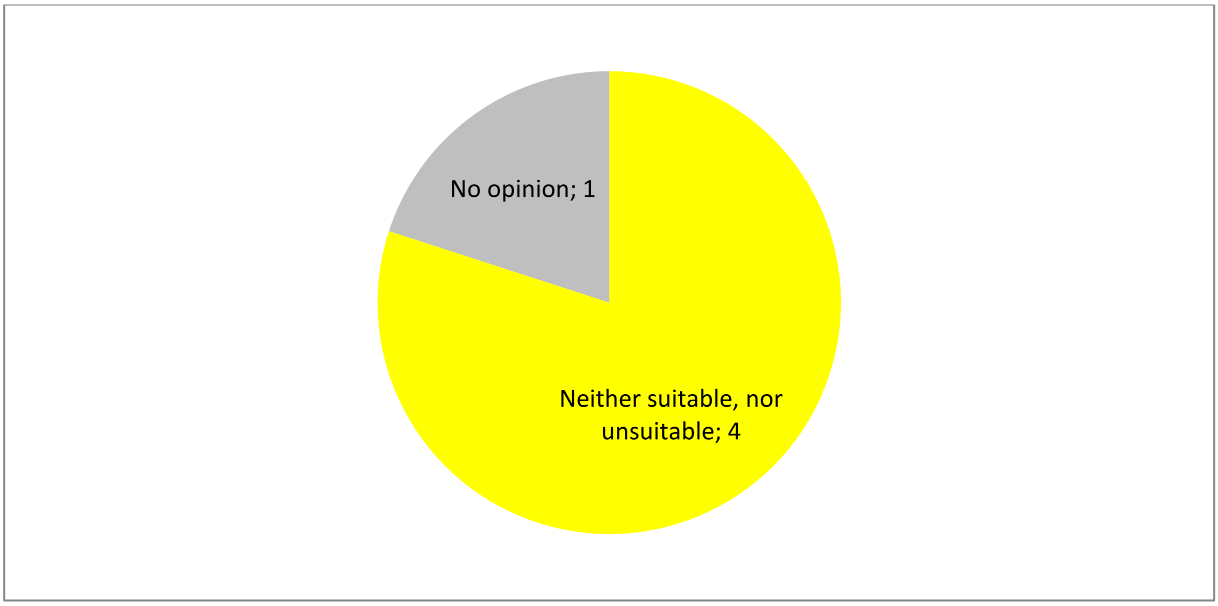


Figure 6-15: The result of the question that assesses the suitability of Component '1. Finding and Selecting Items'

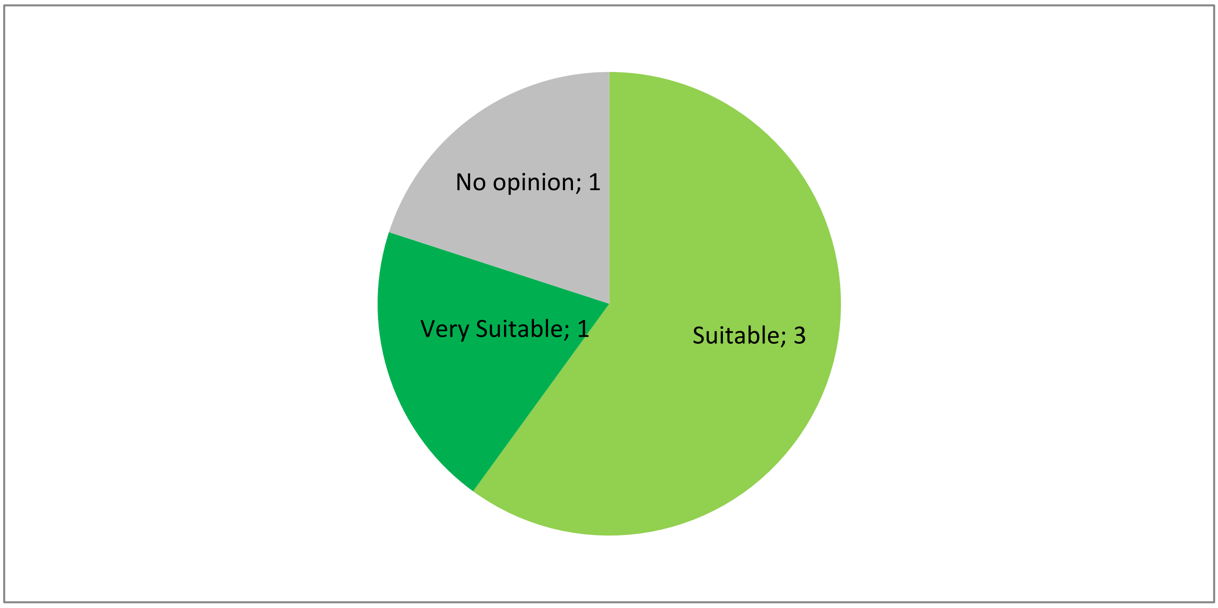


Figure 6-16: The result of the question that assesses the suitability of Component '2. Item Location"

