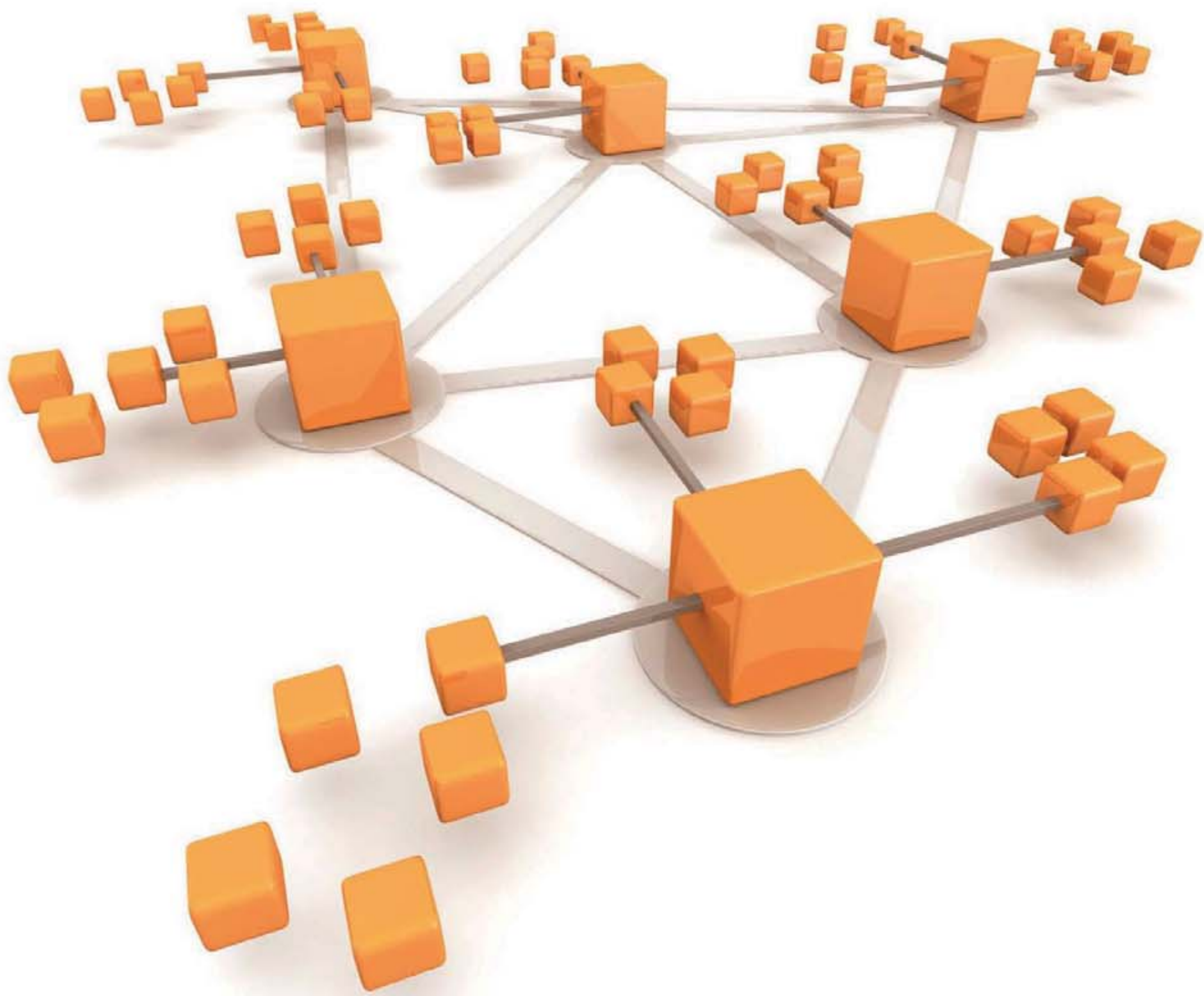
Information Logistics in Agri-Food Supply Networks

An Integrated Framework for Business Information Services

Robert Reiche



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Information Logistics in Agri-Food Supply Networks

Integrated Framework for Business Information Services

Agri-food enterprises are challenged by a multitude of complexities. The globalisation and increasing international competition in the food sector, the high degree of small- and medium-sized enterprises, as well as national and cross-national food crises and related uncertainties for consumers and agri-food enterprises lead to different public and private requirements. Transparency on products and inter-enterprise processes has become an important factor for competitiveness and trust in agri-food enterprises and their provided products. The provision of product- and process-related information for the timely discovery of critical situations in the distribution process requires the efficient organisation and coordination of inter-enterprise communication in order to react to these situations directly and effectively. Transparency, in respect to the shared understanding and undistorted access to product- and process-related information, represents an unresolved challenge for the organisation of inter-enterprise communication of relevant information.

The objective of this thesis is to formulate a generic framework for the development of business information services, which connect distributed information sources at agri-food enterprises along the supply network, to provide relevant information to stakeholders to meet their information needs. Within this framework, generic service alternatives for static and dynamically changing information, service activation patterns matching the organisational needs of business interactions, as well as supportive technology components are described to establish this connection. The framework is applied to an application case concentrating on the fresh- fruit and vegetable supply network. Within this application case, three service alternatives are elaborated out of different identified information needs with the objective to provide decentralised stored product-quality and process-related information to users in order to identify deficient products or other critical issues in the distribution process. These services are developed in different levels of technology. An economic decision model is provided for the selection and adoption of technology related to these technology levels based on a generic cost-benefit-analysis and the consideration of the company's general ability to adopt new technology. The thesis closes with a discussion of different key requirements for the adoption of business information services in the food sector.

Informationslogistik in Netzwerken der Agrar- und Ernährungsindustrie

Ein integriertes Konzept für unternehmensübergreifende Informationsdienste

Unternehmen der Agrar- und Lebensmittelindustrie stehen komplexen Herausforderungen gegenüber, die sich aus der Globalisierung des Lebensmittelsektors sowie der zunehmenden Konzentrierung des Wettbewerbs ergeben. Zusätzlich führen nationale und internationale Krisen innerhalb des Lebensmittelsektors zu Unsicherheiten für Konsumenten und Unternehmen gleichermaßen. Unternehmen im Lebensmittelsektor müssen eine Vielzahl von rechtlichen und privatwirtschaftlichen Anforderungen erfüllen. Dabei gewinnt auch die Transparenz immer mehr an Bedeutung, um die gezielte und individuelle Bereitstellung von Informationen zur Deckung des Informationsbedarfs in kritischen Situationen über die Produkte und unternehmensübergreifenden Prozesse zu ermöglichen. Besonders in der Koordination und Organisation des Informationsaustausches zwischen Unternehmen in der Agrar- und Ernährungsindustrie sind spürbare Defizite vorhanden.

Das Ziel dieser Arbeit ist die Erarbeitung von Grundprinzipien zur Entwicklung von Informationsdiensten. Diese Dienste umfassen die Bereitstellung und Aufbereitung von Produkt- und Prozessinformationen aus verteilten Systemen und die gezielte Deckung des persönlichen Informationsbedarfes in einem individuellen Arbeitsumfeld. Das Konzept beinhaltet allgemeingültige Elemente, die auf der Informationsart, der organisatorischen Aktivierung der Dienste und der technischen Unterstützung, durch Basisfunktionalitäten moderner Informations- und Kommunikationstechnologie, basieren.

Die anschließende Anwendung des Konzeptes auf aktuelle Informationsbedürfnisse im Obst- und Gemüsesektor umfasst drei Informationsdienste in verschiedenen Technologieszenarien. Diese Dienste konzentrieren sich auf die Bereitstellung und Auswertung von dezentral gespeicherten Qualitätsinformationen über einzelne Produkte und deren jeweiligen aktuellen Status entlang der Wertschöpfungskette. Im Anschluss wird ein ökonomisches Entscheidungsmodell auf Basis einer generischen Kosten-Nutzen Analyse erarbeitet. Dabei wird die Anpassung der existierenden Unternehmensinfrastruktur an die diskutierten Technologieszenarien optimiert. In einer abschließenden Diskussion werden diese Dienste und ihre Realisierbarkeit im Obst- und Gemüsebereich und dem gesamten Lebensmittelsektor betrachtet. Abschließend werden kritische Anforderungen für die Etablierung von Informationsdiensten formuliert.

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Abbreviations

AFSN	Agri-Food Supply Network
BISF	Business Information Service Framework
BoxID	Box identification number
BRC	British Retail Consortium
BSE	Bovine Spongiform Encephalopathy
CIAA	Confederation of the Food and Drink Industries of the EU
CO_2	Carbon Dioxide
DC	Data Cluster
DI	Data Input
DO	Data Output
DT	Data Transfer
EC	European Commission
EDI	Electronic Data Interchange
EFSA	European Food Safety Authority
EHEC	enterohemorrhagic Escherichia coli
EPC	Electronic Product Code
FAO	The Food and Agriculture Organization of the United Nations
GlobalGAP	Global Good Agricultural Practices
GPS	Global Positioning System
GS1	Global Standard 1 (also GS1 Germany GmbH)
HACCP	Hazard Analysis and Critical Control Points
ICT	Information and Communication Technology
ID	Identification
IEIS	Intra-Enterprise Information System
IERC	European Research Cluster on the Internet of Things
IFS	International Food Standard
IoT	Internet of Things
IS	Information System
ISO	International Standardisation Organisation
IT	Information Technology
LAN	Local Area Network
LE	Large Enterprises
NDEI	Networked Device enabled Intelligence
NSIS	Network/Sector focussed Information Systems
PM-Info	Product Monitoring Information
POS	Point of Sale
PQ-Info	Product Quality Information
Q+S	Qualität und Sicherheit (quality assurance system in Germany)
QM	Quality Management
RFID	Radio-frequency Identifcation
SAT	Satellite-based Network
SME	Small and Medium-sized Enterprises
SOA	Service-oriented Architecture
TL1	Technology Level 1
TL2	Technology Level 2
TL3	Technology Level 3
UI	User Interface
UML	Unified Modelling Language
WAN	Wide Area Network
WHO	World Health Organisation
WLAN	Wireless Local Area Network

1 Introduction

Food products and their consumption are vital parts of our daily life. Consumers are interested in providing themselves with food that is safe, healthy and meets their quality expectations at affordable prices. Agri-food enterprises are globally connected in a multitude of business relationships to provide the food market with an unprecedented variety of products meeting the consumer demand and reaching from fresh and naturally grown products to complex processed food.

The past decade in the European food sector was and is still tremendously affected by different cross-national and national food crises (e.g. BSE in the early 2000s) as well as food-borne diseases (e.g. the recent outbreak of EHEC O104:H4 in Germany in 2011). These crises increased the awareness for the sensibility of the food production and food-borne diseases and resulted in joint efforts of all European member states to consolidate and adapt the European food law. Concurrently, a shift in consumer awareness (VERBEKE 2005) towards food additives, pesticides, genetically modified organisms for production of food (KUIPER ET AL. 2001), novel food products as well as the sustainability of global food production in general (FRITZ AND SCHIEFER 2008, LEHMANN 2011) challenges agri-food enterprises every day.

Food markets, consumer demand and politics are continuously adapting to recent issues and consequently new challenging requirements for agri-food enterprises emerge. Due to these developments, agri-food enterprises are forced to assure food safety by implementing quality and hygiene management concepts for their production and trade processes to comply with these requirements (HANNUS 2008). Additionally, certification of these activities, based on quality management standards, to control and assure compliance with legal and specific requirements from food retail and industry, is leading to a sophisticated mix of requirements that has to be addressed for market access.

The success of agri-food enterprises is closely linked to the ability to satisfy these requirements. Agri-food enterprises are challenged to provide products according to the required attributes, and to provide additional product information to proof their quality and safety (VERBEKE 2005, MEYER 2010, LEHMANN 2011). Today, the need for transparency related to food products and the status of interfirm business processes are not only a trend, but also a major driver of increasing competitiveness by providing quality and safety guarantees on detailed and reliable data for process flexibility, coordination and optimisation (BEULENS ET AL. 2005, FRITZ AND SCHIEFER 2010). Other trends, such as ecological and social responsibility, are extending the required product quality attributes by new indicators (LEHMANN 2011). This requires the chain-wide collection of related information and its aggregation for measurement and evaluation of these indicators. Because the product life cycle includes all stages of the supply network, the re-organisation of processes for optimising the ecological and economic efficiency requires new approaches and an extension of the current information exchange practice.

The consumer demand on food products is as individual as the demand for information on these products and might not be completely met in future by providing general information. However, information provision to any stakeholder has to address their specific information needs, and requires a form that is directly understandable in order to be effective (VERBEKE 2005).

