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Business Collaboration in Food Networks: Incremental Solution Development

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ABSTRACT

The paper will present an approach for an incremental solution development that is based on the usage of the currently developed Internet based FIspace business collaboration platform. Key element is the clear segmentation of infrastructures that are either internal or external to the collaborating business entity in the food network. On the one hand, the approach enables to differentiate between specific centralised as well as decentralised ways for data storage and hosting of IT based functionalities. The selection of specific data exchange protocols and data models is facilitated. On the other hand, the supported solution design and subsequent development is focusing on reusable "software Apps" that can be used on their own and are incorporating a clear added value for the business actors.

It will be outlined on how to push the development and introduction of Apps that do not require basic changes of the existing infrastructure. The paper will present an example that is based on the development of a set of Apps for the exchange of product quality related information in food networks, specifically addressing fresh fruits and vegetables. It combines workflow support for data exchange from farm to retail as well as to provide quality feedback information to facilitate the business process improvement. Finally, the latest status of the FIspace platform development will be outlined. Key features and potential ways for real users and software developers in using the FIspace platform that is initiated by science and industry will be outlined.

Keywords: Business Collaboration, Food Networks, App Development, FIspace, Future Internet, Fruits & Vegetables

1 Introduction

Food networks have to comply with the demand of the ever growing world population. According to Stiftung Weltbevölkerung, in 2013 some 7,238 bn. people had to be fed worldwide. Neves (2014) outlines that the food production is able to double in the next 10 years, while food shall be produced with sustainability, being aware that half the population is located in less than a third of the arable land, resulting in a large food trade in the future with bigger ships, bigger ports and more efficient logistics and transport systems. At the same time, as Beulens et al. (2005) outlines, the business community in the food supply chain regards the call for safety from their customers, consumers, government and other stakeholders as important driving forces for continuous innovation, while this requires an implementation of an appropriate system support.

For realising such systems that are being able to manage global food supplies and the related business collaboration, Information and Communication Technology (ICT) plays an important role. Considering the global dimension and need for communication in agri-food chains and specifically agri-food logistics, especially so-called Future Internet (FI) technologies are considered to serve specific needs of the different actors. Therefore, Verdouw et al. (2012) addressed the basic demands for FI logistics outlining that a generic and standardised Internet platform that could instantiate specific solutions could overcome current bottlenecks towards affordable systems. However, one needs to consider the agri-food logistics as one element with specific characteristics in the agri-food chain. Since as Lehmann et al. (2012) outlined for FI and the agri-food sector:

- in farming the major interest is in production control;
- in logistics it is in tracking & tracing, monitoring of movements, of production quality and of environmental impacts as well as in communication of information between stages of the chain;
- in agri-food awareness the major interest is in communication with consumers.

Furthermore, it is highlighted that information of interest needs to be collected and communicated along the chain to serve enterprises in logistics as well as consumers in their purchasing activities.

On top of that, Verdouw et al. (2014) identify that there are specific complexities especially for the agri-food logistics what results in a mismatch between the state of ICT in agri-food and the high and increasing need for intelligent solutions that combine interoperability with flexibility and that are both sector-specific and suitable for small and medium sized enterprises (SMEs), while it is highlighted that the possibilities for investments are low, due to the large number of SMEs.

As an example for the challenging situation for SMEs, according to Eurostat (2013), in the manufacture of food products, there were 258.7 thousands SMEs within the EU in 2010. This represents some 64.1% of the total number of persons employed, while only contributing to a sectorial value added of 52.1 %. On top of that, from a global perspective, the World Bank (2008) outlines that agriculture continues to be a fundamental instrument for sustainable development and poverty reduction, since three of every four poor people in developing countries live in rural areas—2.1 billion living on less than $2 a day and 880 million on less than $1 a day—and most depend on agriculture for their livelihoods. On the one hand, this shows the immense global needs and potentials agri-food networks are confronted with. On the other, it identifies the barriers for a holistic exploitation of ICT and specifically FI related technologies when aiming at the realisation of systems that will increase the efficiency and effectiveness in the related food networks.

Therefore, the realisation of systems that are facilitating the collaboration in food networks cannot rely on a simple technology push, but requiring an underlying methodological approach that will guide the potential technology users (i.e. especially the collaborating SMEs) on how to design supportive as well as affordable systems that will enable different actors within a collaborating food network to timely exchange food related information as well as to make a proper use of it. This information is considered as a key enabler for being able to make decisions for a different purpose in the specific vertical stages of the food network.

The research presented in this paper was investigating the applicability of the basic principles of a previously elaborated methodological approach for system design and realisation that was initially focusing on single organisations as well as studied in other business sectors than the agri-food chain. As presented in Kirchhoff et al. (2004), this approach for an incremental solution development is based on an evolutionary (step wise) but continuous business process improvement process that shall guarantee the achievement or at least to cope with a company wide solution. The assumption was that the approach can be used for exploiting the FI related baseline technologies in the collaborating agri-food networks that can be considered as a kind of dynamically adapting organisation, a kind of virtual enterprise that would highly benefit from a target oriented but incremental approach for being able to limit solution complexity and costs as well as drastically reducing the required time for integrating an increment of FI-based technology within an organisation of the food network.

The paper presents the underlying methodology in chapter 2 and introduces the methodological approach for an incremental solution development in section 3. Especially the potentials for realising an FI-based collaboration infrastructure allowing dynamic connectivity is presented section 4. The approach for exchanging information within food networks is presented in section 5. Subsequently, an example with key functionality for the acquisition and exchange of food product quality related information is presented section 6, followed by the conclusions.

2 Methodology

The research presented in this paper is based on methodological approaches for an incremental solution development that were elaborated in the projects COST-WORTH and AMI-4-SME (see also Kirchhoff et.al (2004,) Scholze et.al (2008) and Sundmaeker (2008)). Those projects were specifically addressing the manufacturing business domain. However, the developed approaches were targeting at the solution development for SMEs as well as assuring an incremental solution design for limiting the solution complexity and aligning the envisaged results with the key business objectives of the related actors in the value-chain. The assumption was that these key characteristics will also facilitate the solution design within food supply networks, due to the large amount of SMEs collaborating with each other to assure the timely delivery of produce. Finally, the work was carried out as part of the FIspace project ("Future Internet Business Collaboration Networks in Agri-Food, Transport and Logistics") within one of the eight realised trials of the project, addressing the business collaboration within the fresh fruits and vegetables (FFV) chain.