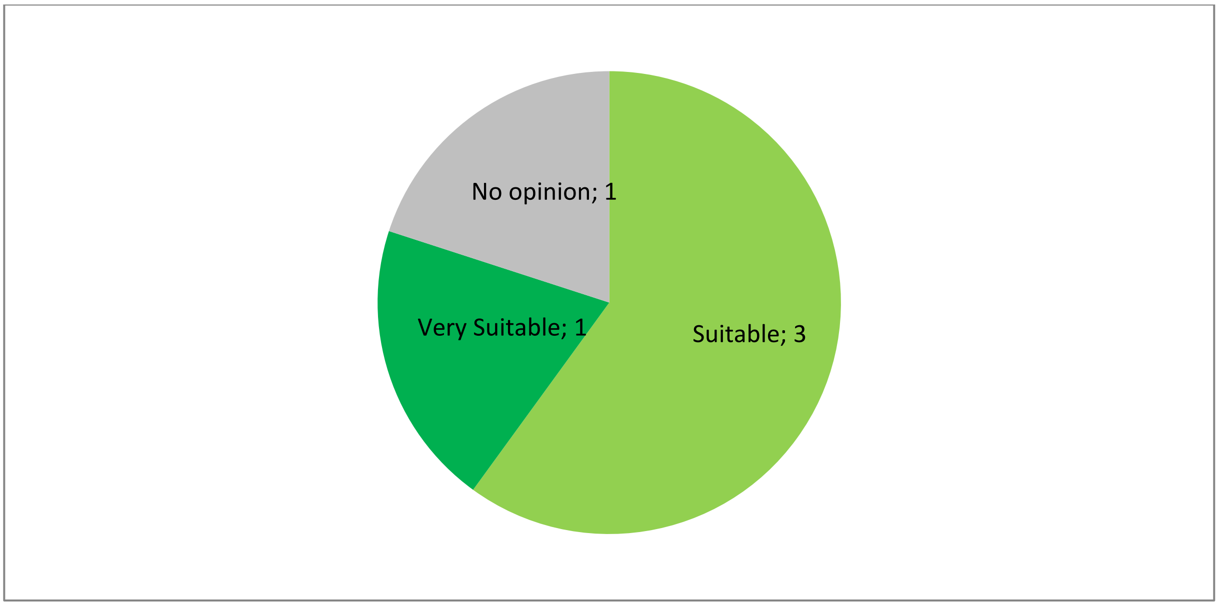


Figure 6-17: The result of the question that assesses the suitability of Component '3. Location Environmental Conditions'

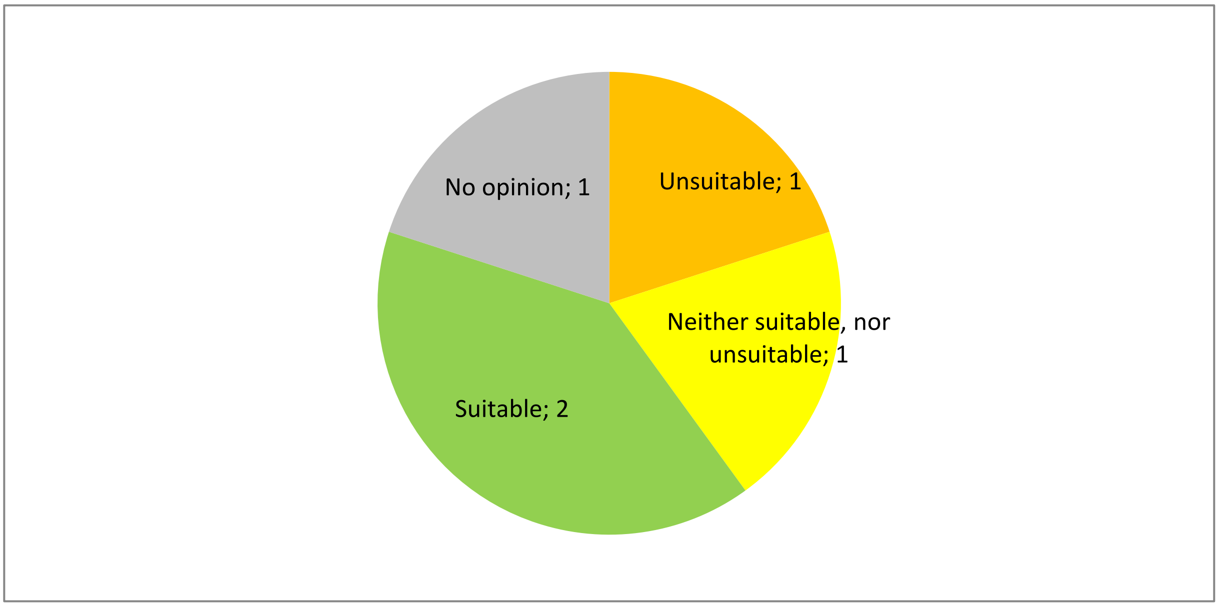


Figure 6-18: The result of the question that assesses the suitability of Component '4. Representative Item Photograph'

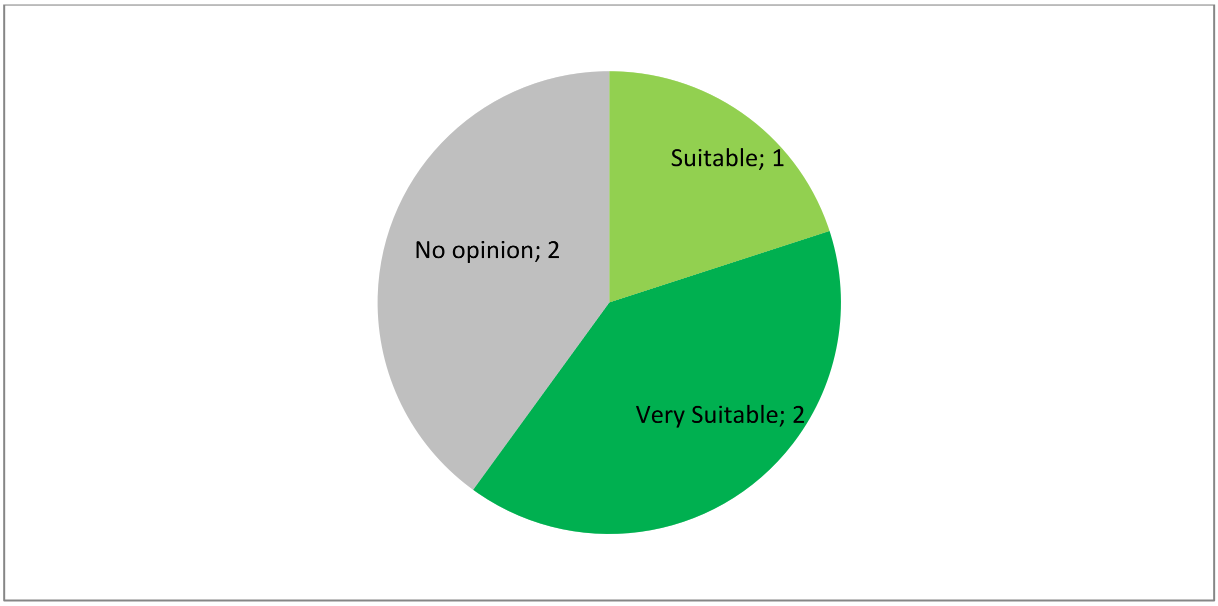


Figure 6-19: The result of the question that assesses the suitability of Component ‘5. Item History Environmental Conditions’