1.1 Problem statement

Answers to specific and individual information needs can often be found in information systems of agri-food enterprises along the food supply chain; enterprises already have systems in place to record, monitor, evaluate and communicate various types of relevant information throughout production- and trade-processes. However, these systems are mostly situated in the individual enterprise or encompass only a few members of the network (SCHIEFER 2004). The communication, especially of food quality and safety information, is poorly developed. In times of a food crisis this lack of communication and resulting long reaction times adds to greater uncertainty at every level. Required information and guarantees about the effectiveness of food safety mechanisms cannot be provided on time to agri-food enterprises along the chain and to the consumer to reduce these uncertainties.

The major reason for this deficit, besides technical issues, is the sensitivity of specific information for the competitiveness of agri-food enterprises. Furthermore, the willingness to share information is decreased by the uncertainty about the information processing and possible provision to actors other than the intended ones. Any information exchange system development has to assure that information is only provided to specific recipients and the protection of data ownership (CUTELOOP 2008).

To overcome these issues, innovations in the fields of process organisation and the way information is exchanged between stakeholders are urgently required. Innovation in this context does not necessarily mean to invent new things, but also to re-organise existing practice to enable new solutions to existing problems (OMTA 2002). Developments and improvements of information and communication technologies (ICT) – more specific digital computing and the internet – offer tremendous chances for the food sector in general and agri-food supply chains in particular to increase market transparency and therefore reduce transaction costs and improving inter-enterprise coordination (BUNTE ET AL. 2009). The adoption of ICT strongly depends on available enterprise resources, which are very heterogeneous in the food sector due to the high degree of small and medium sized enterprises (SME) (SCHIEFER 2004). Innovations in the field of network solutions for the sector require arrangements to include SME's into the innovation process (OMTA 2002, GELLYNCK AND KÜHNE 2008).

1.2 Research objectives

Research needs in the field of information logistics generally focus on the individualisation and task-orientation of information supply to meet specific information needs. New technologies such as radio frequency identification (RFID) or developments of web-based technologies (e.g. web services) offer great possibilities, when combined with each other, to overcome present deficiencies by "Information as a Service" concepts. However, the current landscape of ICT in agri-food enterprises has been developing in the course of 10-15 years and aligned to a multitude of internal requirements leading to a monolithic system landscape with individual character (GABHARDT AND BHATTACHARYA 2008). Electronic data interchange (EDI) has developed to a valuable tool for the exchange of static transaction-related data, but it lacks the ability to communicate product- and dynamically changing process-related data.

Improving transparency by extension of the current information exchange practice for dealing with the previously stated challenges of the food chain, calls for initiatives addressed in this thesis. This thesis concentrates on the elaboration of a framework for flexible communication services that build on interactions between suppliers and customers, so called feedback loops, which serve the communication needs. The framework considers the integration of new technologies to improve the information exchange and thereby improve product- and process-related transparency between agri-food enterprises.

The integration of existing "applications" from different agri-food enterprises along the chain could provide the necessary information through appropriate information collection and processing schemes to serve stakeholders' needs. This integration could mean new developments or, alternatively, the adaption of existing applications to chain and network based communication services. As information needs might change over time, the framework has to provide flexibility in exchange of relevant applications.

Aligned to the increasing need for transparency and the lack of solutions to solve present issues in information exchange, the research objective of this thesis is to develop a general applicable framework for business information services independent from product types or business domains as well as the integration of these information services into business processes by considering supportive technologies.

1.3 Research design

To reach these research objectives, this thesis is based on a design-oriented approach. Design-oriented research originates from engineering science and provides a problem focussed approach for developing solutions alternatives (SIMON 1988, VAN AKEN 2004). The elaboration of a design-oriented concept for solving a problem by the construction of new artefacts (VAN AKEN 2004, SIMON 1988) involves different consecutive stages (DENZIN AND LINCOLN 1994, BARAB AND SQUIRE 2004, HEVNER ET AL. 2004):

1) **Problem identification and description,** encompassing organisational and technological needs, based on different perspectives as well as examining constraints leading to the described deficiencies,
2) **Development of theories or artefacts**, supported by the "knowledge base", which includes foundations (e.g. frameworks, theories, models) and methodologies (a.o. formal descriptions, modelling techniques),
3) **Evaluation** of the developed concept, using analytical methods such as experimental case or field studies, prototyping or simulation,
4) **Drawing conclusions and inferring** from the research to the identified problem and the feasibility of the developed theories or artefacts.

Especially research, involving the development of IT-based concepts, has to address the design tasks faced by practitioners, which requires a proper conceptualisation and representation provided by the application of appropriate techniques e.g. modelling or simulation (MARCH AND SMITH 1995). Additionally, guidelines for the implementation or optional implementation examples are required for testing and evaluation (MARCH AND SMITH 1995). The transfer of this approach into a thesis outline is depicted in Fig. 1.

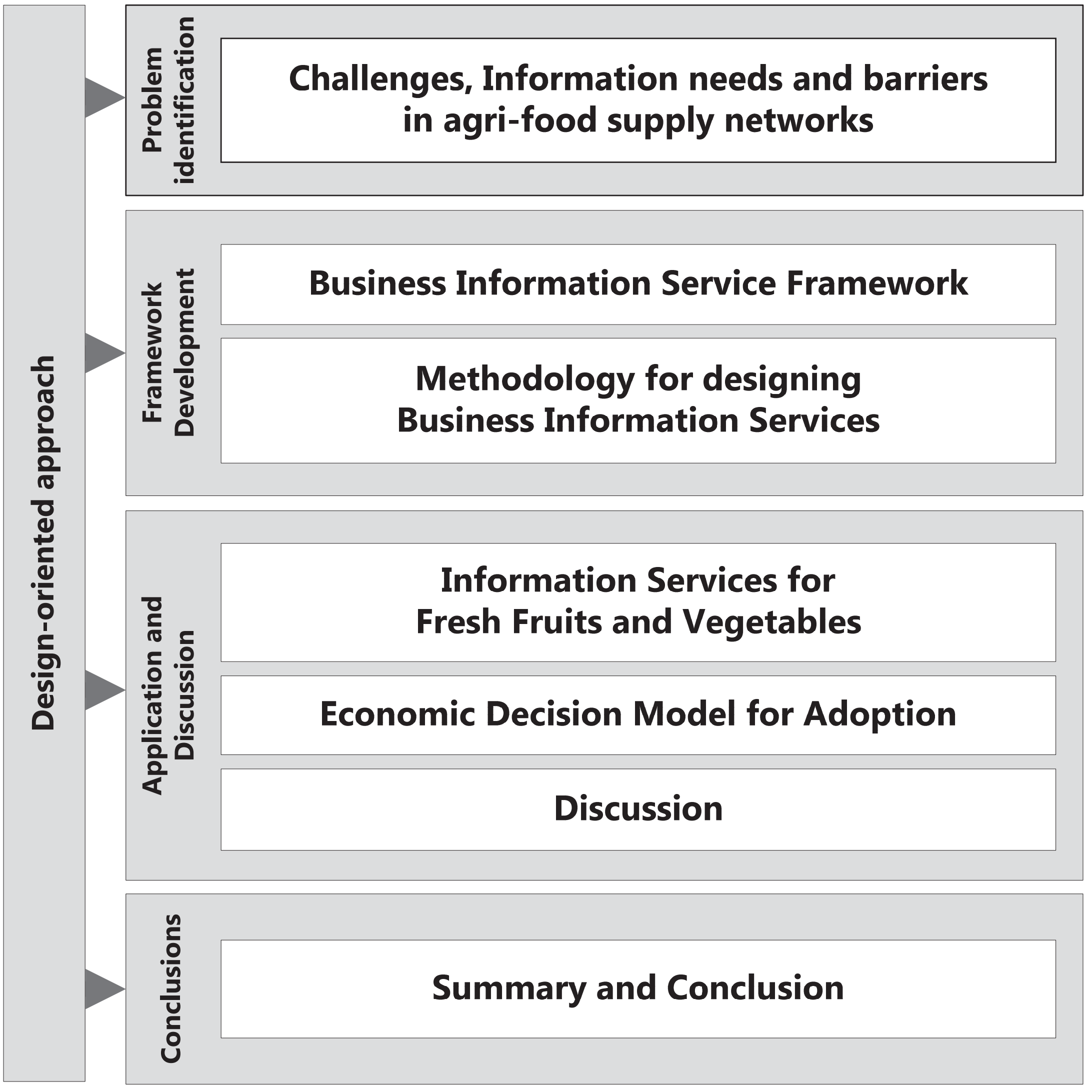


Fig. 1: Outline of this thesis

The outline of this thesis follows the steps of the presented design-oriented approach and is separated it into four parts.

The problem identification and description is presented in chapter 2 based on literature research and preliminary informal expert interviews with representatives from retail organisations (quality management and regional organisation), trade organisations (agricultural co-operative societies and one distribution centre) as well as service providers (logistic and box service providers). This results in different implications for the research objective.

The development of a generic framework for business information services to tackle the research objectives (chapter 3) initialises the second part of this thesis. This includes the definition of generic elements and integrated technical components as well as a methodology for modelling and development of information services (chapter 4).

In the third part of this thesis, the previous developed framework is applied to an application scenario in the fresh fruit and vegetables sector, and three principle reference services are developed focussing on specific information needs identified from expert interviews (chapter 5). This is followed by an economic decision model for adoption (chapter 6) of new technology in conjunction with the elaborated services and the service framework. The third part closes with a discussion (chapter 7) of the findings based on an expert workshop and experience from the application scenario.

The thesis finishes with a summary and conclusion (chapter 8) reflecting on all three parts and outlines implications for the transfer of results to the food sector.

2 Challenges, information needs and barriers in agri-food supply networks

Agri-food enterprises are challenged by a multitude of requirements arising from consumers, policy, industry and other stakeholders along the food value chain (FRITZ AND SCHIEFER 2010). In this chapter an overview is given on different requirements and information needs arising out of these requirements relevant for this thesis are discussed.

Requirements and challenges

The previously described requirements can be divided into public and private requirements depending on the stakeholder formulating them. Fig. 2 the different directions (arrows and lines) from where requirements are addressed to the different entities are depicted.

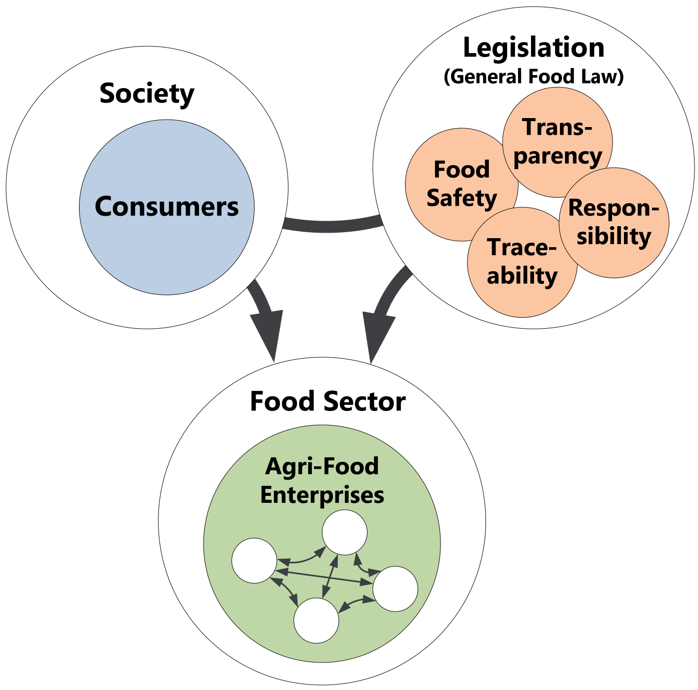


Fig. 2: Public and private requirements

Public requirements primary arise from values of society, including consumers as individuals, and legislative initiatives.

The societies' perception, in respect to the impacts and consequences of global food production activities, on the sustainable development and facilitation of resources, including social, environmental and economic issues, has changed (AIKING AND DE BOER 2004). The success of agri-food enterprises depends on the consumers' acceptance of provided products and services. This leads to a high degree of consumer orientation within the European agri-food markets (SCHIEFER 2003). Consumers follow individual criteria for selecting their food products. The demand and procurement patterns of European customers for food products changed dramatically in the past decades (FEARNE AND HUGHES 2000). The consumer demand few decades ago was met to a high degree by regional and seasonal available products. Today, consumers are more demanding concerning safety and quality, integrity as well as diversity and availability of food products and the associated provision of information in order to better select the products and comprehend the impacts of their buying decisions (see a.o. BEULENS ET AL. 2005, VAN DER VORST 2000, BUNTE ET AL. 2009, HAAS AND WEAVER 2010, FRITZ AND SCHIEFER 2010). The development of new information technologies, especially the emergence of the internet, enabled new ways of gaining knowledge about food products and therefore influences the decision process (VAN DER VORST 2000). Following the logic of Fig. 2 consumers' demands represent critical requirements to the food sector that have to be met by agri-food enterprises to stay competitive.