In a first step, the research team was analysing the business objectives, the current workflow realisation and basic constraints of the involved collaborating business actors (i.e. producers, trader, transport and retail). Several ICT related features were identified that could serve for an improvement of planning and control of added-value activities at the different collaborating business partners. Based on the approach for an incremental solution development, the potential features were grouped and their realisation sequence prioritised. Therefore, the prioritisation was defining those features that need to be realised in a first step as a prerequisite for business collaboration along the chain. As a second priority, those features were identified that could offer the most probable added-value for the collaborating business partners. Finally, all remaining features were identified that are either lacking a critical mass of added value and/or incorporating the highest amount of organisational as well as technological complexity.

Within the FIspace FFV trial, the provision of product quality related information was prioritised as most relevant increment for being able to exchange information in relation to the flow of the produce. This was addressing the forward path of information exchange along the chain. The backward provision of information along the chain was not included, due to the related complexities with aggregation and disaggregation of supplies along different steps in the chain. However, the single feedback from one customer to the direct previous supplier was included, due to the limited organisational and technical complexity.

The paper will further outline the methodological background; explain the key potentials of the underlying FI based technologies that are considered as prerequisite for being able to realise the required feature at all as well as finally present the realised implementation, explaining the developed concept for implementing the functionalities, the information storage and the required connectivity for business collaboration in food networks.

3 Background

3.1 Coaching oriented Support for SMEs for an Incremental Solution Development

Business process innovation and the related introduction of innovative technologies cannot be considered as an everyday task for the employees. They need to be enabled to continuously drive the company's improvement processes. We elaborated on methodologies for a so-called coaching oriented support that shall specifically help small and medium sized enterprise (SME) type organisations to overcome their reluctance to introduce urgently required competition relevant technologies. This is specifically addressing an incremental innovation, due to its higher acceptance and lower reluctance compared to business process redesign (BPR) approaches. While it does not exclude BPR initiatives that can complement the continuous improvement in smaller steps as also highlighted by Verdouw (2005).

Therefore, according to Kirchhoff et al. (2004), the basic idea is to facilitate the innovation in SMEs by reducing the complexity within one innovation cycle. At the same time, the elaborated methodology shall assure not to lose the relation to the identified business objectives. This enables the realisation of separate innovation and change cycles that are logically connected to a holistically planned and prioritised improvement/ innovation, while each cycle is combining changes within the business processes with the related ICT. Each innovation cycle is structured in three main life-cycle phases, the analysis & conception, the specification & selection and the implementation phase. At the end of each phase, the team needs to review the key decision points for being able to decide on continuing the planned innovation or to stop the related efforts. This needs to be based on a cost-/ benefits estimation of the envisaged improvement measures. After implementing a solution the need for corrective actions has to be analysed. This needs to be based on the benefit proof of the improvement measure. For a structured approach, the life-cycle phases are organised at additional sub-decision points that are required for being able to make the key decisions at the end of each life-cycle phase. Moreover, the sub-decision points also facilitate to stop an innovation cycle or to reiterate on identified issues.

Those innovation cycles can be considered as increments for developing solutions that improve added-value processes especially in terms of planning and control of process realisation. Due to the systematic and structured approach, those increments can be realised in a sequential way as well as realised in parallel. The clear assignment to the identified weak points and the business objectives to be achieved shall assure that the innovation focus is not lost and to enable agreed decisions on which improvement measures shall be realised at which point in time. The innovation results shall be measured with related key performance indicators (KPI) to learn from successful as well as not successful measures. Moreover, there shall be KPI that can quantify gains w.r.t. savings and productivity increases. This will allow an assessment of the envisaged Return of Investment period, taking into account the efforts and costs for realising the improvement measures.

3.2 ICT Support for the Networked Enterprise

For being able to supply food from farm to fork, the related actors need to collaborate in a sequential supply chain or even in more complex network structures. Therefore, food chain SMEs can be characterised as kind of networked enterprises. Those networked enterprises can benefit from interconnected ICT systems to reduce the effort for information exchange and interactively use ICT supported features for planning and control of interaction (e.g. order management, transport monitoring, tracking & tracing). According to Sundmaeker et al. (2010) such an ICT system support can be assigned to business processes as an intermediate support between a supplier and its customer in a supply chain, while the governance needs to be realised in relation to the processes.

This support can be realised without an interfacing of existing systems. However, from system efficiency point of view, interconnected business systems in the organisation (e.g. ERP, order management, FMIS – with ICT system governance in relation to the organisation) reduce efforts and risks of errors compared to the manual handling of data. Nevertheless, any interfacing with existing systems causes related efforts and costs as well as requires time for harmonising the individual environments. This triggered our previous work in the CuteLoop project (2008) to aim at the development of a so called "networked devices enabled intelligence" that is able to provide process related features, while implementing an ICT support that is working fully decentralised, leading to a governance model that is related to the networked device or a "thing". The idea was to combine such digital networked devices (i.e. enhanced RFID-based systems) as physical object with the real product that is traveling along the supply chain. The networked device offers the capability to instantiate virtual representations of process related objects (e.g. product, returnable transport item, shipment, order). At the same time, the networked device can provide required functionality for e.g. an event-based operation, localisation, information acquisition and/or monitoring to acquire contextual information. Within the analysed real-world business cases, challenges remained specifically with respect to the interoperability of existing systems at the individual actors, costs of devices, and security constraints with respect to such external systems that would need to access available systems used at a specific organisation. It was considered specifically questionable, if the available multi-agent platforms can cope with requirements like robustness, scalability and security compared to available service oriented architectural frameworks used within Internet based solutions.