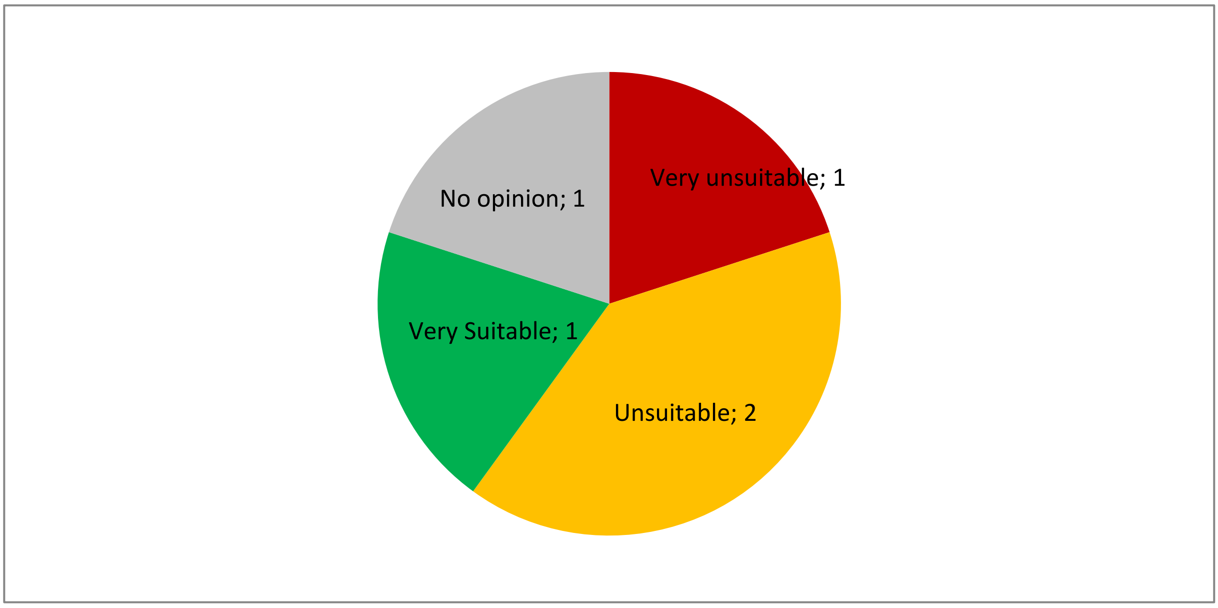


Figure 6-20: The result of the question that assesses the suitability of Component ‘6. Prediction Quality Decay’

In sum, overall the prototype was evaluated very positively, but several components were considered to be not yet very suitable, i.e. concerning Finding and Selecting Items, Representative Item Photograph and in particular Prediction Quality Decay. The respondents understand that this is explainable in this phase of the programme and suggest improving these components in the future.

6.5.5 Impact and adoption

The involved parties all find the pilot project very interesting and like to continue or even increase their involvement in the pilot during the next phase. They all agree that a supply chain system as described in the pilot will lead to much more insight in what happens in the chain. However, proper implementation will require a different way of working. Changing the processes and altering the way of working in the chain requires a lot of effort. This will probably not happen on the short term. However, on the long term the chain members foresee that this is the way to go.

In the figures below, the results of the demonstration software evaluation are presented. All results reflect the opinions of the stakeholders.

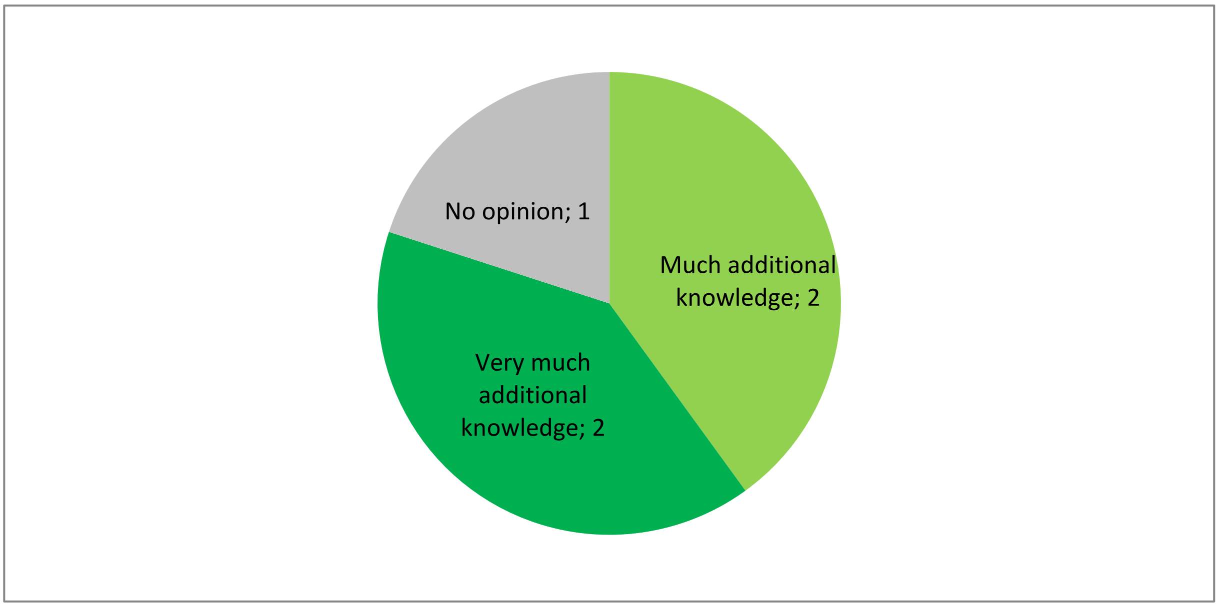


Figure 6-21: The result of the question that assesses the addition of knowledge to the sector by the in the pilot proposed solutions