Legislative requirements for agri-food enterprises

The European Parliament and national governments create the legislative fundament for the food sector based on societal needs. Due to several crises in the food sector in the past decades, the uncertainty regarding the safety (e.g. food borne diseases) and healthiness (e.g. additives) of food products increased at consumer level (VERBEKE 2005). This reflected by a multitude of regulations, formulating requirements for agri-food enterprises and the marketability of food products, including regulations such as e.g. the recently enacted regulation on labelling of food products generalising the information that has to be provided attached to the product or specialised labelling legislation (a.o. EC NO. 1830/2003 and EC NO. 1924/2006).

Looking at the motivation for the consolidation of the European food law four major drivers can be identified (EC NO. 178/2002, for details see Appendix A):

1) The protection of consumers by ***improving food safety,*** which is realised by setting up food safety standards and introducing mandatory requirements for agri-food enterprises (e.g. "Food Hygiene Package" (EC NO. 852/2004, EC NO. 853/2004),

2) ***Traceability of food products from "farm to fork"*** to enable the identification of harmful products and to follow their distribution path through the sector,
3) Increasing ***transparency*** to prevent misguidance of consumers by setting up explicit requirements for labelling of food products,
4) Defining ***responsibilities for agri-food enterprises*** to meet legislative requirements.

Additionally, the consolidated food law focuses on the alignment with global guidelines of the Codex Alimentarius (EC NO. 178/2002) to establish a common view on the previous presented issues.

Private requirements originate from agri-food enterprises, which have to meet the previously described public requirements to be successful on the market. Enterprises in the European food sector operate in a globalised environment. A high number of small and medium-sized enterprises (SME), mostly at local agricultural production plants, provide raw materials for the food industry as well as fresh produce to large scale international food retail groups (see a.o. FRITZ AND SCHIEFER 2002, O'REILLY ET AL. 2003, CIAA 2011). The food value chain can be divided into different stages from agricultural production, processing, trade, to retail, representing the major interface to the consumer with a market share of 66% (WIJNANDS ET AL. 2007). The sector is characterised by a high degree of fragmentation with a high number of enterprises. This relation is presented with an example from the food industry in Table 1.

Table 1: Structure of the food industry (adapted from CIAA 2011)

	Annual turnover (2007) by group	**Number of enterprises in the food industry**
Small enterprises	21,1%	95,5%
Medium enterprises	27,1%	3,6%
Large enterprises	51,8%	0,9%
Food sector total	**954 bn Euro**	**310.000**

Definition of Small, Medium and Large Size Enterprises: small = 0 to 49; medium-sized = 50 to 249: high > 250 employees

Agricultural production and retail are connected by a number of different enterprises, specialising in trade and processing, and are supported by a number of enterprises providing services (e.g. production resources or transport logistics).

In literature, different approaches to describe these relationships and connections can be found. The definitions are “supply chain” (CHRISTOPHER 1992), “supply network” (HARLAND 1996) and “netchains” (LAZZARINI ET EL. 2001), which are summarized in Table 2.

Table 2: Definitions of supply chain, network and netchains

Author (year)	Term	Definition
CHRISTOPHER (1992)	Supply Chain	„The network of organisations that are involved, through upstream and downstream organisation linkages, in the different processes and activities that produce value in form of products and services in the hands of the ultimate customer.“
HARLAND (1996)	Supply Network	„Set of supply chains, describing the flow of goods and services from original sources to end customers.“
LAZZARINI ET AL. (2001)	Netchain	„Set of networks comprised of horizontal ties between firms within a particular industry or group, which are sequentially arranged based on vertical ties between firms in different layers (Suppliers, Manufacturers, Distributors, Consumers).“

Although supply chains represent a straight forward vertical linkage of different stages, the reality in the food sector is even more complex. Because of the diversity of agricultural and processed food products, agri-food enterprises usually have multiple suppliers and customers, which may change over time (OMTA 2002, VAN DER VORST ET AL. 2005a). Looking at the different stages, close horizontal co-operations between enterprises, especially in the agricultural production and processing stage, and vertical co-operations between all stages are of relevance and have to be taken into consideration. These characteristics are captured under the term “agri-food supply networks” (AFSN) in the remainder of this thesis.

Challenges arise from this complexity for the management of these relationships. To meet the responsibilities formulated by the European food law, enterprises have to ensure that their products meet the high quality and safety standards. Due to the division of labour and the participation of a number of enterprises in the food value chain, the verification of the compliance of other enterprises with these requirements is difficult. A reason for this is the complexity of relationships in the food sector as such. Based on this, private requirements formulated by agri-food enterprises within the food sector arise from the previously stated responsibility of agri-food enterprises to comply with legislative requirements.

Due to the high degree of fragmentation and product-related specialisation, agri-food industry and retail enterprises formulate a number of different requirements for their suppliers to ensure food quality and safety. These requirements are usually represented by certification schemes and quality standards, which have to be met by actors in the previous stages building the supply base for these enterprises (TRIENEKENS AND ZUURBIER 2008). Examples for these standards are the International Food Standard (IFS), ISO 22000, the standard of the British Retail Consortium (BRC) and the standard provided by "Qualität und Sicherheit" (Q+S), a chain-wide certification scheme for fresh products and feed. Especially the retail driven standards (IFS, BRC) are continuously updated and supplemented with arising public and private requirements, concentration e.g. on the reduction of packaging in order to reduce its environmental impact (BRC 2011). However, the compliance with required standards developed to a critical private requirement for establishing supplier-customer relationships in agri-food markets (KRIEGER 2007).

2.1 Information needs and transparency in agri-food supply networks

The complexity of the food sector and the diversity of products offered, raise uncertainties for consumers, as well as for agri-food enterprises. Information needs for agri-food enterprises arise preliminary from the previous described challenges (see a.o. VERBEKE 2005, VAN DER VORST ET AL. 2005a). Based on the compliance with public and private requirements transparency has become an important issue in the design and management of food chains and networks (FRITZ AND SCHIEFER 2010, BEULENS ET AL. 2005). HOFSTEDE (2002) defines transparency within a supply network as *"the extent to which all network's stakeholders have a shared understanding of, and access to, product and process related information, that they request, without loss, noise, delay and distortion"*.

Based on this argumentation, BUNTE ET AL. (2009) define different levels of transparency in agri-food supply networks focusing on:

- Product transparency, including information on the product and process history of food flowing through the AFSN, as well as food quality, integrity and safety issues,
- Operational transparency, including information on logistics and other parameters across the AFSN,

- Strategy transparency, including jointly activities to find opportunities and threats for AFSN to enable adaptive responses to the previously described requirements.

Following this train of thought, the following part of this chapter concentrates on the first two categories and the related information needs.

2.1.1 Quality, integrity and safety of food products

In today's highly competitive agri-food markets the provision of food on a high quality level has become a precondition for competitiveness for enterprises within the food sector (SCHIEFER 2003). However, intensive discussions in literature about the term food quality show significant differences between scientific disciplines (LEHMANN 2011). Information for transparency of food quality in this thesis focuses on all product characteristics that are summarized under the term food quality, including information on food safety and food integrity as well.

In a narrow sense focussing on the food product itself, **food quality** describes all intrinsic and extrinsic factors linked to a specific product. While intrinsic factors are representing product inherent characteristics, extrinsic factors describe quality attributes which are linked to the product by external parties (SCHIEBEL 2005). Intrinsic factors include characteristics, such as the cultivar of agricultural products, sensory characteristics such as colour and taste, and also the content of major nutrients, ingredients and secondary substances as well as technological attributes e.g. texture and consistency (WINTER 2002, KRUG ET AL. 2002, HERMANN 2001). These product characteristics are directly measurable using sensory analysis or simple measurement methods such as e.g. penetrometric, refractometric or chemical analysis.

Extrinsic factors, however, describe attributes, which are linked to the product without being a direct part of it. Traditional extrinsic factors are the origin of products, brands, signals and prices of products (HAAS AND WEAVER 2010). Topics such as ethical, environmental or social aspects of food production and products, summarized under the term **food integrity**, are of interest to consumers and are covered by specialised standards and certifications as well as signals a.o. for fair trade or organic production.

Food safety is often mentioned in combination with food quality. However, food safety is a prerequisite for the marketability of food products and can therefore be seen as the main food quality issue. The product-related safety is defined by the World Health Organisation (WHO 2002) as *"the assurance that food will not cause harm to the consumer [...]"* (CODEX ALIMENTARIUS 2003, WHO 2002) because of *"the absence of physical and chemical substances and (micro-) biological contaminations harmful to human health"* (EC NO. 178/2002). Whereas food quality can be observed by sensory analysis or simple measurement, the discovery of food safety issues require laboratory procedures including microbiological techniques or chemical analysis.

Information needs regarding product quality originate from the required compliance with public and private requirements as well as personal needs. However, these information needs can be satisfied in different ways. Information provision to consumers concentrates on:

a) private labels and signals, highlighting product characteristics (e.g. organic products, fair trade), as well as
b) legislative required information elements such as e.g. list of ingredients,

implying secured product characteristics and including information e.g. on allergens, that might be required or undesired by the consumer.

The provision of food quality information to agri-food enterprises has to be more detailed. Quality assurance is and supposedly will become one of the central competitive factors in the agricultural and food sector (SCHIEFER 2003, DOLUSCHITZ AND KUNISCH 2004). Suppliers need to ensure specific characteristics of their provided raw materials or food products, which are required by retail or industry groups. Information needs of agri-food enterprises concentrate on the innocuousness of food products and their conformity with all requirements.

2.1.2 Traceability

Due to the increasing global cross-links in trade activities, traceability is an inevitable aspect of food safety, especially since the introduction of the general food law.

Traceability in the legal context (EC NO. 178/2002) focuses on:

- the traceability of food, feed, food-producing animals and all substances incorporated into foodstuffs; it must be established at all stages of production, processing and distribution.

- the requirement for agri-food enterprises to apply appropriate systems and procedures to record all suppliers providing those products as well as all customers to whom products are provided.

Traceability focuses on the ability to document and trace a specific product forward and backward along its path through the supply network and on the tracking of products moving downstream (see a.o. VERNÈDE ET AL. 2003, VAN DER VORST ET AL. 2005a, FOLINAS ET AL. 2006, GELLYNCK ET AL. 2007, FRITZ AND SCHIEFER 2009).

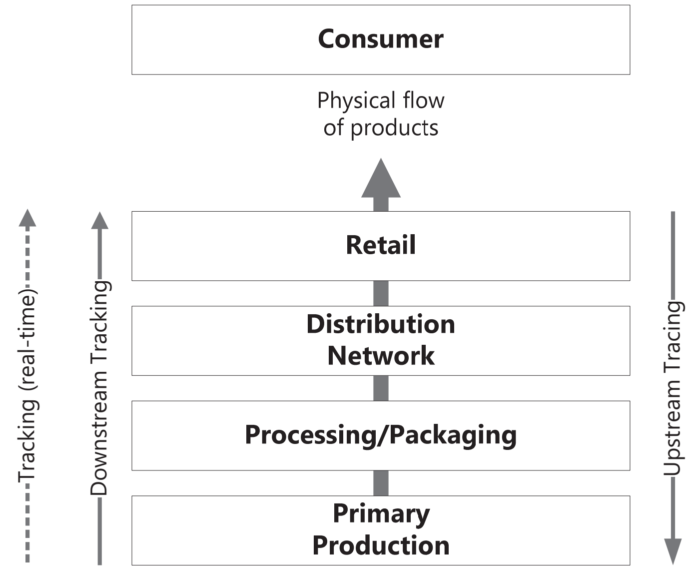


Fig. 3: Tracking and tracing of products (adapted from VERNÈDE ET AL. 2003, FOLINAS ET AL. 2006)

According to GANDINO ET AL. (2009), traceability management has to assure internal and external traceability of a specific product unit. External traceability concentrates on business-to-business and business-to-consumer traceability of trade units. Internal traceability focuses on the tracking and tracing of incoming and outgoing products as well as raw materials along internal production processes.