However, a basic concept addressed was the usage of so-called "shared zones" for being able to exchange information between collaborating business entities as well as decouple internal systems from an external access. Especially the usage of distributed data storage was considered by the end-users as key requirement for solutions that could be accepted for real world usage. At the same time, within interviews it was identified that the collaborating business partners are generally willing to widely exchange data and information in case of exceptional events like emergencies that are due to situations when produce is e.g. contaminated with bacteria or pesticides at a hazardous level. For being able to do so, the access rights to data and information need to be defined in relation to the business interaction/context. Therefore, the system design of data fragments, functionality and related interfaces was separated for being able to realise the concept towards a networked devices enabled intelligence that can provide added value features for collaborating business partners.

Separating the design of an ICT system in such fragments of functionality facilitates to define and maintain a systematic design (i.e. hierarchical and structural concepts) of an increment within an overall larger solution. The SME will be enabled to select those technological increments for development that can directly contribute to the elimination of those weaknesses that were prioritised with highest importance and/or urgency. On top of that, the coaching oriented support for the elimination of weaknesses can only work properly, if such a focused and incremental realisation of ICT systems is possible, since the underlying ICT architecture needs to be able to facilitate compatibility of increments as well as their evolutionary combination.

3.3 Innovation Potentials of the Future Internet Public Private Partnership Initiative

The Future Internet Public Private Partnership (FI-PPP) is an initiative funded by the 7th Research Framework Programme organised by the European Commission. As further outlined by Sundmaeker (2013), it mobilises resources of some 500 mEuro public and private funds for realising a multi-disciplinary and integrated approach for being able to develop technological enablers that are representing a kind of up-front investment in the technological infrastructure that is paving the way towards the realisation of a Future Internet. This technological environment currently under elaboration is providing so called generic enablers that are required by different types of business related use cases (e.g. food chain, logistics, multi-media, manufacturing, health, energy). Moreover, the generic enablers are combined for business related purpose in the form of FI-enabled platforms that are providing the baseline functionality for the usage of innovative software applications (apps). For the first time, a large number of EC funded research projects are aiming at the realisation of a common technological environment, aiming at the provision of technologies that help to drastically reduce the development effort as well as providing a baseline for generating growth and jobs.

Initial pilots and further trials of FI enabled ICT are realised in close cooperation with several business partners. In the scope of the SmartAgriFood and FISapce projects*, a fruits and vegetables trial served as business case for analysing requirements, developing a concept as well as to elaborate and validate related solutions. Especially due to the nature of the technology and the architectural approach, the FI-PPP results and specifically the business collaboration platform that is currently being developed by the FIspace project is promising an easy adaptation to business needs and facilitating the incremental solution development that was difficult to achieve with other technological approaches as experienced in the CuteLoop project. FIspace is specifically addressing the business collaboration in food networks as well as logistics and transport matters, aiming at the realisation of an app-based solution environment to facilitate business collaboration, to:

- Support dynamically changing interaction of business partners
- Facilitate exchange of data between stakeholders
- Assure a secure data storage and controlled ownership
- Limit effort and costs for system and process redesign

The following chapter is outlining the overall FIspace concept and related principles that can help to support SME type business partners to benefit from the Future Internet enablers.

4 Incremental Solution Development for Business Collaboration in Food Networks

As outlined in section 3.1 the approach for an incremental solution development is targeting at the reduction of complexity within one innovation cycle. At the same time, an underlying objective is to focus the investments on the elimination of weak points that are critical for the competitiveness of the company. Therefore, as a very first step of an innovation cycle, the company objectives are detailed within an initial interview. They will be structured according to the main classes of quality, cost, schedule, the company focus as well as the market strategy. Those objectives are serving as basic reference scheme for being able to aim at a goal oriented and time optimal execution concerning planning and implementation of process improvement measures. This is followed by the analysis of the main added-value/ primary business processes, while the supporting processes in the organisation (e.g. human resource management, facility management, and financial administration) are not addressed. Especially the order management, product development, product handling/processing, materials management and delivery management are analysed, using best practice principles as interview guideline. They are serving as reference for identifying weak points in the process execution. Finally, a prioritisation is taking place that shall focus the investments for the elimination of those weak points that are critical for the competitiveness of the company.

The prioritisation serves for a conception of the envisaged future process execution as well as of the envisaged ICT support, while the concepts for future process execution and envisaged ICT support are separately documented to allow a traceability of envisaged improvements and related measures. Subsequently, indicators for assessing the envisaged business benefits are identified for the future realisation of the business process. This is structured in economic, customer as well as other not

* http://www.smartagrifood.eu & http://www.fispace.eu/

quantifiable benefits. Within the final phase for analysis and conception, a rough cost benefit analysis is prepared. This compares the envisaged benefits with the estimated costs for realising the envisaged future processes and ICT support.

Such an assessment enables a sound management decision that facilitates subsequent realisation and change processes within the organisation. We practically applied this approach within several business cases. However, it requires quite an involvement of the end-users, the ICT support and the management function in the organisation. Within daily business work, this requires a clear commitment of the organisation's employees and an availability of the related resources. On top of that, it is asking for an inter-disciplinary management for being able to identify consequences and implications on existing processes and ICT systems as well as on how to cope with non-functional requirements (e.g. performance, security, privacy, interoperability). Therefore, such an incremental analysis and conception cannot be realised without an analysis or at least proper understanding of a wider process and ICT dimension in the organisation. This is even more important when addressing the business collaboration in food networks, due to the requirements with respect on joint usability, interfacing, performance, privacy, security, availability and dynamic interoperation of changing business partners. Especially those aspects are generally applicable and not specific to a key feature that shall be realised for improving the business collaboration like exchange of specific information or knowledge, joint planning of resources or risk assessment based on specific events.