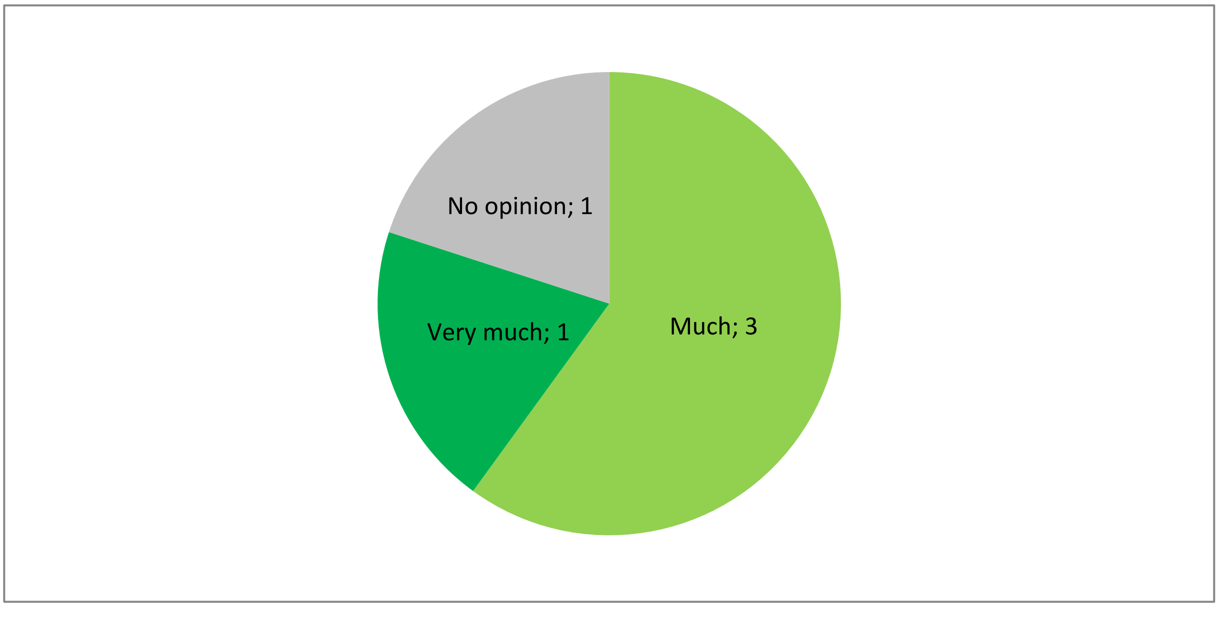


Figure 6-22: The result of the question that assesses the impact on the current way of working when in the supply chains of the stakeholders organisations, the proposed solutions were to be implemented

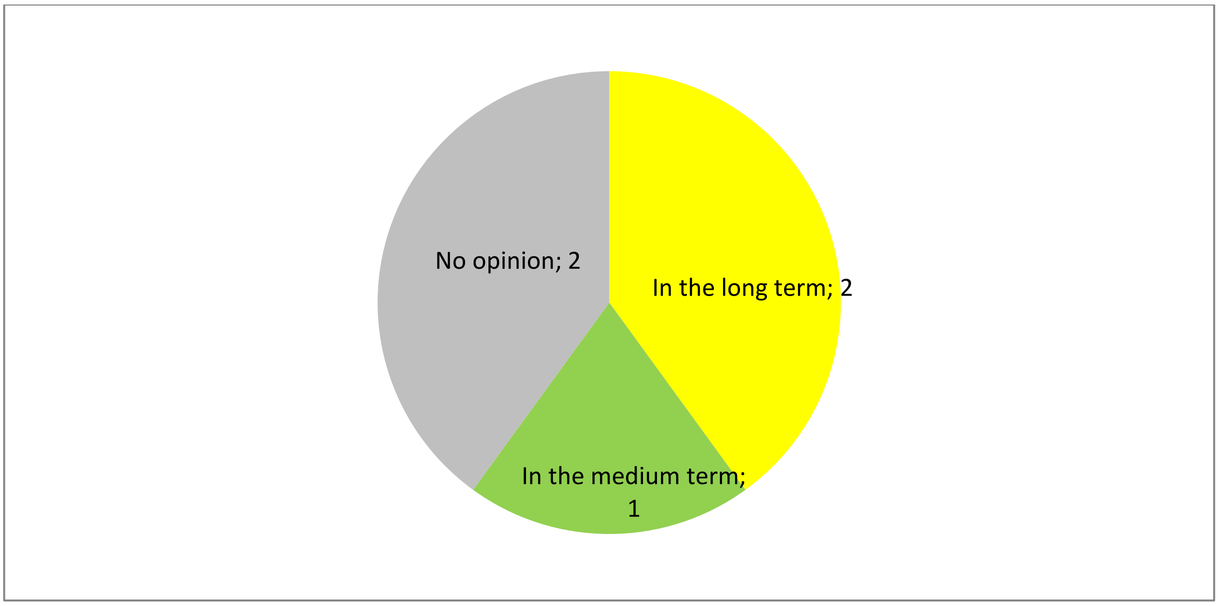


Figure 6-23: The result of the question that assesses if stakeholders are planning to start using a system as was proposed in the evaluation

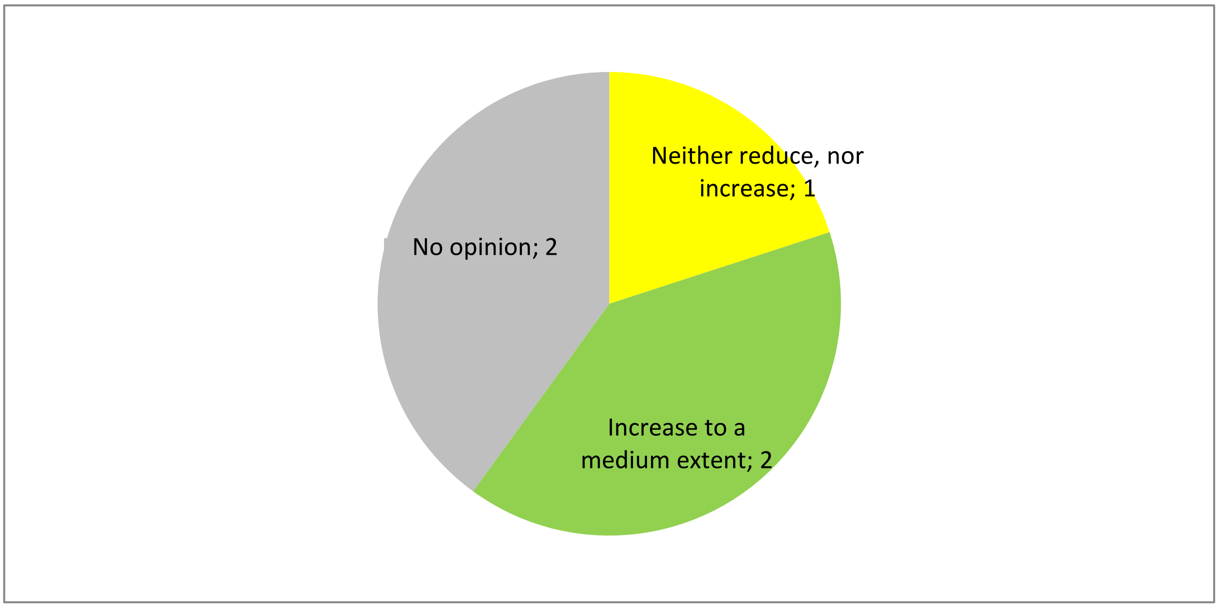


Figure 6-24: The result of the question that assesses the intentions of the stakeholders regarding their future involvement in this project

7 Conclusion and next steps

The main objective of this document was twofold:

1. To present the final architectural specifications the system that have been designed for Agri-Logistics;
2. To evaluate the extent to what the architecture and prototypes meet the previously defined requirements.