Traceability of food products is not only a legislative requirement, but also the major precondition for the exchange product- and process-related information based on modern tracking and tracing systems (BEULENS ET AL. 2005, KALFAGIANNI 2006, FRITZ AND SCHIEFER 2009). Important information needs, in the focus of different stakeholders, originates from uncertainties about the origin of food products and other aspects related to food integrity. This results in a need for guarantees based on traceability information focussing on aspects such as:

- the labelling and traceability of genetically modified food and feed products based on the regulations (EC NO. 1829/2003 and EC NO. 1830/2003, KUIPER ET AL. 2001, THEUVSEN AND HOLLMANN-HESPOS 2005),
- the guaranteed origin of regional products based on traceability information (POIGNÉE ET AL. 2004),
- the traceability of the origin of organic products and the guaranteed compliance of the agricultural production practice with the legislation for organic products (EC NO. 834/2007, EC NO. 889/2008, EC NO. 271/2010).

All these aspects require inter-enterprise communication schemes for the exchange of information on traceability through the supply network.

2.1.3 Logistics and organisation of agri-food supply networks

Additional challenges and information needs originate from the complexity of food supply networks, their organisation as well as logistics in these networks, summarised by BUNTE ET AL. 2009 under the term "*organisational transparency*". The increasing distance, agricultural production and the final consumer that has to be bridged, is a tremendous organisational challenge (METRO GROUP 2011). To provide the demanded diversity of products with a high availability as well as the previous described division of labour on a global scale, agri-food enterprises have to co-operate in supply chains and networks covering different stages (VAN DER VORST ET AL. 2005a, BERNING 2002, FLEISCHMANN ET AL. 2008). According to LAMBERT ET AL. (1998) logistic management covers all activities, that are "*[...] part of the supply chain process, that plans, implements and controls the efficient, effective flow and storage of goods, services and related information from the point-of-origin to the point-of-consumption in order to meet customer requirements [...]*" (LAMBERT ET AL. 1998). The basic functions of logistics are concentrating on services to provide products (IHDE 2001) at the right time, in the right quantities, at the right place and in the quality as they are required (AUGUSTIN 1990, VAHRENKAMP 2005, FLEISCHMANN ET AL. 2008). Following the given definition, control and management activities in logistic processes include different aspects, such as procurement, processing, inventory control, order processing, material handling and customer service (VAN DER VORST ET AL. 2005a). The efficient organisation of these processes requires reliable, detailed and timely information based on information exchange between production, distribution and trade. Additionally, these processes are considered as "*information intensive activities*" (VAN DER VORST ET AL. 2005a) whereby information on process-and product-related aspects is preliminary required for decision making.

These information needs are closely related to performance sensitive aspects of logistics covering a.o. the reliability of deliveries (VAN DER VORST 2000). Due to the perishability of food products as well as the naturally caused variability of quality and quantity (SCHIEFER 2002, VAN DER VORST ET AL. 2005a), transport and storage processes have to be organised efficiently and effective to reduce spoilage, especially of fresh products requiring cold storage such as meat, fresh fruits and vegetables or processed frozen food products (KADER 2005). This requires product-related information on the quality status of products as well as process-related information e.g. the temperature during transport and storage. Especially critical situations during transport regarding these factors have a huge impact on all consecutive processes. The discovery of such events during logistic processes and the management of these events require decisions based on timely, reliable and detailed information and are summarised under the term "supply chain event management" (HELLINGRATH ET AL. 2008).

2.2 Barriers

As described previously traceability is a prerequisite for product-centric information exchange. Due to the requirements of the general food law, current traceability systems of agri-food enterprises are designed to follow individual needs for compliance and show differences result from individual organisation of internal enterprise activities, the type of product and the product composition. The realisation of chain-wide tracking and tracing schemes, in order to enable information exchange to increase transparency, requires agreements and coordination between suppliers and customers along the supply network (FRITZ AND SCHIEFER 2008).

2.2.1 Managerial and organisational barriers

Managerial and organisational barriers arise from different aspects of transparency. The identification of information needs of stakeholders to-be-addressed by transparency initiatives as well as the identification and access to information sources are major pre-requisites (FRITZ AND SCHIEFER 2010). Additionally, organisational efforts have to be taken in order to collect, to process, to prepare and to provide the required information (BEULENS ET AL. 2005, FRITZ AND SCHIEFER 2010). This might require the alignment of existing information systems to provide information to meet new information needs or the development and organisation of new systems. The enterprises' ability to provide transparency information is highly dependent on these aspects, which are summarised by FRITZ AND SCHIEFER (2010) under the term "*t-readiness*". The most important aspect for improving the current practice is the enterprises' ability to adopt and re-organise technology for the provision of information on the previously presented background.

2.2.1.1 E-readiness

The individual prerequisites of enterprises for technical readiness for information provision are very heterogeneous in the food sector. Due to the high degree of small enterprises and complexities for ICT adoption (GELB 2009, BUNTE ET AL. 2009), especially in agricultural production, as well as the differences between the infrastructural differences on country level (ECONOMIST INTELLIGENCE UNIT 2009) represent managerial barriers, that have to be considered. The term "e-readiness" is a measurement that defines, in the business context, the degree to which a company is able to adopt information and communication technology and use it efficiently for a specific purpose. Enterprises operate in continuous interactions with other organisations (suppliers and customers) and the sector environment (HÅKANSSON AND SNEHOTA 2006). This includes according to ARNOLD AND KÄRNER (2003), to participate in electronically supported inter-enterprise business process activities and transactions. Conclusively, this requires the alignment of business ICT to common sectorial conditions. For this thesis, the definition is extended towards the ability to participate in sectorial e-business activities as well as the digital technology based information provision and exchange between actors in sectorial business networks (FRITZ ET AL. 2011, REICHE ET AL. 2011b). However, the adoption of ICT is highly influenced by the enterprise resources as well as sector prerequisites (REICHE ET AL. 2011b). In an enterprise context the focus shifts towards the allocation of available resources and other strategic or operational aspects, which are influencing the adoption decision. Different levels of e-readiness of an enterprise are defined by the availability of a specific combination of criteria that include (JUTLA ET AL. 2002, CHOUCRI ET AL. 2003, RUIKARA ET AL. 2006):

- the available IT budget for adopting and maintaining ICT,
- the existing ICT infrastructure (applied technology in the company and regional available IT infrastructure) and its reliability,
- the literacy based on knowledge and skills of employees to use the applied ICT efficiently,
- the social and cultural environment (i.e. acceptance of ICT implementation),
- the legal framework, and
- the managerial ability to realize an organizational change and related issues.

In order to meet the dynamically changing requirements in the food sector, efficient and responsive coordinated communication networks are needed (SCHIEFER AND FRITZ 2010) to gain a high degree of flexibility. However, the organisational and managerial basis for the establishment of communication and monitoring systems along the chain is poorly developed.

2.2.2 Technical barriers

The improvement of product transparency is closely linked to the emerging so-called "internet of things"-technologies and concepts aiming at the connection between physical objects and virtual data about this object (GS1 2005, GUILLEMIN AND FRIESS 2010). The most important technologies of this concept (WAMBA ET AL. 2008, GUILLEMIN AND FRIESS 2010) are:

- Identification technologies (e.g. RFID) enabling the uniquely identification of objects by electronic product codes (EPC),
- Information systems linking captured product- and process-related information with object identification information (virtualisation of product information),
- Web-based technologies for connecting information systems through web services for information provision on every single object.

Barriers regarding the adoption of identification technology

Although, new technologies, such as RFID, have proofed to be a key technology for the next step in technical evolution (KÄRKKÄINEN 2003, GANDINO ET AL. 2009), but their diffusion in the food sector is still at a low level. Successful application cases show, that RFID technology has tremendous benefits for process improvements on enterprise and on chain level (for examples see Appendix B and C). However, the preferred identification technology for transport units and packaging for the point of sale in the food sector is still based on barcodes. Important reasons for that are

- the need to build individual RFID applications in the sector, due to the lack of system integrators (MARTÍNEZ-SALA ET AL. 2009),
- the willingness to investments in tags and scanners is reduced by uncertainty about the future developments and possible lock-in effects after adoption of specific RFID technology standards (KÄRKKÄINEN 2003).
- differences in costs and benefits for single companies and benefits for enterprises at later stages of the supply network arise from the implementation of network technology (TAMM AND TRIBOWSKI 2010, MARTÍNEZ-SALA ET AL. 2009).

Especially in the case of RFID technology, costs for enterprises providing finalised products with RFID-tags are expanding, but most beneficial effects of this technology are discovered at retail stage. This shift represents a tremendous major organisational and managerial barrier (TAMM AND TRIBOWSKI 2010).

Barriers for Information exchange

Looking on the diversity of information needs in the area of transparency, technical barriers occur inhibiting the exchange of information between enterprises in the sector. Due to the naturally grown number of enterprise-centric, individual and heterogeneous systems at the different enterprises, a number of challenges concentrating on four major aspects:

- The availability of information, especially focussing on organisational processes and dynamic product characteristics (e.g. sensor networks, networked devices and systems for data collection) (BEULENS ET AL. 2005, SCHIEFER 2004),
- Accessibility of information (e.g. information systems, portals, technical architectures, interfaces) based on flexible connections (BUNTE ET AL. 2009) between different systems protecting the interests of the providing enterprise (data ownership) (see a.o. BEULENS ET AL. 2005, CUTELOOP 2008),
- Commonly agreed information reference models providing content based on vocabularies and semantics (BUNTE ET AL. 2009), as well as standards for information exchange (MARTINI ET AL. 2009),

- Ways of delivering information to stakeholders using web-based technologies for services and content (BEULENS ET AL. 2005).

2.3 Implications for the research objective

The previously describes transparency issues and their importance for different stakeholders raise managerial, organisational as well as technical challenges to agri-food enterprises. Although progress has been made in the past to tackle these issues, important problems still remain. In the past decade crises in the food sector (e.g. BSE, Dioxin, EHEC) showed, that the availability and the exchange of information has been (WILSON AND CLARK 1998) and is still deficient in one or all important aspects

a) Completeness and accuracy of food safety and quality information,
b) Accessibility, availability and reliability of necessary information related to the causes of the crisis (e.g. recently in the EHEC outbreak in Germany 2011),
c) Untimely provision of necessary and urgently required information for reducing the spreading unsafe products and the reduction of negative impacts on the involved parts of the agri-food sector as well the maintenance of consumer trust in affected agri-food products (e.g. Dioxin in feed in Germany 2011).

The presented listing demonstrates, despite the differences of the involved examples of food products, the most pressing information needs of agri-food enterprises to handle critical and unexpected situations. To narrow down the most important aspects related to this thesis, a series of informal expert interviews with representatives from retail organisations (quality management and regional organisation), trade organisations (agricultural cooperative society and distribution centre) as well as service providers (logistics and pooling service provider) has been carried out preliminary to this thesis. The most important and pressing information needs and focus domains of this thesis are related to:

- **Information on food quality and safety issues**, in order to identify specific products, which fail to meet demanded quality expectations or in an extreme case are harmful to consumers' health.
- **Information on the position of these products in the different distribution channels** as well as the origin of food products based on tracking and tracing information.

However, agri-food enterprises collect and store tremendous amounts of data arising out of required process documentation for certification and compliance with legal requirements. This collection bears huge potentials for communicating the effectiveness of implemented food safety and quality arrangements. Due to the high throughput of products and the relatively short shelf-life of most food products these information loses relevance after time. The extension of the information lifecycle by further facilitation of these records (SOLLBACH AND THOME 2008) for providing transparency information enables further diversification potential and therefore potential for increasing competitiveness (PORTER AND MILLAR 1985). This thesis focuses on the facilitation of this potential by providing a general applicable framework for business information services based on the connection of these different information clusters along the food supply chain.

The emergence of new technologies, especially RFID and web-based technologies for information provision, promises improvement potentials e.g. by automation of process tasks and a higher level of transparency realised by available, detailed and reliable data for decision making. The combination of identification technology and web-services bears a powerful potential to provide product- and process-related information with a high level of detail for unmistakeably identifiable packaging units and therefore enables the ability to satisfy specific information needs. However, a chain wide application of these technologies in the food sector is still not archived due to the previously described barriers. This increases the need for investigating potentials triggering investments and adoption in the food sector. Several European research projects (e.g. CuteLoop) and initiatives (e.g. European Technology Platform Food for Life) focus especially on application scenarios and demonstrators for the implementation in specific business domains. The consideration of facilitation and integration of these technologies into the service framework is part of the objective of this thesis.