Therefore, the analysis in the SmartAgriFood project and the subsequent development work in the FIspace project were able to identify such general supporting functionality and aimed at the realisation of the FIspace platform. This platform specifically provides such supporting features for collaboration of business partners. The main focus of the ICT support is on features that can be used in the direct collaboration of different business actors. It is not focusing on the technological support of internal tasks within the organisation but all those activities that are in direct relation with e.g. suppliers, customers or consulting experts. Therefore, existing/ legacy systems in the organisations shall not be replaced by the FIspace concept, but being complemented with added-value functionality. The platform combines basic capabilities to offer an entry point for trusted business collaboration, offering the related front-end and components that can take care for flexible workflow control and integration with existing systems.

The general platform capabilities are complemented by so called "Apps" that are providing the required added-value features for the business collaboration. On top of that, different apps can be selectively combined to provide specific functionality required in the inter-organisational workflow. The following Figure 1 is presenting this overall approach as baseline for the incremental solution development.

The FIspace platform is providing a complete set of components that allows an operation within a business to business context. All those features that are technically relevant for the direct interaction between the organisational ICT environments are located in the cloud, based on a secure and scalable infrastructure. It provides a basic front-end that is the representation layer for the basic settings and the related user and organisational interaction management. Due to the business context, this requires an additional consideration compared to social network type of platforms that do not need a hierarchical and profile based access and privileges management. It can facilitate the matchmaking of individuals as well as of businesses, just in accordance to the willingness of each business actor.

At the same time, the platform provides an app store that provides the basis to motivate developers to provide their services to a large professional target audience, while the collaborating business partners can easily trigger the uptake of certain functionalities by their collaborating partner. Therefore, in the core of the platform, it contains a business to business collaboration core that enables a business architect to specify the workflow, logically combine the usage of different Apps and collaboratively design the steps of interactions between different business actors.

The critical mass of users and available apps is of utmost importance for the successful usage of such a platform. On the one hand, users need to get acquainted with the benefits in using the platform. On the other, as a kind of hen and egg problem, developers need to be involved to develop such Apps that are required for optimally supporting the business interaction and underlying workflow. A software development kit is provided that will provide the required guidelines and APIs for usage of the FIspace platform functionalities as well as the toolkit for configuring and customising the Apps and the platform.

As a baseline, the first version of the FIspace platform will also be equipped with a number of "Initial Apps". These initial apps are representing basic functionalities that can be used by different business actors. The development of initial apps targeted at such kind of features that are likely to be reused by different types of actors as well as of different business sectors. Furthermore, it was searched for apps that cover a series of interaction in the business chain. This allows for an orchestration of apps, while workflow events are triggering the interaction between organisations and in between the related apps.

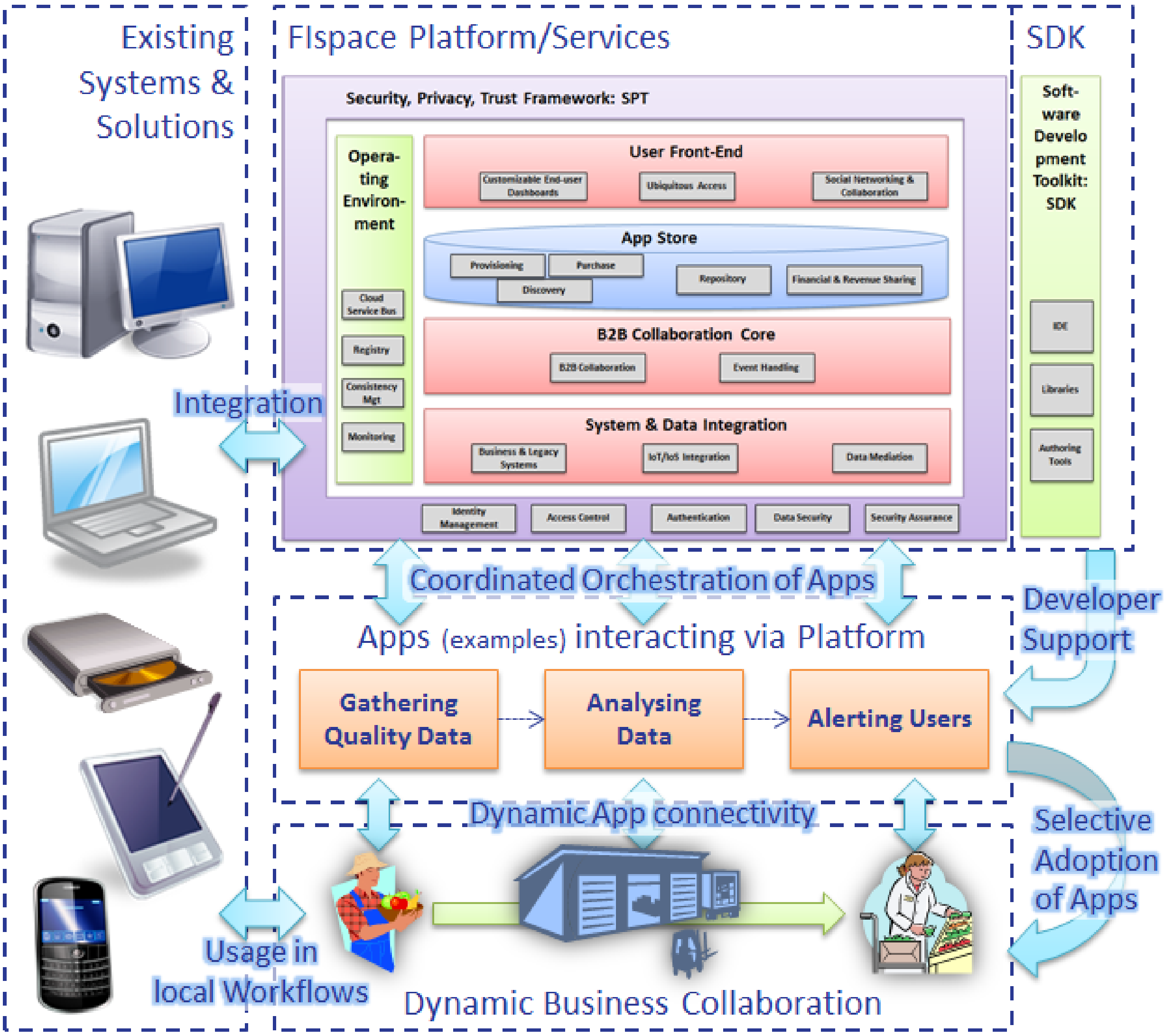

Figure 1. FIspace platform and app model for dynamic business collaboration and incremental solution development.