This chapter summarizes how these objectives are achieved and discusses next steps.

7.1 Architectural specifications of the Smart-Logistics Sub-system

The architectural specification started with an overall architecture for Smart Agri-Logistics that serves as a common base for the detailed architectures of both pilots that are conducted in two specific sectors, i.e. the Fresh Fruit and Vegetables (FFV) industry and the Plants and Flowers (PF) industry.

Both pilots have defined different challenges in the logistics scope, and therefore, developed different solutions independent from each other. Nevertheless, common and generic features of such architecture can be combined and merged to achieve several synergy effects as well as to present both pilots as one final solution, based on the external connectivity, a web service layer and the management of the data and the request to the system.

Based on this overall architecture, the pilots focus on complementary issues that i) on the one hand are considered to be a major business challenge in the sector and that ii) on the other hand are challenging from an information technology perspective.

The FFV pilot concentrates on the topics transparency and information exchange between agri-logistics enterprises which includes the management, tracking and tracing of the product and returnable packaging in order to enable the provision of product quality information from actors to actors in a supply network. It is based on a dual approach concentrating on the “management of product & information carrier” and the “provision of product quality information”. Both use cases are elaborated with European-wide acting business partners from the sector. Domain specific enablers (DSEs) and generic enablers (GEs) are used in the pilot for prototype development. The main DSEs are a web service layer, to feed the user Interface (UI) and to communicate with the user; an external connectivity module, to connect with external system; a data management service, which provides an abstraction layer to handle different kind of data; and an exception propagation module, improving the reaction time and quality on possible harmful food problems. The GEs integrated in the application are the CEP (Complex Event Processing) and the Identity Management. Other GEs are envisaged to be used during Phase II.

The PF pilot analyses and demonstrates the possibilities of Future Internet technologies for dynamic Quality Controlled Logistics in floricultural supply chains. In this approach, logistic processes throughout the supply chain are continuously monitored, planned and optimised based on real-time in-formation of the relevant quality parameters (such as temperature, humidity, light, water). The pilot leverages the currently implemented logistic tracking system, which is based on the ultrahigh-frequency RFID tags that are attached to the complete pool of plant trolleys. The pilot has developed several domain specific enablers (DSEs) to realise the prototype. The main DSEs are an Event Platform, in which the scanning events are stored and processed; an Expert System that predicts the quality decay of products related to the events in the platform; and a Cloud Dashboard, which is the User Interface and the related web services that integrates the event platform and the expert system. The pilot is currently working on the integration of the

Complex Event Processing (CEP) generic enabler (GE) in the prototype. Furthermore, the pilot exploits Fosstrak, the open source RFID platform [8] that implements the GS1 EPC Network specifications, which is suggested by FI-WARE [3], but it is not present in the catalogue at the moment of writing this deliverable. Other GEs are envisaged to be used during Phase II.

Regarding the needs for standardisation, which are extensively analysed in D300.4 [2], it can be concluded that currently semantic standards are lacking at the document level that apply across the full range of business functions in agri-logistics. Most are too specific in terms of functionality to be applied in other business functions or are at best an ill fit. On the higher levels (organizational and legal) hardly any standards are found that can be applied. At this moment it is not feasible to strive for interoperability across the chain enforced by standards on these layers, due to the lack of availability of such standards. On other levels (vocabulary, identification and syntax) we find ample proof of standards that apply across a broad range of business functions.

7.2 Evaluation results

First, the validation started with an overall analysis of the extent to what the specific challenges on logistics in the food and agribusiness domain as defined in D300.2 [5] are addressed in the overall design. This analysis shows that the defined agri-logistics specific challenges are well addressed. Next, both pilots have described the implementation of the functional modules that were defined previously, in particular in D300.2 [5]. The document also included an introduction of the overall technical validation, which will be reported in the D500.6 [27].

Second, the requirements verification has analysed to what extent the functional requirements as defined in D300.2 [5] have been encapsulated in the architecture design and finally implemented in the pilots. Table 6-1 summarises to what extent the defined functional requirements are addressed by design and implemented in the prototypes. The analysis shows that most functional requirements are addressed in the design (96%). Next, it is concluded that 33% of the functional requirements is implemented, 25% is partly implemented and 42% is not implemented. The reason is that the implemented conceptual prototypes are used to demonstrate key functionalities and consequently the requirements have been implemented only on a limited scale.

Third, the pilot results are evaluated by the stakeholders of both pilots. This evaluation has focussed on the conceptual and face validity of the designed pilot architectures and the developed prototypes. The stakeholder evaluation was setup systematically based on a structured questionnaire (see Appendix C), which comprises six parts: 1.) stakeholder objectives and requirements, 2) desired situation and process design, 3) system architecture, 4) prototype demonstration and 5) Impact and adoption.

In both pilots the stakeholders are very committed and evaluated the results positively. More specifically, below some specific remarks are summarized.

Some highlights of the stakeholders' feedback in the PF pilot:

- The overall response to the demonstrated software was positive and enthusiastic; one stakeholder literally said "this exactly corresponds with what I had in mind myself but did not manage to put on paper";
- Several components were considered to be not yet very suitable, i.e. concerning Finding and Selecting Items, Representative Item Photograph and in particular Prediction Quality Decay. The respondents understand that this is explainable in this phase of the program and suggest to improve these components in the future.
- The expert system for quality prediction should be improved to make it suitable for practical usage e.g. by making the system self-learning;

- Most respondents do seem to trust cloud-based solutions provided that authorization is covered. They also indicate that a chain wide platform would be suitable approach;
- The involved parties all find the pilot project very interesting and like to continue or even increase their involvement in the pilot during the Phase 2 of the FI-PPP.

The FFV evaluation showed very positive tendencies from the key stakeholders, especially from partners in retail (EDEKA), trade organizations (Landgard, Pfalzmarkt) and RTI Pool Management. Euro Pool System tested the RTI management part of the prototype in their operative business environment which advanced towards the scope of phase 2 already.