3 The Business Information Service Framework

The Business Information Service Framework puts emphasis on the satisfaction of information needs of agri-food enterprises concerning product quality and process-related information following a product-centric approach.

Looking at the current situation of the food sector, information technology and developed systems enabled the collection of information on food products in a high level of detail. Due the fact, that agri-food enterprises are required to document product- and process-related activities to comply with certification schemes and legal requirements, the amount of data available at the companies is tremendous. Following the logic of PORTER AND MILLAR developed in 1985, information creates competitive advantages on the one hand by enabling new diversification strategies in providing products with additional information above the legal required level and on the other hand the facilitation of information in order to lower costs (PORTER AND MILLAR 1985). Information services could provide flexible, cost- and time-saving solutions for enterprises to meet their increasing information demands, therewith improving the competitiveness of enterprises, by providing these services for creating added value to their customers, and supporting the sector by satisfying different information needs on characteristics of food products (LEHMANN 2011).

From this perspective, **information services are defined as the provision of information on a product and it's characteristics to a customer, whereas the provision and the content of the provided information has or creates a certain value by satisfying the information needs of this customer.**

Information as a company service is based on the idea, that product- and process-related data, stored in internal formation systems and repositories, is made accessible in a standardized way to interested parties by using standardized web-based technology. This requires standardised transformation of data as well as open standards and protocols for access to this data by service requestors regardless of the systems they are using (CREESE ET AL. 2009).

Aligning this framework to food products would require the identification of product- and process-related data captured and stored at different locations or actors in the food chain and its exchange between agri-food enterprises (LEHMANN 2011). The digital information either can be transferred from different actors to central systems, or the data remain at these actors and are made accessible by information services on a regular basis or on demand. However, the organisation of information exchange between actors has to match with inter-firm coordination mechanisms (FRITZ 2003). The centralised approach is not feasible for open market relationships, because of the low acceptance of the participants, especially in agricultural production (compare with case study from the pork sector). On the other hand the acceptance of internet-based central systems increases in closed supply chains and long term business relationships. Looking at quality certification schemes such as GlobalGAP or Q+S, the transfer of information to central databases as a requirement are aligned to the participation in these schemes. Focussing on the food sector as a whole, a centralised approach would not be feasible due to the amount of data and the low acceptance caused by data ownership issues and failures in the past. The establishment of a decentralised framework as a base for information services is one of the objectives of different European research projects (see a.o. CUTELOOP 2008, SOA4ALL 2011 and projects of the European Research Cluster on the "Internet of Things" (IERC 2011)). The framework developed in this thesis follows this decentralised approach.

The need of customers for information and transparency in dealing with the inherent complexities of the food chain calls for three initiatives (REICHE ET AL. 2008, SCHIEFER AND FRITZ 2010):

1) Establishment of communication services that build on customer loops, serving the communication needs. These services have to build on an infrastructure that allows the interaction with network actors from outside the coordinated business relationships.
2) A framework which has to assure system trust through the provision of information that supports the reliability of information, the integration of appropriate system security schemes, and the protection of data ownerships.
3) A framework which has to integrate different applications or existing systems that could provide the necessary information through appropriate information collection and processing schemes to serve the actual actors' needs which are specified previously. The integration could mean new developments or, alternatively, the adaption of existing applications to the chain and network based communication services.

Before defining the framework for business information services, an overview is given on related topics required for the development of this framework.

3.1 Information logistics of business information services

The framework of information logistics was developed in the late 1990s (see a.o. KRCMAR 1991, AUGUSTIN 1990). The role of information changed tremendously with the emergence of modern ICT and became a valuable factor in the value creation process that has to be managed (KIM AND ROGERS 2005). Based on this, the framework of information logistics focuses all business activities and functions that are required to control and coordinate information flows within enterprises and their environment (SZYPERSKI AND KLEIN 1993). Therefore, information logistics is part of the management activities regarding information and related technologies, which are summarised under the term "information management" (a.o. KRCMAR 2005, HEINRICH 2001).

WINTER ET AL. (2008) define information logistics in business management according to this view as "*the planning, control, accomplishment and supervision of the required flow of data, which reach beyond an observation unit [...]*" for decision support.

Observation units are scalable from the smallest independently acting element of the process organisation over the individual business areas to the examination of the entire company (WINTER ET AL. 2008). However, the increasing information availability and ubiquity of information provided by information and communication technology on the one hand and the lack of appropriate task-oriented information provision on the other hand, is a challenge, which has to be met by developing new frameworks and solutions, which aim at the individualisation and purpose-orientation of information supply (FRAUNHOFER 1999, HASELOFF 2005). Additionally, the information, which is critical for accomplishing tasks in a business process, is often available at the time when it is generated and not when it is required by the individual. This divergence between place of generation of information and the point in the process, where this information is required is another challenge that has to be tackled by information logistic frameworks and leads towards a process orientation of information logistics.

Taking the observation unit as a starting point, one arrives at a process-oriented view on logistics. The value-creating activities in a company are supported by information logistics through the provision of information for decision-making (BUCHER 2008), through which the effectiveness and efficiency of these activities are positively influenced.

Process-oriented information logistics summarises, according to BUCHER (2008), "*all functionalities [...]" and services "[...] for data evaluation and provision, which are embedded in business processes and focus on the support of a human actor with task-oriented information to take process-inherent decisions [...]*". This opens a new perspective on information logistics, which is not only aiming at purpose-oriented and individualised information supply, but also aiming on data evaluation for decision support in a specific context. This context specific information supply was highlighted by HASELOFF (2005), by adding to the previously presented definition, that information logistics "*has to ensure that only the right and effectively needed information is made available to individuals at the right time in the right context*" (HASELOFF 2005).

Hereby it is crucial that the information, which is provided in the operative context, is provided in real-time or near-real-time. The increasing effectiveness and efficiency of the activities of a process is dependent on minimizing the so-called latency time between the occurrence of an event and the decision-making or respectively the initiation of measures to-be-taken (BUCHER 2008). Therefore obtaining and providing information with the help of information and communication technology is also an integral part of information logistics.

KRCMAR (2005) describes this integration of technological and IT-measures, further described as functionalities, as integrated technical components. These components represent application-independent combinations of basic technology and basic functionalities in order to realise specialized IT-concepts. Basic technology is hereby described as a platform based on ICT, which provides basic functionalities (KRCMAR 2005). Storage, processing and communication are to be understood as basic functionalities, following the common definition of information and communication technology. In the following, a compilation of all functionalities in this context is given:

- Communication: data capturing from users and systems and data provision to users facilitating User Interfaces (UI) or between systems (machine-to-machine). Hereby communication networks may be incorporated for the data transfer. The communication of data is realised through a multitude of interfaces.

- Processing: Includes all software functions i.e. to store, compare, aggregate or merge, to manipulate data or information.
- Storage: comprises the deposit and retrieval of data on physical data carriers.

An integral part of information logistics results from the necessity to plan the implementation and facilitation of ICT in such a way, that information can be provided properly and timely to meet user requirements. All information logistic issues will be addressed in the BISF and further elaborated in the application case.

3.2 Service-oriented architecture for business information services

The concept of service-oriented architecture (SOA) and information logistics are closely related. While information logistics focuses on the task-oriented and context specific provision of information for an individual, SOA focuses on how this information provision can be realised in an architectural way.

The framework of service-oriented architecture is concentrates on the provision of information as a service or described by GABHARDT AND BHATTACHARY (2008) *"SOA is about connecting customer requirements with enterprise capabilities, regardless of technology landscape or arbitrary organisational boundaries [...]"*. Breaking down this general definition, SOA is about meeting information needs of customers by facilitating enterprise informational resources and exchange capabilities.

The implementation of SOA as an technology architecture consist of a combination of different technologies, systems as well as interfaces (ERL 2007), focussing on orchestration of

a) **operational resources** such as existing systems, applications and databases, that are individually developed or purchased from a vendor, to establish
b) **services**, in order to link and re-arrange content from different operational resources and provide more sophisticated content (ERL 2007, GABHARDT AND BHATTACHARY 2008).

These services are developed closely linked to satisfy different information needs of business units and other enterprises in connected business processes and are listed in service inventories. A service inventory "*is an independently standardized and governed collection of complementary services*" (ERL 2007) linked to an organisational unit such as a business unit or an enterprise. These inventories allow identification of available service and the point where they can be requested (GABHARDT AND BHATTACHARY 2008).

SOA and the food sector

Following the SOA framework, a decentralised approach for the food sector, would require the establishment of access points to exisiting systems where product- or process-related information is stored. This employs a combination of services and interfaces which interact with the existing systems-landscape, e.g. within an enterprise (blue) and the access platform (green) (see Fig. 4). These access points offer an identifiable point in the internet, were information services with a specific content for a specific product can be requested. With this structural element information can be made accessible in a controlled way supporting the ownership and control of data.

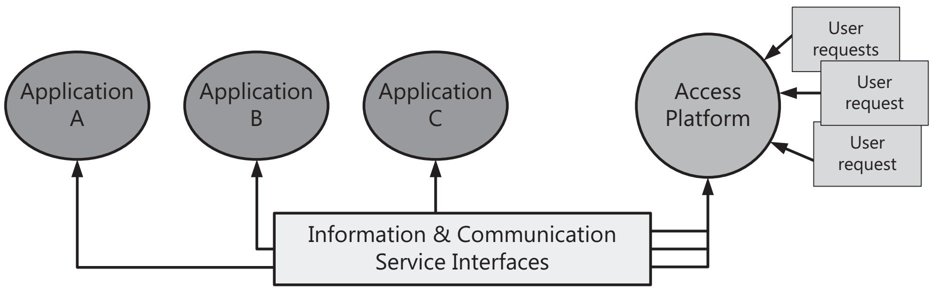


Fig. 4: Access platform framework (adapted from REICHE ET AL. 2008)

The interconnection of these access platforms can be realised by establishing communication services on a peer-to-peer basis (CUTELOOP 2008). The long-term impact of this approach could lead to the establishment of an infrastructure based on access platforms, enabling the development of a sectorial network for the food-/ feed-supply network as whole (see Fig. 5).

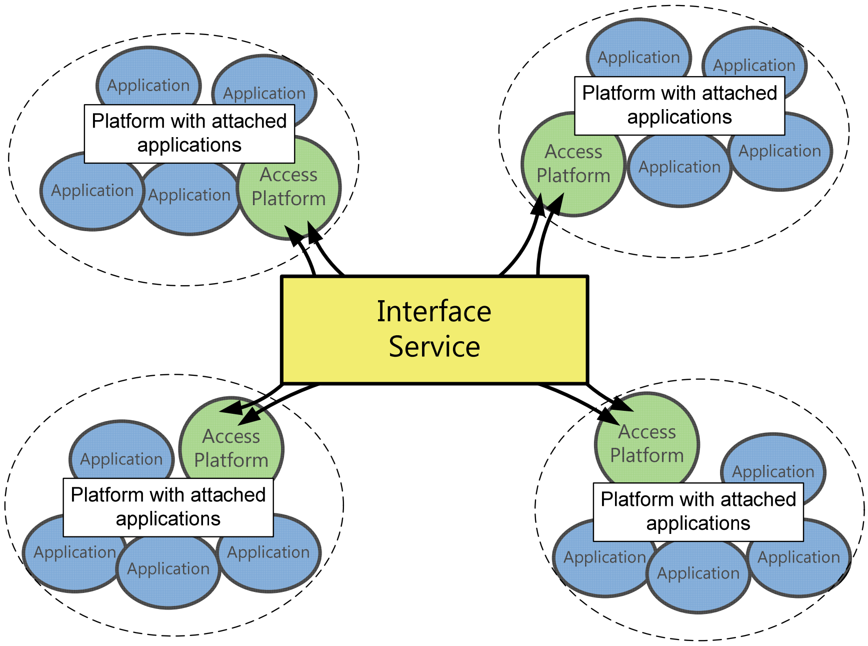


Fig. 5: Long term vision – network of platforms connected by information services (adapted from REICHE ET AL. 2008)

This structure is similar to the current structure of the internet based on web servers all over the world linked by protocols for data transfer and communication. The benefit to the sector is generated through the ability to transport information in accordance with the complex network structure of the agri-food sector with its multitude of alternative trade- and production processes as well as multiple connections between different branches. This infrastructure enables the exchange of information among actors in the sector based on business information services to-be developed and is used as a fundament for the framework development in the remainder of this thesis.

3.3 Framework development

After shaping the idea of business information services from an information logistical point of view and elaborating the idea of a service-oriented architecture for connecting the actors in the food sector, the connection of both concepts is developed in this subchapter.