A business architect can carefully decide in close collaboration with the business actors on which functionality shall be made available in the workflow to which end-user, while the integrated approach of the platform allows but does not immediately ask for an interfacing with legacy systems before an App can be used. Therefore, the selective approach allows to experience the App based features before being able or having the time, resource and budget to allow for a full integration with existing systems. A business actor might even decide to use certain app based functionality with some additional manual effort, but being able to immediately and dynamically interact with numerous business partners in its large professional business network.

An App based flexible approach for exchanging product quality related data within a collaborative food network is presented in the next section, outlining key features and the flexibility with respect to reuse, data models and functionality.

5 Product Information Exchange within Collaborative Food Networks

5.1 Product Information Exchange in Food Networks

Business processes and current ICT systems were analysed in the scope of the SmartAgriFood project. Taking into account the business objectives of the different actors in the fruits and vegetables pilot, especially the following innovation potentials were identified, that served as input for the FIspace project:

- Forwarding of extended product quality information to facilitate quality monitoring and assurance
- Tracking of reusable packaging resources to assure availability and forecasting
- Risk analysis to identify potential quality problems
- Exception reporting to trace food that must not reach the consumer

After accomplishing the first analysis, the forwarding and exchange of product quality information was prioritised for design and development. As a result, the so called Product Information App (PIA) was designed and developed. The main goal of the PIA is to enable product information exchange between the stakeholders of a supply chain, based on the B2B collaborative and system integration capacities offered by the FIspace platform. The PIA enables the exchange of product related characteristics along the workflow/product flow specifically focusing on a food chain, and finally allowing access to information that flows via several nodes in complex supply networks. This includes the information flow from farm to fork as well as vice versa. On the one hand, actors in the chain as well as the consumers are interested in the product characteristics to check for certain quality characteristics as well as to properly control the flow of produce (i.e. also enabling the withdrawal of harmful produce). On the other, also the suppliers of food are interested in the feedback from their customers and the customers of their customers to get an understanding on how to improve their offerings and process design.

The basic objective for developing a PIA is to provide support to the different stakeholders and stages in a supply chain/network as well as to provide the basis for the realisation of related apps that can make use of the available information. Therefore, the PIA cannot be considered as a single solution that would fit all needs in the chain. Instead, to comply with the needs of an incremental solution development, it needs to be configurable for being able to address the specific needs of different supply chain actors. Each related app configuration includes specific features that are assigned to business stakeholders in the food chain/network. To accomplish this objective the following strategies were applied:

- Identifying specific features that are either used by one stakeholder or are reusable features so as to avoid redundant implementation effort.
- Focus on specific pilots for prototyping efforts to enable the gathering of feedback from real end-users (i.e. specifically involving fruit & vegetable and tailored information pilots for the functional features; involving the flower, meat and greenhouse pilots for working on the product information model).
- Splitting app development into two main functional bundles; forwarding and feedback of information in the chain (i.e. focusing on provision of data in a raw way along the chain) and the transformation of data into information based on preferences and rule settings (i.e. with a first focus on the provision of information from retailers to consumers).

In the following, especially the app with respect to the business to business related forwarding and feedback of information in the chain is outlined. It is designed to allow capturing of, and access to, product quality related information that flows via several nodes in complex supply networks. The main features of the PIA-App include:

- Easy and secure exchange of product quality related information between supply chain partners, while avoiding centralized storage of information. This is to ensure the PIA-App ability to store data decentralised to facilitate an acceptance of business stakeholders. Nevertheless, it would also be possible to store data in centralised databases reachable via an Internet connection.
- Access control over own product data by supporting private data sources per stakeholder with access management.
- Provisioning of product information from trusted sources (business relations established via FIspace).
- Access to information that is published by the supplier(s).
- Enabling bi-directional communication through the supply chain, especially with a focus on product quality related feedback with respect to shipments forwarded in the chain.

5.2 Information Model Development of the Product Information App

Beyond the functional model of the PIA, also an information model was developed that shall be compatible to the incremental solution development in food networks, since information items of the product as well as context related information are relevant to diverse interactions and processes when aiming at the support of business collaboration between different actors within a supply network. To structure the exchange of product-related information between supply chain actors, three main stages were identified:

1. Initial supply of goods and capturing of initial product information.
2. Aggregation, disaggregation and processing of goods, adding and forwarding of associated product information, baseline for traceability by linking incoming and outgoing goods and
3. Receiving product information (accumulated along the supply chain) of incoming goods and establishing the basis for providing product information to customers.

The information model design focused on the PIA and analysed requirements with respect to the product quality information exchange as realisation increment. However, to assure and elaborate an approach for an incremental compatibility, also other pilots in the FIspace project were involved (e.g. meat, flowers, greenhouse, fish). For all those pilots, in general the related shipments are forecasted, planned, ordered, announced, aggregated, transported, delivered, checked and paid. In combination with those shipments, the stakeholders in the food chain need to forward information with respect to product quality related characteristics. Therefore, for the food-supply chain the shipment has been identified as business entity between actors. The PIA-App deals with the virtualization of shipments between supply-chain actors using FIspace. In these virtualized deliveries, process and product related information is included. In the following it is referred to the combination of product name, product quality information, and quantity as well as packaging information as “item” in a virtualized shipment.

The first release of the PIA-App includes three different configurations. Each of them is addressing a specific stage in the supply/information chain described above. However, the main purpose of this first PIA-App release is to validate the app functionality and elaborate business requirements together with trial partners. This iterative process of validation and app refinement is ongoing and will lead to more specific requirements and more mature functionality in the later releases of the PIA-App.