However, two issues resulting from the evaluation discussions (which are not related to technical issues) relevant for the large-scale implementation remain unsolved at this point of the project:

- Payment and trade mechanisms of product- and process-related information in an environment, where large-scale companies are dominant in the market, and
- Rules for further usage of information provided by the Product Information Service.

These two issues have to be solved with a Code of Conduct-kind way, which has to be developed by the involved stakeholders in the sector. Such a compromising solution has to be supported by the project with ideas and functionalities which enable its implementation.

The results from the Pilot in Phase 1 were promising in different ways:

- Key stakeholders are discussing about information exchange and possible applications for future collaboration (already a discussion towards Phase 3 developed in the past month);
- The prototypes have been evaluated positively ;
- The most important point however is, that key stakeholders from different stages use the project as platform to discuss about the previously summarized organizational issues in a joined way, which is a major step into the direction of large-scale implementation;
- The flexibility of using different batch sizes (boxes, pallets, dollies) is one of most important requirement for successful implementation;
- RFID technology would tremendously reduce the effort of RTI scanning and increase the adoption potential, but it requires sectorial coverage of RFID technology;
- Exception reporting would have an enormous potential to help companies to investigate their supplies in case of food crises;
- The local server was rated as very good concept to extend the existing IT infrastructure of the interviewed stakeholders without large investments; however, for smaller enterprises with less IT infrastructure a cloud-based service could be helpful, especially focusing on farmers;
- The stakeholders want to manage the access rights for their data on their own; it is not thinkable to leave the data at a neutral party for further distribution.

7.3 Next steps

Both pilots will continue in the second phase of the FI-PPP programme as part of the cSpace project. For a detailed implementation planning we refer to D600.4 [30].

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9 Appendix A - Contribution to agri-logistics specific logistic challenges

Table 9-1: Comparison between functionalities defined in D300.1 and the ones address in the specification of the pilots

Key agri-logistics specific characteristics	Impact on Smart Agri-Logistics	Contribution of the designed architecture to these sector challenges
Agricultural production is depending on natural conditions, such as climate (day length and temperature), soil, pests and diseases and weather. This results in unpredictable variations in quality and quantity of supply (unpredictable yields in primary production and uncertain output of food industry processes, e.g. sugar or fat content)	• Flexibility in logistic processes and planning in order to deal with high supply uncertainty • Dynamic supply chains which means that, depending on the state of the product and the market demand, the product at one moment has to be shipped to customer x and another moment to customer y, with different requirements for information communication; • Use up-to-date supply information (supply forecasts, availability) of suppliers to continuously optimise logistics planning and scheduling • Emphasis on Quality Management Systems and Certification to minimize supply uncertainty • Quality variation between different producers, between different lots of produce and within lots • Different markets (for different qualities) have to be taken into account	• The architecture is designed in such a way that intermediates can have continuous insight in current and expected supply of produce from growers and planned and actual demand of retail stores. This enables supply chain participants to plan dynamically. • The architecture is designed to enable actors in the chain to continuously monitor the quality of incoming and outgoing products and advanced sensor data can be accessed timely via the internet and peer-to-peer. This enables actors to react on quality and safety issues in a timely manner. • Expert quality assessments and certifications are an essential element of the designed architecture to calibrate and check calculated product quality. • Based on quality events the products can be reallocated to alternative buyers if the quality parameters do no longer match the requirements of the original buyer. • Based on the current state of products in the supply chain, flexible logistic interventions are supported as well as forwarding exception notifications in critical situations (e.g. unsafe products, unexpected product quality) to involved actors is assured. • The feedback of remaining quality and shelf-life of products backwards to growers is supported.
Agri-food products are natural products with a	• Very short order-to-delivery lead-times	• To reduce order-to-delivery lead-time the orders for inbound and outbound

Key agri-logistics specific characteristics	Impact on Smart Agri-Logistics	Contribution of the designed architecture to these sector challenges
high perishability (in particular fresh food)	• Importance of temperature conditioned transportation means and warehouses (cold chains) • Application of specific techniques for packaging, way of loading, etc. to increase shelf life • Flexible logistic planning and scheduling systems enabling last minutes changes and reallocations, but also provide a robust multi-modal planning; • Back orders occur only incidentally • Traceability info must include also best-before-date / Production Date, Production Location and Country of Origin • Logistics planning systems must be based on forecasted/calculated best-before-dates • First Expire First Out (FEFO) replenishment • Much pre- and re-packing and postponement of labelling	transport are sent before the products are picked. • Temperature conditions are monitored throughout the supply chain. • Exception notifications are generated in case of actual or expected incidents that decrease shelf life. • Planning is done according to anticipated demand/supply developments, but the scheduling is carried out according to the latest information updates.
Seasonal growing: primary production is often limited to a specific period, dependent on the climate, weather conditions and variety. This results in an unpredictable supply of produce in a short period of time.	• Logistics has to implement specific methods and systems to ensure year-round availability, especially: • Global sourcing: diversification of production locations, in different climates and weather conditions, spread the risk for pests • Techniques for long-term storage *e.g.* fresh food in controlled atmosphere storage (ULO) and storage of processed food in frozen form • Possibility to use different varieties with slightly different characteristics (weight, colour) for the same (fresh) agri-food product. For example: there are many varieties of red roses, but they are all sold as red roses, the same holds true for agricultural	• The design of the architecture enables that the information can be shared irrespective of specific locations. • In the designed architecture the flexibility to use different varieties with similar properties is supported. In this way intermediaries have more flexibility to match supply and demand than when having to find specific varieties on order of the retailer.