The objective of the Business Information Service Framework (BISF) is to provide a generic framework for improving customer services, customer satisfaction and sector competitiveness through improvements in transparency and interaction between suppliers, customers and consumers based on a service oriented approach (see Fig. 5). To serve the previously presented public and private requirements, the framework is concentrating on the establishment of generic information services based on the previously discussed theoretical background. By integration of principles of information logistics and service-oriented architecture, this framework aims at the provision of context-specific information to manage and control the distribution of food products towards the consumer. Major objectives in this relation shall enhance the current practice by focussing on:

a) Improving the effectiveness of food safety and quality related activities, and
b) Improving the efficiency of distribution processes.

Following the principle of service orientation, this framework is focussing on the provision of product- and process-related information to meet customer needs with enterprise capabilities (GABHARD AND BHATTACHARYA 2008), which is closely linked to the competitiveness of enterprises and has far-reaching implications for business capabilities, organisation structure, technical infrastructure, and the overall agility and efficiency of enterprise operations (HEUTSCHI 2007, ERL 2007, GABHARD AND BHATTACHARYA 2008).

The BISF contains different layers from the definition of different information demands up to the sources where the required information is available. The overall framework is depicted in Fig. 6.

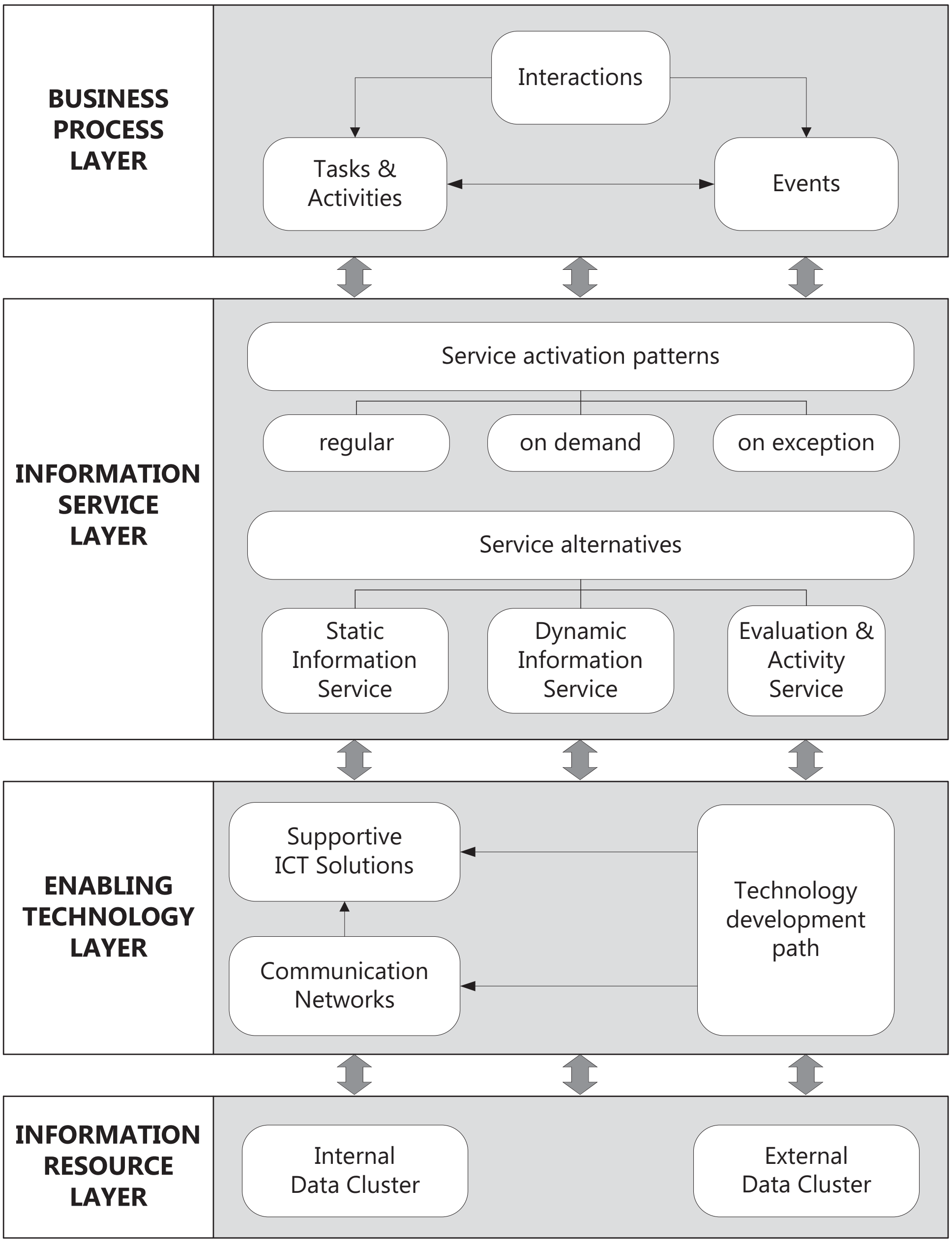


Fig. 6: Overview on the integrated framework (modified from GABHARD AND BHATTACHARYA 2008)

The different layers are described in the following part of this chapter.

3.3.1 Business process layer

The business process layer defines the specific context and the resulting information demand that has to be met by the business information service. The business process layer of the framework integrates different perspectives:

a) *Workflows* as an organisational and operational element in the value creation process in an enterprise. Tasks and activities related to this operational perspective include decisions regarding the distribution of products, which are supported by business information services. The business process layer defines the specific situational context and the resulting information demand which has to be met by the information service.

b) *Events*, which trigger specific information demands in a situational context to manage and control the business process. These events can be divided into regular and exceptional events.

c) *Inter-enterprise interactions*, which are required for the exchange of physical products and transaction-, product- and process-related information, which are triggered by specific events and tasks in the workflow.

These perspectives are further described in this chapter.

3.3.1.1 Workflow

In general, a workflow describes a planned and organised sequence of consecutive tasks and activities in the scope of business processes (VAN DER AALST AND VAN HEE 2004) within or between enterprises. Due to the interrelation of these tasks and activities, information exchange is evident for optimal coordination between actors participating and interacting in this workflow (BECKER AND VOSSEN 1996). An essential part of workflows are decisions, which have to be taken on the basis of reliable information. The specific information demand is one starting point for the elaboration of business information services, which aim at the provision of information to support actors in the workflow.

3.3.1.2 Events

In general, events are described as specific situations that require the intervention of an actor to control and manage a process (NISSEN 2004, HELLINGRATH ET AL. 2008). Focussing on logistics, distribution process related events occur during the distribution of physical products and require actions to continue, stop or change the process flow. These events can be separated into critical exceptional events and regular events.

Regular events include all points in the process, where planned actions and tasks can be applied to control and manage the business process (HELLINGRATH ET AL. 2008). The appropriate reaction to regular events requires information from different sources to make a reliable and appropriate decision for event handling (NISSEN 2004).

Exceptional events relate to critical exceptional situations, where the process execution is distorted (HELLINGRATH ET AL. 2008). The classification of an exceptional event is based on rules that define in which context an event has to be classified as an exception. To manage these events, on demand information provision is necessary for decision support and minimizing negative effects on the business process (NISSEN 2004).

3.3.1.3 Inter-enterprise interactions

Within this context, an interaction is determined as a cross-organisational exchange of information and tangible or intangible products, whereas intangible products are referred to as services. Interactions are based on workflows and control mechanisms in each of the participating organisations that are mutually agreed and harmonized.

The widely accepted workflow pattern applying to the described interactions include push, pull and poll patterns (VAN DER AALST ET AL. 2003). To be specific, the described interactions can take place in a planned and organised way or on certain events requiring an inter-enterprise interaction based on exceptional events. Additional requirements for inter-enterprise interactions can be found in the European and national food legislation, i.e. emergency product recalls protecting consumers from deficient products.

The generic patterns for information exchange between enterprises based on the previous described interactions are depicted in Fig. 7

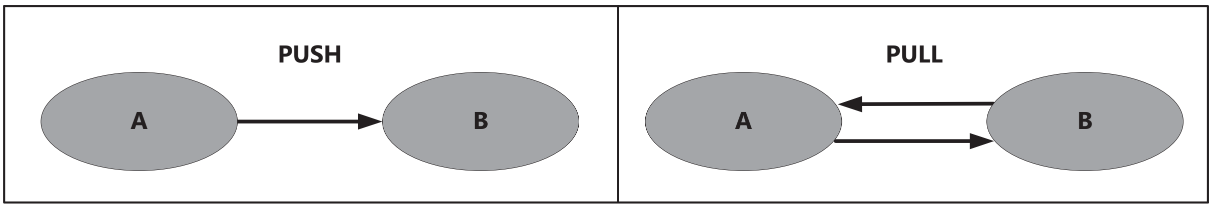


Fig. 7: Push and Pull patterns in inter-enterprise interactions

Interactions between enterprises concerning business information service is based on push and pull patterns, whereas the pull pattern is defined as feedback loop. The push pattern is applied, when product- and process-related information is provided directly with the product based on common business practice. The pull pattern is applied, when information in a specific context is requested and provided detached from the product.

Additionally, a third pattern could be facilitated by the introduction of the aforementioned decentralised approach previously presented in Fig. 5. In a network of identifiable access platforms, a so called “poll” mechanism could be facilitated to access each platform to request information on a specific product. If information matching the request is available, it is provided to the platform where the request was initiated. This pattern is based on the pull-pattern, but is facilitated on a 1-to-n base. However, this pattern is a theoretical opportunity; it is not followed further in this thesis to reduce complexity.

3.3.2 Information service layer

The information service layer discusses the business service alternatives as well as their activation patterns.

Due to the previously described information communication requirements in the food sector, information on products as well as enterprises handling the product are of importance. In the BISF, information can be distinguished between static and dynamic product- and process-related information:

- Static information, defined as information that is collected once and does not change during the product’s lifecycle.
- Dynamic information, defined as continuously changing information during the product’s lifecycle. For example, product quality related parameters may change over time and require continuous monitoring to evaluate the products quality status. Another example might be the progress of the distribution process as well as process-related parameters, which change over time.

For providing the different information types, three generic information services alternatives are intended:

- Static information service focussing on the provision of static information, and
- Dynamic information service focussing on the collection, aggregation and provision of dynamic information,

- Evaluation and Activity Service, for evaluation of received static and dynamic data for event handling and provision of appropriate actions.

The sum of static and dynamic product information represents a virtually complete set of the products' history during the product's lifecycle and contains valuable information for tasks and activities in business processes. Therefore, both service alternatives provide the actors in the workflow with the required information for the specific event-related context. Due to the large amounts of products distributed within the food sector, the need for disburdening the user from evaluating single information of single product boxes is evident. The information service framework includes an activity service, which is linked to the static and dynamic information service alternatives and evaluates the received information according to predefined rules.

3.3.2.1 Static information service

The static information service provides information about products that does not change during the products' lifecycle (REICHE ET AL. 2008). This information may include not only production-related quality parameters, but also information linked to the agri-food enterprises (e.g. certification information) the product passed during the distribution towards the consumer. Due to market developments towards higher requirements on transparency, the need for regular information deliveries is increasing. Discussions on the safety and quality attributes of products, including the environmental impacts of production, or the social background of enterprises involved, ask for the provision of appropriate information and guarantees. These guarantees are the main content of static product information.

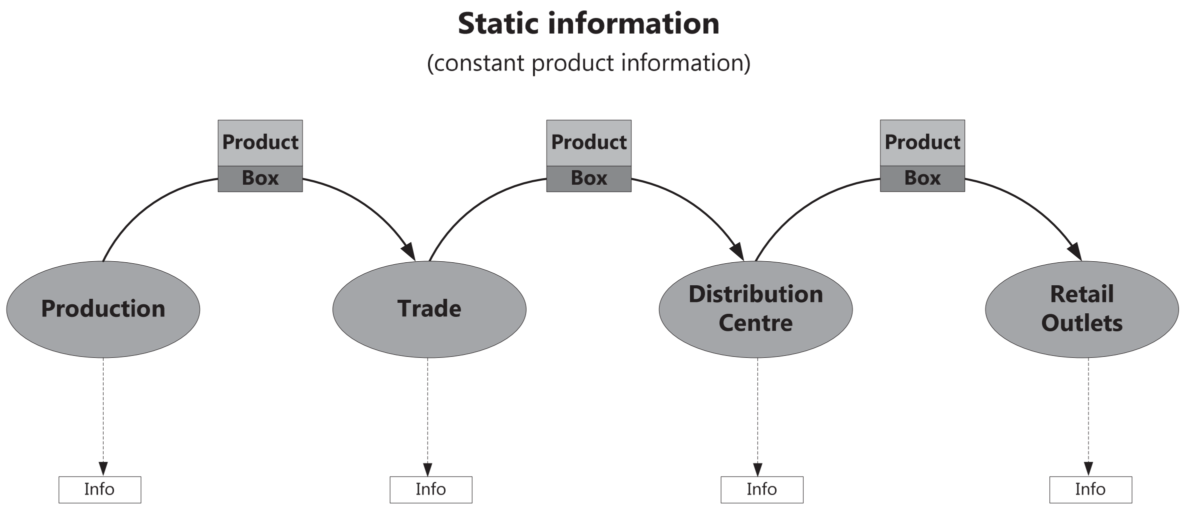


Fig. 8: Static product information

Static product information is delivered on a request-reply basis and is collected once and provided by the agri-food enterprises. Examples for static product information include all constant attributes referring to the product, the enterprises handling the product or other related objects e.g. the packaging. Prominent examples for static information might be the place of primary production (origin), or sustainability-related parameters, e.g. on the certification of ecologic friendly production and transportation methods or the products' packaging.