To facilitate the test, master data records of the PIA-App were designed in the scope of the Intelligent Perishable Goods Logistics domain and focused on the Fresh Fruit and Vegetables Quality Assurance Trial. Within this trial the three stages of the supply chain are represented by following types of actors: farmers, traders and retailers. For each actor type there is a special configuration of the PIA-App. The “Trader App” (incoming and outgoing goods) covers the complete bandwidth of functionalities offered by the PIA-App. The “Farmer App” (outgoing goods) and the “Retailer App” (incoming goods) only provide a subset of the functionality. For simplicity we refer to these three configurations as “PIA-App” and only use the terms “Farmer App”, “Trader App” and “Retailer App” where the distinction is necessary.

Shipments have domain-independent information attached such as customer, supplier, delivery number, date and location. Domain-specific information concerns the type of products, their packaging, and possible product information attributes (e.g. country of origin, date of harvest, GTIN, or quality certificates). Such domain-specific information could be provided in the form of data records describing products and associated attributes to adjust the PIA-App to various domains. The requirements regarding products and associated product information attributes have been collected from different trials. After a first consolidation round and taking the shipment-centric view into account, a first version of the data model for the PIA-App has been developed (see Figure 2).

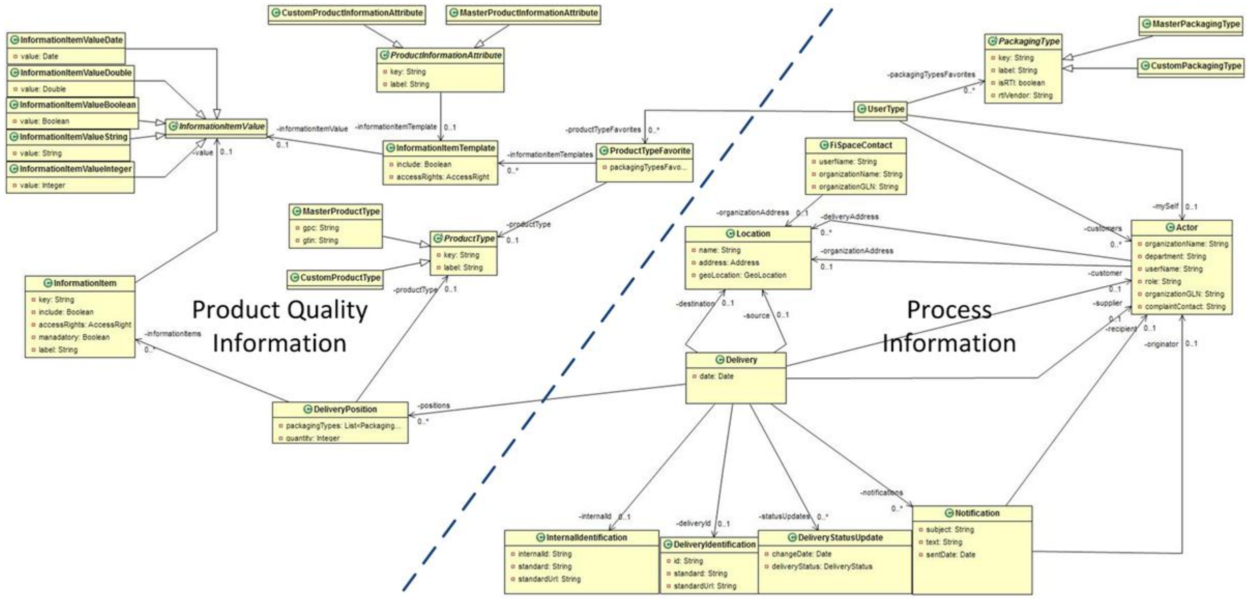

Figure 2. PIA-App Data Model.

The PIA-App data model is separating the data in a process and product related part. The basic idea in terms of reusability was as follows:

- ***Process related data:*** This data needs to be generally considered when exchanging a product within a chain. It is also used to uniquely identify a shipment and the related stakeholders.
- ***Product related data:*** The focus was on designing a reusable data model. To achieve this objective the "information item" is representing a kind of template for storing all the required information items that can be somehow put in relation to the product quality. Such a data base can be dynamically extended and is not limited to a predefined set of items that are selected at design time. On top of that, the data model can be used for different product types.

Moreover, to assure its applicability for future solution increments, this approach is not determining/predefining the usage of a certain standard, but to allow the usage of the most appropriate standard for data exchange in accordance to the needs of the stakeholders. Therefore, the development of the PIA is not driving standardisation tasks, but aiming to use available standards and the related master data for being able to populate the data base. The usage of such standardised master data shall also be promoted to facilitate the interoperability within the food chain, while the data model and the app themselves shall not limit its usage to e.g. a specific identification scheme. It shall be specifically compatible to diverse identification schemes (i.e. used by different actors on different levels of packaging and transport) as well as allowing adding, deleting, replacing or extending product information that shall be exchanged within the supply chain/network.

It is envisaged that trials, which are addressing the forwarding of different products can use the PIA, while the underlying master data needs to be individually compiled and imported as configuration in the data base. The basic functionalities for gathering, compiling, forwarding and receiving information can be generally used. The specialisation of PIA is realised with respect to two dimensions:

- Stakeholder related configuration – the PIA-App is configured with respect to the type of stakeholders. There were three main types identified:
  - Farmers as initial actors in the chain gathering the initial data that is relevant in the subsequent food chain stages.
  - Traders or manufacturers that are receiving products from their suppliers and are forwarding products to their customers. Within their organisation, they are aggregating and disaggregating deliveries received before. Therefore, they need to track such internal activities for being able to support the identification of which of their inputs are matching with the outputs of their organisation.
  - Retailers that are finally receiving batches of products and are providing individual food products to final consumers that are interested in diverse quality characteristics.

- Product type related configuration:
    - It is assumed that specifically the process and entity related information can be used in different business sectors. The need for specific product related information is varying in accordance to product types to be forwarded in the chain.
    - It is possible to configure products that the organisation supplies. This could be done manually what would impose a large effort and could cause many differences in wording and spelling of same types of products. Therefore, the PIA-App can be configured with master data in relation to the specific products handled in the chain.