Key agri-logistics specific characteristics	Impact on Smart Agri-Logistics	Contribution of the designed architecture to these sector challenges
	products with different production schemes (organic apple vs. conventional produced apple)	
High demands from consumers and society, including food safety legislation and quality standards (food is something that is directly affecting the human body)	• Ability to trace the production data of agri-food products in transit (batches or single products) including environmental data such use of pesticides or antibiotics • Ability to calculate environmental impact e.g. ecological foodprints • Emphasis on environmental issues in Quality Management Systems (QMS) and Certification • Labelling products with quality and ecological certificates	• The availability of advanced product information including certification information throughout the supply chain is an important part of the designed architecture. • Functionalities for product logo recognition are addressed. • In the designed architecture the information of the current and expected quality of the product is available to the consumer.
High volume distribution combined with frequent delivery and increasingly fine-mesh distribution	• Combining speed, efficiency and customisation • Importance robust and real-time planning and control systems • High volume distribution causing a high impact on (global) transportation	• In the designed architecture all relevant objects are uniquely identified using standards. Furthermore, the control systems are highly automated, particularly with UHF RFID technology, which reduces human errors. This is presumed to be more robust that manual control measures.
High flow complexities, in particular: - Sequential continuous (bulk, volumes/weight) and discrete (countable) product flows - Alternating diverging and converging processes and by-products	• High tracking and tracing complexities, such as: lots of bulk products downstream have to be linked with packaged products upstream; many composite products, contamination, waste and by-products • Highly interdependent product flows, e.g. by-products of one end product are input of other food products • High planning and scheduling complexities, in particular in situations where the discrete production part is customer specific (as is often the case in the packaging stage)	• The facilitation of EPCglobal standards in the architecture enable to use different identification technologies as well as aggregation and disaggregation events to handle different traceability schemes in the sector.
Important role of import/export, including phytosanitary and	• Additional inspections, resulting among others in longer lead-times • Country-specific trade and phyto-	• Not in scope of the Smart Logistics Prototypes

Key agri-logistics specific characteristics	Impact on Smart Agri-Logistics	Contribution of the designed architecture to these sector challenges
veterinary inspections	sanitary/veterinary requirements, resulting in different information needs • Need for separated quarantine storage	
Complex network structure where small and medium enterprises (farms and parts of the processing industry) trade with huge multinationals in the input and retail sector.	• Importance of collection and regional orchestration in logistic mainports • Importance of proper allocation mechanisms to connect aggregated demand with fragmented supply (in particular of raw materials). • Much horizontal supply cooperation of SMEs to achieve the appropriate countervailing power in respect to their big customers or suppliers • SMEs often lack the resources of money, technical expertise and management skills to develop and implement the required advanced and integrated systems required in Agri-Logistics	• The architecture allow for decentralised approaches, which supports a high variety and variability of supply chain networks. • The designed architecture assigns a supply chain coordinative role to the trader in order to match the multinational demand of a big retailer with the fragmented supply of many different growers of flowers and plants. • The architecture enables all agri-logistics companies independent from their size to participate. • The approach includes cloud-based solutions to ensure participation of SMEs without sophisticated IT infrastructures. • The use of Generic Enablers support a rapid development of customized solutions at minimal costs

10 Appendix B - Requirements Verification Matrix

A crucial part in system validation is the verification of the initial user requirements. Towards this end, in this appendix we describe to what extent the requirements as defined in D300.2 [5] have been encapsulated in the architecture design and finally implemented in the pilots. Regarding the implementation it should be noticed that this phase of the FI-PPP programme is concerned with requirements definition. The implemented conceptual prototypes are used to demonstrate key functionalities and consequently the requirements have been implemented only on a limited scale.

Table 10-1: Comparison between functionalities defined in D300.2 and the ones address in the implementation of the pilots

#	Functional requirement	Addressed by design	Implemented
1	The profile information of (agri-logistic) objects must be online accessible via the internet.	YES	YES (PARTLY)

#	Functional requirement	Addressed by design	Implemented
2	Configuration possibilities for a wide range of supply chains (no 'one size fits all').	PARTLY	NO
3	Administration of replacement policies, responsibilities, escalation mechanisms.	YES	NO
4	It should be possible to authenticate objects/actors and to authorise them for specific tasks.	YES	YES
5	It should be possible to add and/or revoke access rights automatically.	YES	NO
6	Display of the available/executable options for SCEM.	YES	NO
8	Search capabilities to find companies certified by the relevant standards.	YES	NO
9	Update possibilities for certification information.	YES	NO
11	Advanced sensor capabilities, e.g. ripeness, temperature, humidity should be in place.	YES	NO
12	It should be possible to access advanced sensor data on-line via the internet.	YES	YES (BASED ON SIMULATED EVENTS)
13	It should be possible to communicate quality alerts about products in transit online via the internet.	YES	YES
14	Simulate action alternatives (if-then) for supply chain events.	YES	NO
15	Simulate the impact of supply chain incidents.	YES	NO
16	It should be possible to monitor quality of products during transport and conditions during loading, transport and unloading.	YES	YES (BASED ON SIMULATED EVENTS)
17	It should be possible to notify, simulate, and control the decline in quality of products during transport and storage.	YES	YES (PARTLY)
18	A selection of the information about agri-logistic objects must be stored and updated in the cloud for planning and scheduling purposes.	YES	YES (PARTLY)
19	It must be possible to timely access to intra- and inter-company information systems in order to obtain reliable planning data.	YES	NO
20	Appropriate management information should be available.	YES	NO
21	Necessary data input for order forecast.	YES	NO
22	Control the load (e.g. pallets) that leaves the warehouse towards the different retail stores.	YES	YES (PARTLY)
23	Agri-logistic objects must be unique identifiable on different levels of aggregation (in particular batches, containers and products).	YES	YES (PARTLY)
24	Agri-logistic objects must generate a unique identifiable and reliable profile, i.e. a virtual representation of the object including location and state information.	YES	YES
25	Real-time updating of agri-logistic object profiles.	YES	YES (BASED ON SIMULATED EVENTS)
26	It should be possible to identify products, containers etc. automatically.	YES	YES (PARTLY)
27	A standardized classification of products and attributes (including quality classes) should be available.	YES	NO
28	Calculate the most appropriate routes based on real-time information.	NO	NO

#	Functional requirement	Addressed by design	Implemented
29	Forecasting the order and delivery of fresh products from/to the retail store.	YES	NO
30	Agri-logistics security systems should allow for trusted human interventions.	YES	YES
31	Logistic objects should allow for decentralised generation of trusted relationships.	YES	YES
32	Readable RFID chips from logistic assets (e.g. pallets, trolleys, boxes)	YES	YES (PARTLY)
33	The user interfaces of mobile logistic devices should be OS or platform-independent.	YES	YES
34	Provision to consumers of up-to-date certification information via websites and mobile devices.	YES	YES
35	Supply chain monitoring systems must support different communication media/ devices.	YES	YES
36	Local routing of messages must be possible.	YES	YES
39	Notification about detected problems or risks very rapidly to the product owner.	YES	YES
40	Asynchronous communication of exception event/messages must be possible.	YES	YES
41	It should be possible to smoothly connect the logistic information systems of different actors ('pick, plug and play').	YES	NO
42	Allow functionality without an internet connection.	YES	YES (PARTLY)
43	Compensate loss of connectivity in rural areas.	YES	YES (PARTLY)
44	Create/join/leave P2P networks.	YES	YES
45	Safety risk information has to be communicated very rapidly to the involved stakeholders.	YES	YES (PARTLY)
46	It should be possible to forecast the consequences of detected changes by the time the product reaches destination (e.g. best-before date simulation).	YES	YES (PARTLY)
47	Conversion of any GS1 key into a FQDN for querying information via ONS.	YES	YES
48	Create virtual object ID.	YES	YES (PARTLY)
52	Enable storing of knowledge rules.	YES	YES (PARTLY)
54	Enable recording of measurements.	YES	YES (BASED ON SIMULATED DATA)
55	Determine product quality.	YES	YES (PARTLY)
58	Function that stores sensor data in a local (legacy) system.	YES	NO
59	Allow standardization of data.	YES	YES
60	Realise communication between two systems.	YES	NO
61	Compare data.	YES	NO
62	Alarm and adjust relevant actuators	YES	NO
63	Create and send orders.	YES	NO
64	Confirm or reject orders.	YES	NO
65	Broadcast status of a process.	YES	NO