3.3.2.2 Dynamic information service

Dynamic product information can be described figuratively as the product's backpack of information which increases throughout the product's lifecycle (REICHE ET AL. 2008). It is supplemented by information collected at the different actors including transport in the supply network handling the product. A single not aggregated piece of information in this context is defined as status information, which can e.g. refer to the actual position of the box in the distribution process or a temperature at a fixed point in time in the box ambience. The aggregation of this status information pieces is part of information services and creates a complete picture of the distribution process or the product quality development during the distribution process.

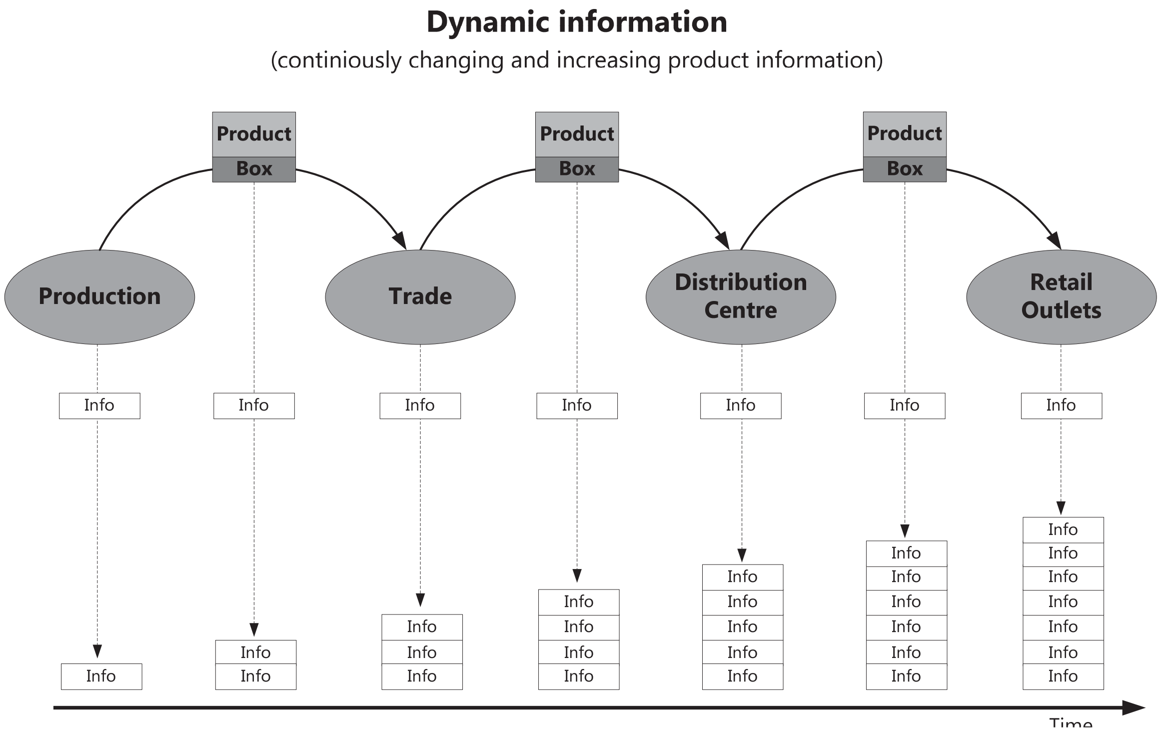


Fig. 9: Dynamic and status information on a product

The service is based on regularly repeated information collection, which can build on push or pull mechanisms. This service is of relevance for improvements in the food sector, because the missing communication and aggregation of single dynamic information pieces leads regularly to uncertain decisions.

Examples for dynamic product information include all continuously changing product- or process-related attributes, such as e.g.:

a) a set of changing positions of transport units showing the complete path of this unit during its distribution (tracking and tracing information),
b) the temperature in the product’s ambience or aggregated the storage conditions of the product along the way through the supply network,
c) Sustainability parameters, e.g. the carbon footprint, which requires aggregation of the different amounts of carbon dioxide produced at all stages including transport referring to a specific product.

The decentralization options for this service are strongly depending on the technological development path. At the present level of technology, a central organization is required for collecting the information from the different actors participating in the distribution of a product. Due to the high degree of mistrust in respect to centralized data collection and the fear of losing competitive advantages by providing information, some actors refuse to participate in such activities.

3.3.2.3 Evaluation and Activity service

As mentioned before, the presented service framework enables the provision of product- and process-related information on transport unit level and below. The high amount of transport units distributed between enterprises on a daily basis requires a service for disburdening the user from screening every piece of information provided by the previously described information services.

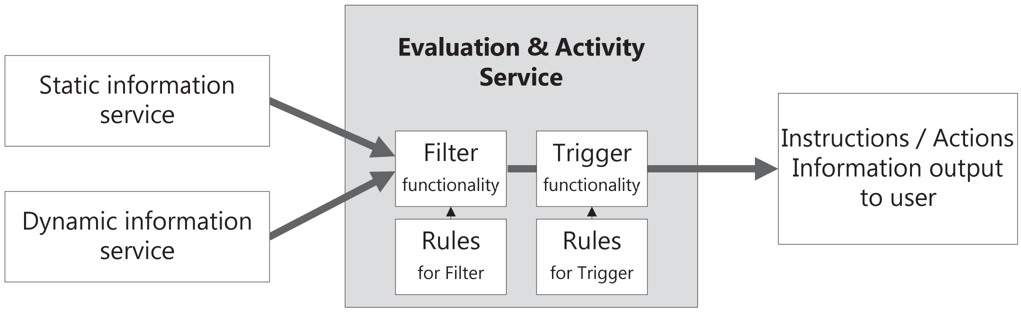


Fig. 10: Evaluation & Activity Service with rule-based system functionalities

Thus, the objective of this service is to analyse the incoming data from the information services based on predefined rules and to provide formulated requests for actions in cases where action is required to prevent negative impacts on the process or deficient products reaching the consumer (see Fig. 10).

Static and dynamic information is provided for a specific product unit. In this context, rules for filtering generically follow the question:

Does the product or process comply with my requirements for it? –Yes or No

This requires the identification and definition of indicators, thresholds and acceptance levels for comparison with received data from the information services as well as the definition of triggering rules for triggering the appropriate automated actions or presenting instructions for actions. Examples are provided in the reference processes in chapter 5.

3.3.3 Service activation pattern

The initiation of the business information services builds on a number of distinguished activation patterns. These patterns are closely linked to the previously described events in the business process. Three different but general activation patterns can be distinguished that focus on (REICHE ET AL. 2008):

a) *regular information delivery*, where the information request between customer and supplier is usually initiated by the delivery of goods (regular event),
b) *information on demand* (querying for information), where the information request is initiated by a context-specific information demand or as an reaction to an event, usually at customer's end, and
c) *on exception*, where the information provision is initiated by an exceptional event, usually at sender's end (push approach). In the food sector, these events might include product recalls due to food safety issues or situations in processes, where negative impacts on food products have to be prevented.

Regular information provision concentrates on all information that is provided attached to the product, including product-related information such as ingredients lists or quality signs, and process-related information such as e.g. delivery notifications.

Information on demand deals with the satisfaction of irregular information demands arising in relation to a specific event at the users' end. However, it is also an approach that supports the interest of providers of data regarding data ownership and data confidentiality, because the provision of information can be denied or granted based on predefined rules. Information is just provided in case of formulated requests, serving a specific need, and in a controlled environment to support trade relationships or legal requirements. It is evident, that potential users of data have an interest in receiving data on a regular basis and not just "on demand". There have been attempts in food chains to replace serving irregular information needs "on demand" by general data transfers from data generating groups to data users at later stages of the chain. As an example for the approach, retail might be interested in receiving farm production records on a regular basis to be able to always check for possible causes of product deficiencies in case deficiencies have been detected and to avoid the data request activity "on demand". However, such requests meet resistance when data ownership is considered of competitive value. In the food chain scenario, information on demand is of broad interest. Its focus may involve the provision of information on product quality provided by traders in their data bases, from online monitoring of the quality and spatial location of products, and on the origin of products and their distribution throughout the chain to allow the identification of their tracking and tracing history in case of need.

Exception reporting is based on a routinely automated background query of available product information from other information services. If there are irregularities with incoming products (captured through applications) that require specific attention by the customer, an exception is reported to the user. Missing or incomplete information on a product, such as product laboratory results or certification information can have a negative effect on distribution even if the product is in an uncritical condition (SCHRÖDER 2008). Exception reporting is of specific attractiveness as they support the identification of deficiencies without information overload at the user's end. With relation to the information needs in the food chain scenario, exception reporting could focus on (REICHE ET AL. 2008):

a) quality deviations in harvested products, product origin or producers (e.g. missing certification),
b) critical situations during transport, that are able to influence quality deteriorations of products,
c) delivery and transportation delays that may be identified through online monitoring activities.

3.3.4 Enabling technology layer

Information and communication technology (ICT) developments and improvements, especially in the area of Internet related technologies, are fast paced and provide potentials for companies to improve business processes by integration of technologies e.g. for automation of processes. Especially network technology, such as RFID, has a tremendous improvement potential for inter-enterprise processes in supply networks. However, given the wide variety and the fast development, the selection of suitable technologies for existing business processes is a complex task, which involves the analysis of process support potentials provided by technological advances and provided functionalities. In the enabling technology layer different information and communication technologies represent supportive ICT solutions, providing the technical base for the realisation and implementation of business information services.

3.3.4.1 Supportive ICT solutions

Supportive ICT solutions are described as integrated technological components based on stationary or mobile networked technological devices with the ability to communicate over a communication network. The establishment of information services providing information from a source (data cluster) to another require infrastructural and operational functionalities. Infrastructural functionalities are all functionalities for establishing the information flow and include data output, data input and data transfer functionalities. Operational functionalities include rule-based functionalities for filtering the information flow and triggering required actions. These functionalities are integrated in networked devices for realising the business information service and connect the information source and business process layers of the framework. Besides prominent examples such as existing systems, mobile computers or handheld devices such as scanner or smartphones, technologies such as RFID devices are taken into consideration. The technology layer describes the application of key technologies, which enable and support the information exchange related to the physical product. While, the available supportive ICT solutions in an enterprise environment are highly heterogeneous, this approach focuses on technology required to link physical products to information available at the information resource layer. Examples of selected key technologies are:

- **RFID** linking physical products to information by unique identification of products,
- **Scanner devices** (stationary or mobile), which interact with the RFID-tags and the user to receive and provide information from and to data clusters, and
- **Software agents** that autonomously interact with devices and data clusters to search relevant data related to an identified physical product.

3.3.4.2 Technological development path

Due to the traditionally high dynamic and heterogeneity of technological development in the IT sector, the impacts for the competitiveness of enterprises have to focus not only on today's IT infrastructure, but also on emerging new technologies offering improvement potentials (FRIEDLI 2005). To optimise the facilitation of technology in this framework a technology impact assessment based on technology characteristics and their impact is done on a generic base. According to BULLINGER (1994) such an analysis has to include the long-term effects gained by implementation and facilitation of new technologies compared to existing technologies. This requires not only the analysis of the internally existing ICT, but also of external conditions set by the business sector as well as possible future developments (GESCHKA ET AL. 2005). Especially the aspects of future developments are critical for sustainable ICT adoption decisions and are part of so called technology roadmaps. These roadmaps represent development paths of different technology alternatives based on expert knowledge and analysis. The objective of technology roadmaps is therefore, the communication of visions, the investigation of impacts of new technologies as well as the monitoring of progress in the field of ICT, to enable improvements in planning ICT investments (GESCHKA ET AL. 2005, KRCMAR 2005)

The framework takes a generic development path of technology, or a so called technology roadmap, into consideration. A possible development path of networked devices could be specified in three levels:

a) a present level, employing today's technology base,
b) an intermediate level, with a five year development focus, and
c) a visionary level.