This clear structure of PIA in relation to the different stakeholders and type of information was specifically based on the elaborated solution increments that are required in the food chain/network. Therefore, from an overall view on the solution, the PIA could be considered as a compilation of several simpler apps dedicated to specific users and steps in the collaborative workflow.

5.3 Implemented features of the PIA-App

For the first release of the PIA-App the following features have been implemented in form of frontend prototypes and a rudimentary backend with simulated platform functionality:

- Overview of the history and current status of incoming and outgoing shipments.
- Composition of outgoing shipments of products.
- Assign product information to products of an outgoing shipment.
- Set access rights for product information.
- View and edit the details of an outgoing shipment (products, packaging, and product information).
- Announce deliveries to customers.
- Accept or reject incoming goods and give product quality feedback to suppliers.
- Establish traceability of products by linking outgoing to incoming products.
- Configuration of the app
- Load and save templates of (re-occurring) shipments.

Finally, the PIA-App consists of frontend, backend and data storage. The paragraphs below describe the current status of development and envisaged functionality for each of the three components, while the presented setting was developed for the integrated test along the platform development, simulating certain functionality finally located in the platform itself.

- Frontend:
  It contains the GUI for user interaction, and input validation as well as display logic that is mainly concerned with enabling, disabling and dynamically adding/removing GUI elements depending on the current state of the shipment and on actions of the user. The frontend is provided in the form of a W3C widget using HTML, CSS, and JavaScript. For the communication with the backend the frontend uses AJAX.

- Backend
  The backend connects to the FIspace Platform and to interface with the app data storage. Currently it serves as connector between the data storage and the frontend and simulates aspects of missing platform modules (e.g. accessing FIspace business contacts). In further releases an API will be exposed that makes parts of the app's functionality accessible to other apps via the FIspace Platform. The backend prototype is implemented in Java and provides RESTful web services to the frontend to perform CRUD operations on the App data storage.

- Data storage:
  To store data (to be) exchanged between stakeholders in the food chain, the app requires a data storage accordingly. Currently, it is realized in the form of a MongoDB database utilizing the Spring framework. It is connected to the backend where requests of the frontend are translated into queries to the database. The results of these queries are sent back to the frontend in the form of JSON data structures from which information items can be read and directly used by JavaScript.

A main window of the different GUIs of the PIA-App is presented in Figure 3, representing the user interface to assign the specific produce to a shipment. Every new shipment that is being composed starts with the status "In Work". Once the user has finished working on the shipment with the app, he can announce the delivery to his customer, which is accompanied by a status change from "In Work" to "Announced". In the case of the farmer, the customer would be a trader (or possibly a retailer). The app – by means of the FIspace platform business to business collaboration core – sends the information about the announced delivery to the customer (trader or retailer) app. From that point in time, the customer can also view the details of the shipment. When the user ships the physical goods represented by the announced delivery, the status shall be set from "Announced" to "In Transport". In the case of farmer and trader, the Farmer App relays the status change to the Trader App.

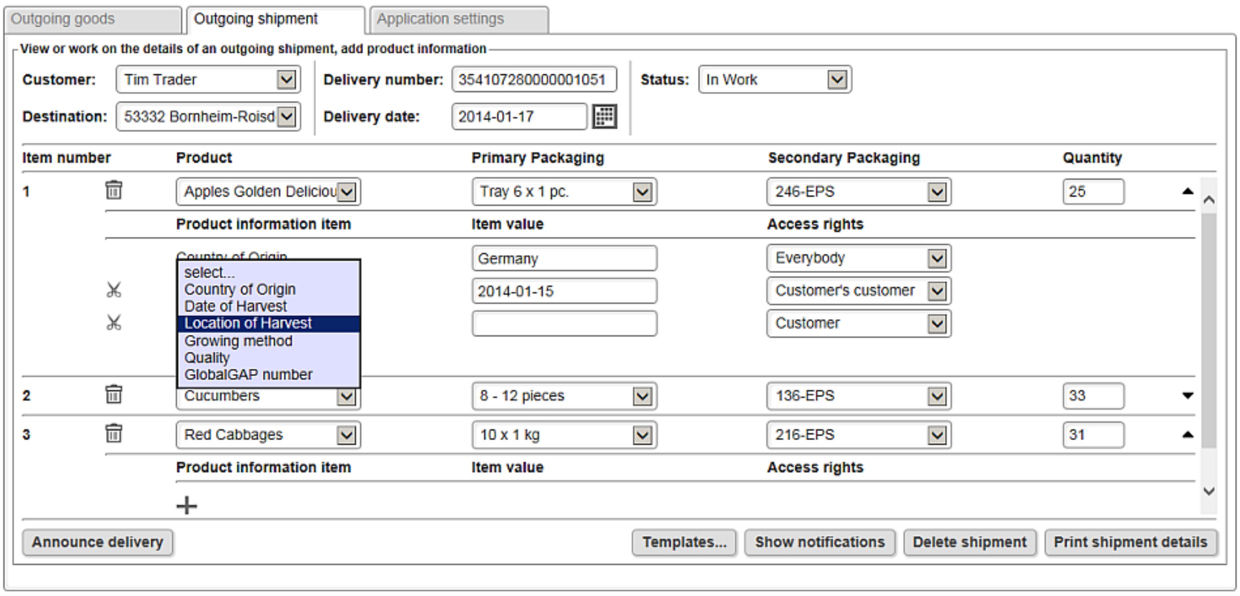

Figure 3. Composition of an outgoing shipment and assigning product information.

As outlined before, the PIA can be considered as an increment that can provide product and process related information to other apps. By means of the FIspace collaboration core, this interaction of different app increments can even be dynamically adapted. Moreover, the current version of the PIA was limited to the key added-value functionality. Also from the viewpoint of the PIA additional features for data acquisition (e.g. QR code or RFID scanner) could be useful that could be implemented in future increments in the scope of the overall solution.