11 Appendix C - Questionnaire Stakeholder Evaluation

This Appendix summarises the questionnaire used for stakeholder evaluation. For each part, first the developed definitions, models, diagrams have been presented followed by a discussion. After a discussion, the stakeholders filled in the questions below. For each question listed below there was asked for comments and additions.

Stakeholder Objectives and Requirements

1. In the context of the pilot, the **drivers** that are defined in the stakeholder diagram:

(in contradiction to my view)	1 – 2 – 3 – 4 – 5	(in agreement with my view)	or 0 (no opinion)

2. In the context of the pilot, the **drivers** described in the diagram are:

(very incomplete)	1 – 2 – 3 – 4 – 5	(very complete)	or 0 (no opinion)

3. In the context of the pilot, the **goals** described in the diagram:

(in contradiction to my view)	1 – 2 – 3 – 4 – 5	(in agreement with my view)	or 0 (no opinion)

4. In the context of the pilot, the **goals** described in the diagram are:

(very incomplete)	1 – 2 – 3 – 4 – 5	(very complete)	or 0 (no opinion)

5. In the context of the pilot, the **requirements** described in the diagram are:

(in contradiction to my view)	1 – 2 – 3 – 4 – 5	(in agreement with my view)	or 0 (no opinion)

6. In the context of the pilot, the **requirements** described in the diagram are:

(very incomplete)	1 – 2 – 3 – 4 – 5	(very complete)	or 0 (no opinion)

Desired situation and process design

1. In the context of the pilot, the **desired** processes in the diagram are:

(in contradiction to my view)	1 – 2 – 3 – 4 – 5	(in agreement with my view)	or 0 (no opinion)

2. In the context of the pilot, the **desired processes** are:

(very incomplete)	1 – 2 – 3 – 4 – 5	(very complete)	or 0 (no opinion)

System architecture

1. In the context of the pilot, the above described **architecture** is:

   (unsuitable) 1 – 2 – 3 – 4 – 5 (very suitable) or 0 (no opinion)

2. The **functionality** that the user interface application provides with (Functional Module 1, Functional Module 2, Functional Module n), is to my opinion:

   (unsuitable) 1 – 2 – 3 – 4 – 5 (very suitable) or 0 (no opinion)

3. Collecting identification and sensor data via a **chain wide event platform**, is to my opinion:

   (unsuitable) 1 – 2 – 3 – 4 – 5 (very suitable) or 0 (no opinion)

4. **The data**, collected in the pilot system has to be organised as follows (circle the most desirable alternative):

- 1 –	- 2 –	- 3 –	- 4 -	- 5 –
Maintenance by a neutral party and access to all chain parties	Maintenance by a neutral party and access depending on authorisation by the data source	Maintenance by the data source and access depending on authorisation by the data source	Maintenance by a chain coordinator and access to all chain parties	Maintenance by a chain coordinator and access depending on authorisation by the data source

5. Databases and application that run **"in the cloud"** are:

   (not trustworthy) 1 – 2 – 3 – 4 – 5 (very trustworthy) or 0 (no opinion)

6. The **quality predicting module** is to my opinion:

   (unsuitable) 1 – 2 – 3 – 4 – 5 (very suitable) or 0 (no opinion)

7. The most important **technical requirements** that have to be met architecturally, are:
   a. ....
   b. ....
   c. ....

Functionalities and access rights

Please indicate in the table below which functionalities have to be accessible to which chain stakeholders.

System functionality	Grower	Inbound LSP[1]	Trader	Outbound LSP[1]	Retail	Quality control company

System functionality	Grower	Inbound LSP[1]	Trader	Outbound LSP[1]	Retail	Quality control company
Functional Module 1						
Functional Module 2						
Functional Module n						

[1] Logistic Service Provider

Software demonstration

1. The in the demonstration software presented **screens** are to my opinion:

   (incomprehensible) 1 – 2 – 3 – 4 – 5 (very easy to understand) of 0 (no opinion)

2. The **design** of the demonstration software is:

   (in contradiction to my view) 1 – 2 – 3 – 4 – 5 (in agreement with my view) or 0 (no opinion)

3. The **information** that is presented in the proposed system is to me:

   (useless) 1 – 2 – 3 – 4 – 5 (very usefull) of 0 (no opinion)

4. Component **'1. Name'** is to my opinion:

   (unsuitable) 1 – 2 – 3 – 4 – 5 (very suitable) or 0 (no opinion)

5. Component **'2. Name'** is to my opinion:

   (unsuitable) 1 – 2 – 3 – 4 – 5 (very suitable) or 0 (no opinion)

6. Component **'n. Name'** is to my opinion:

   (unsuitable) 1 – 2 – 3 – 4 – 5 (very suitable) or 0 (no opinion)

General questions

1. The in the pilot proposed solutions will for the sector lead to:

   (no additional knowledge) 1 – 2 – 3 – 4 – 5 (very much additional knowledge) of 0 (no opinion)

2. When in the supply chains in which my organization is active, such solutions were to be implemented, this would affect the current way of working:

(not at all)	1 – 2 – 3 – 4 – 5	(to a large extent)	of 0 (no opinion)

3. I am planning to use a system such as was described today:

(never)	1 – 2 – 3 – 4 – 5	(on the short term)	of 0 (no opinion)

4. When this project proceeds, I would like to see our involvement:

(reduce to a large extent)	1 – 2 – 3 – 4 – 5	(increase to a large extent)	of 0 (no opinion)