6 Conclusions

The business collaboration in food networks is characterised by a high number of interacting SMEs with a large variety in the adoption of ICT support. SMEs are often lacking capacities and resources for being able to take advantage of innovative ICT potentials to fully exploit the collaboration opportunities. An approach was presented that is targeting at the support of such SMEs. It shall facilitate the ICT based solution development, while aiming at the elimination of weaknesses as well as increasing the competitiveness of SMEs in food networks. It supports the realisation of innovation cycles as kind of increments for solution development.

At the same time, realisation of innovative and commercially viable ICT solutions that are supporting collaboration in complex business networks is asking for sophisticated and integrated solutions that are requiring large investments and available competencies for solution design, specification, implementation and integration. This is due to functional requirements but also due to a large amount of non-functional requirements like performance, security, privacy or interoperability that are generally required.

There is generally a mismatch of an incremental solution development with respect to the design and specification of the highly focused added value features from a business process perspective, compared to the ICT implementation perspective that gets easily unmanageable by SME type organisations. This gap is currently being bridged by the development of the FIspace platform. This platform represents a SaaS environment that disburdens the SMEs especially from the realisation of background functionality. It provides the opportunity to focus on competition critical features that can be implemented in so called apps. Different instances of an app as well as different apps can be orchestrated according to the demands identified by SMEs that are collaborating in food networks. The solution development complexity can be decreased to a very large extent, enabling a new dimension for saving efforts, time and costs. Therefore, the FIspace platform provides a kind of up-front investment that needs not and cannot be tackled by individual SMEs, but by a joint European effort realised in FIWARE, the European Future Internet public private partnership.

The basic features of the FIspace platform were outlined. It was elaborated on how to use its key features within the scope of realising an integrated workflow support in food networks based on the example of an application that is supporting the exchange of product quality related information within food networks. The presented PIA is a configurable app that can be used in different steps of the food chain as well as for different types of products. It can be used within the workflow, by configuring PIA in three specific apps/solution increments that provide the appropriate features to the different types of stakeholders (i.e. farmers, traders and retailers). PIA is enabling to collect and to forward information as well as to make information sources accessible. To facilitate the unique identification of products as well as to enable the realisation of traceability, the information is combined with the unique identification of related shipments. The first release of the PIA-App was developed and is currently under test. Further involvement of business end-users is currently being organised and managed to validate the usability and flexibility of the app as well as to identify additional functionalities for future increments that can generally improve the business collaboration between business actors in food networks.

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References

Beulens, A.J.M., Broens, D.F., Folstar, P.,and Hofstede, G.J. (2005). Food safety and transparency in food chains and networks - Relationships and challenges. *Food Control*, **16**, 6: 481-486.

CuteLoop Research Project (2008). CuteLoop Concept exploring how Intelligent Networked Devices can be used to effectively integrate customers within an Integrated Enterprise. Retrieved January 07th, 2014, from: http://www.cuteloop.eu/index.php?id=12,0,0,1,0,0

Eurostat; Manufacture of food products statistics - NACE Rev.2 with data from April (2013). Available at: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Manufacture_of_food_products_statistics_-_NACE_Rev._2

Kirchhoff, U., Sundmaeker, H., San Martín, F., Wall, B., Campos, J., Xeromerites, S., and Terziovski, M. (2004). How to Speed-up the IMSS Related Innovation in Manufacturing SMEs. International IMS Forum 2004, Villa Erba, Cernobbio, Lake Como (Italy).

Lehmann, R.J., Reiche, R., and Schiefer, G. (2012). Future internet and the agri-food sector: State-of-the-art in literature and research. *Computers and Electronics in Agriculture,* **89**, 0: 158-174.

Neves, Marcos Fava (2014). The Future of Food Business: The Facts, The Impacts and The Acts. 2nd Ediotion, World Scientific Publishing, Singapore, 2014.

Scholze, S.; Sundmaeker, H.; and Kirchhoff, U.(2008). Ambient Intelligence Technologies for Industrial Working Environments in Manufacturing SMEs. 14th International Conference on Concurrent Enterprising. Caparica, Portugal, June 2008.

SmartAgriFood Project (2013). SmartAgriFood Final Project Report. Available at: http://www.smartagrifood.eu

Stiftung Weltbevölkerung (2014). Länderdatenbank. Available at: www.weltbevoelkerung.de/

Sundmaeker, H.; Scholze, S.; Stokic, D.; and Faltus, S.(2008). Intelligent Networked Devices for Enabling Proactive Collaboration with Customers. 14th International Conference on Concurrent Enterprising. Caparica, Portugal, June 2008.

Sundmaeker, H., Kovacikova, T. (2010). CuteLoop - an approach for Networked Devices Enabled Intelligence. ICSEA 2010, The Fifth International Conference on Software Engineering Advances, Nice, France: 205-212.

Sundmaeker, H. (2013). Realising Future Internet Potentials for Food Chain SMEs: A Hierarchy of Needs*. Special issue .International Journal on Food System Dynamics*,.**4**, 4: 273-282

The World Bank; World Development Report (2008). Agriculture for Development. Washington DC, 2007. Available at: http://web.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTWDRS/0,,contentMDK:23062293~ pagePK:478093~piPK:477627~theSitePK:477624,00.html

Verdouw, C.N., Wolfert, J., and Beulens, A.J.M.(2005). Enhancing transformational and incremental innovation with ICT. In: Proceedings of EFITA, the 5th conference of the European federation for information technology in agriculture, food and environment, Vila Real, Portugal, 25-28 July 2005: 103 - 110.

Verdouw, C.N., Sundmaeker, H., Meyer, F., Wolfert, J., and Verhoosel; J. (2012). Smart Agri-Food Logistics: Requirements for the Future Internet. Proceedings of the 3rd International Conference on Dynamics in Logistics (LDIC 2012), 28.02.-01.03.2012, Bremen, Germany: 247-257.

Verdouw, C.N., Vucic, N., Sundmaeker, H., and Beulens, A. (2014). Future Internet as a Driver for Virtualization, Connectivity and Intelligence of Agri-Food Supply Chain Networks. *Special Issue*, *International Journal Food System Dynamics* **4**, 4:261-272.