Technological development increases the capabilities of networked devices and thus the integration of additional infrastructural and operational functionalities. Due to the general technological development the capabilities of the networked devices increase over time. In respect to the emerging mobile technologies, the second and third level emphasises the integration of mobile technologies and related communication networks for information provision. The development path is depicted in Fig. 11.

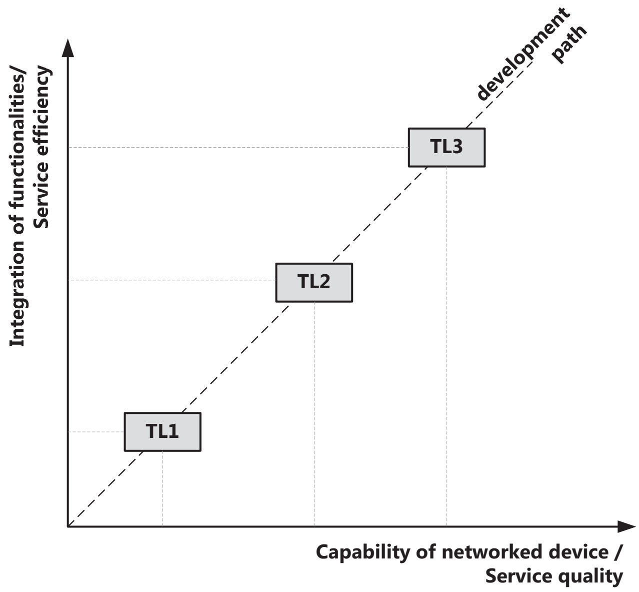


Fig. 11: Generic technological development path (REICHE ET AL. 2008)

The technology developments lead to service improvements in two principal dimensions:

1. Technology developments allow increased integration of different components into single network devices leading to **improvements in service efficiency.**
2. Technology developments provide increased capabilities of network devices in storage, processing, sensor or communication which allow improvements in filters, triggers and other components leading to **improvements in service quality**.

The technology development path focuses on the increasing opportunity to build decentralised communication schemes that make centralized coordination obsolete. This is a critical success factor for the improvement of current practice, since centralised solutions are not accepted for the purpose of broad exchange of product- and process-related information. Due to this lack of acceptance many centralised solutions failed because of data ownership issues and possible negative effects on competitiveness. The visionary level aims at minimizing the required central coordination needs. This enables the identification of intermediate and advanced opportunities provided by the abovementioned development path adapted for these technologies.

3.3.4.3 Communication networks

The interaction between the distributed data sources and networked devices providing the service result to the user is based on two assumptions:

a) the data between clusters and devices is exchanged via defined data exchange interfaces
b) the data transfer between both elements facilitates communication networks.

Data exchange interfaces between systems are mostly individually developed using predefined standards such as e.g. the Electronic Data Interchange Standard (EDI).

Communication networks describe the communication infrastructure available within the enterprise or its environment. Communication networks are generally divided into earthbound cable-based and different wireless radio-based communication networks (WAMBA ET AL. 2008). The following table shows the different options:

Table 3: Classification of communication networks

	Type		Range		
	cable-based	radio-based	local	continental	global
Local area network (LAN)	X		X		
Wide area network (WAN)	X				X
Wireless local area network (WLAN)		X	X		
Global system for Mobile communication (GSM)		X		X	X
Satellite networks for communication (SAT)		X			X

Communication networks connect sources providing content for the information services to the internet and on the other side service consumer and their networked device to the internet.

3.3.5 Information resource layer

The information resource layer defines the data sources or clusters, representing collections of specific information, required as sources for the business information service.

In the food sector, the most important sources for food safety and quality information are either information systems in the enterprise (IEIS), information systems that focus on quality management schemes (e.g. Q+S, GlobalGAP) or focus on traceability (e.g. GlobalGAP) summarised under the term network/sector focussed information systems (NSIS) (SCHIEFER 2006, DOLUSCHITZ ET AL. 2007, LEHMANN 2011).

Due to division of labour and the agricultural production and industrial processing of food products over different stages in the supply network, information is generated at each participating enterprise at every level of the food supply network. This leads to a primarily stage-specific character of information (GAMPL 2006). Another important factor is the agricultural production stage, where fundamental food quality and safety information is generated during the production and quality control processes.

4 Methodology for designing business information services

The business information service framework that has been developed in the previous chapter describes the integration of an information service into business processes, which define its scope and requirements. The next step towards the development of an information service and the connection of information sources to user information needs is elaborated in this chapter. The different perspectives of BIS development require a clear modelling approach for identification of the service context and content as well as the integration of technology to establish the service. However, most existing modelling frameworks in the field of business process and information management focus on the organisation of intra-enterprise production and information processes (LEHMANN ET AL. 2010). This framework follows the design-oriented approach of this thesis, by the construction of new artefacts (VERDOUW 2010) referred to as interaction models for business information services. These aspects are commonly captured in reference processes, which in general represent reusable variants of processes, which involve the best practice for a specific type of business process within a particular industry sector (MATOOK AND INDULSKAA, 2009).

Due to their normative character, reference models represent often recommended future aspects of reality. The prediction of reference models therefore relate to future circumstances and must enable the deduction of operational possibilities. Reference processes are per definition at the same time not only employed in a singular situation, but also refer to a class of application cases (BECKER AND PFEIFFER 2007).

In the context of this thesis, reference processes capture and integrate available technology potentials of different levels and of sophistication and the integration of generic infrastructural and operational functionalities to provide information from one point to the point where it is required. An overview on this design framework is presented in the following figure.

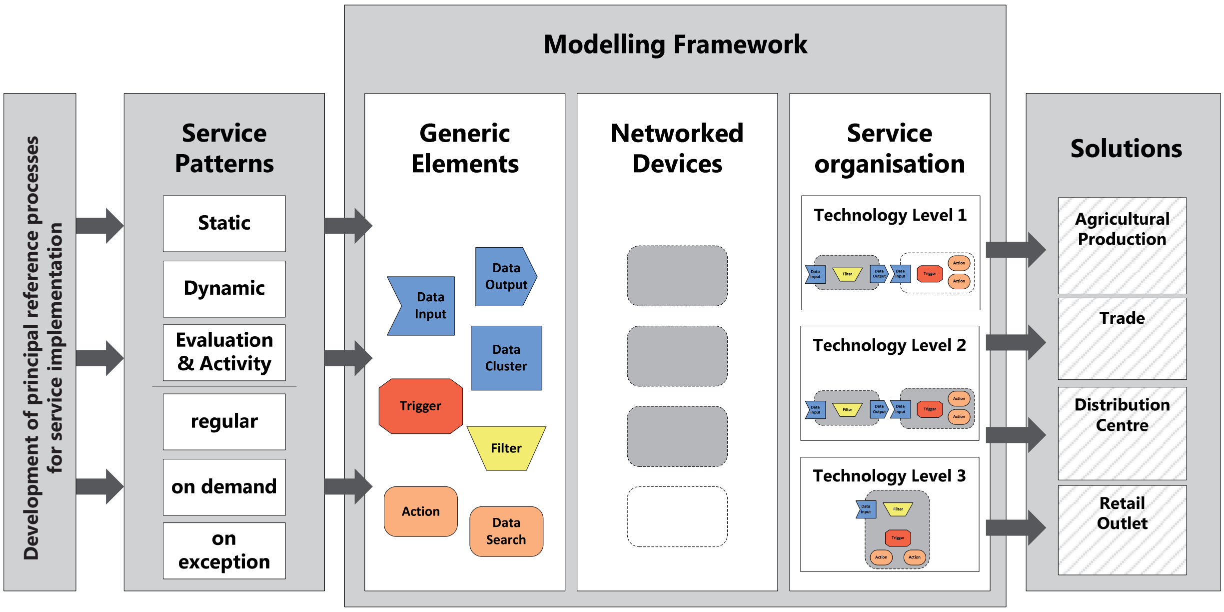


Fig. 12: Overview about the BIS design framework

While the scope and purpose of the information service where discussed previously, the description of the modelling framework based on generic elements representing functionalities, their integration into networked devices and the composition of these integrated components for service organisation are the objective of this chapter.

4.1 Modelling Framework

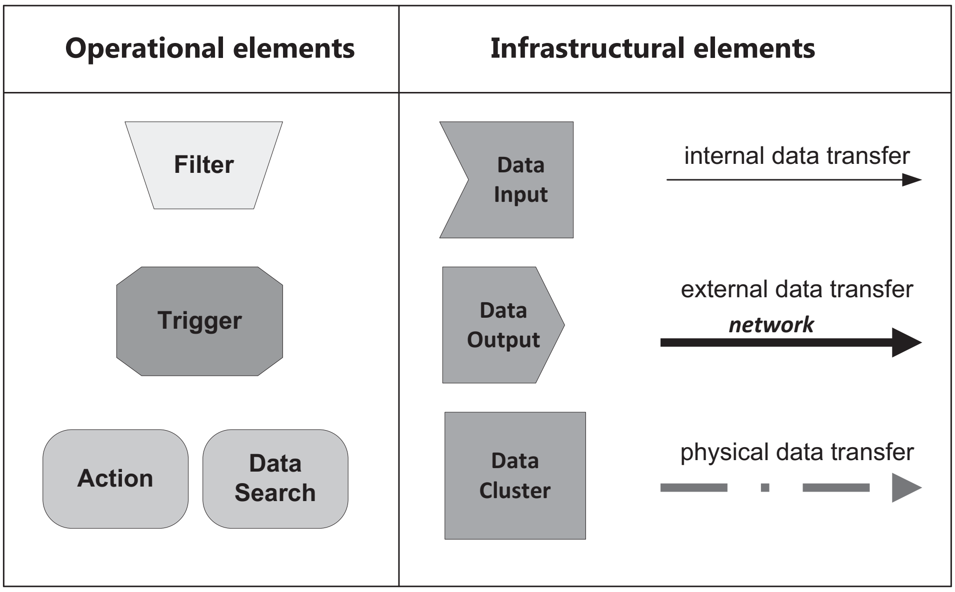
The modelling framework is oriented at the Unified Modelling Language (UML), which is the de facto modelling standard for this purpose (LEHMANN 2011). However, using UML models for this purpose would generate models that may have a high level of detail but reduce the comprehensiveness. To reduce this complexity, a modelling scheme is presented in this chapter that focuses on the description of system components and functionalities in a simplified way. This modelling framework has been developed for the description of reference processes in the CuteLoop project and is part of REICHE (2010a).

As previously described, business information services require information provision from different sources. Technically, the information services can be described as a sequence of integrated technological components, establishing a directed information flow from the distributed information sources to an information service consumer. The objective of this modelling framework is the description of information exchange processes between two observation units and the description of processing received information for decision support. Information exchange processes take place between different integrated technical components providing basic functionalities for information exchange and processing. In order to establish business information services, both issues have to be taken into consideration. To meet this requirement, the modelling framework defines graphical representations of the previously discussed basic functionalities of integrated technological components. It consists of two element categories representing basic functionalities:

- **Infrastructural elements**, such as data input and output, transfer and storage (data clusters) elements enabling the information exchange between different integrated technical components.
- **Operational elements,** such as filters, triggers, actions and search elements representing the information processing, evaluation and provision of the service results to the service consumer.

The shapes for the different modelling elements are depicted in the following table.

Table 4: Modelling shapes representing the elements



The generic character of this framework enables modelling information transfer processes independent from business domains.

4.1.1 Infrastructural Elements

Infrastructural elements can be separated into data input, data output, data cluster as well as data transfer elements. The main objective of infrastructural elements is the establishment of an information flow between two integrated technical components by forwarding data and reception of data.

Data Input

The data input element defines the functionality, which is required during the information exchange process, at the point where data is received or collected using system-to-system or system-to-user interfaces. Data input elements can be linked to data clusters or operational elements using data transfer elements. Data transfer and data input combinations (DT-DI) represent the receiving part of a system-to-system interface, which is required for information exchange processes.

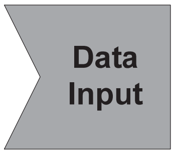


Fig. 13: Data input element

Data Output

The data output element defines the functionality, which is required during the information exchange process, at the point where data is send using system-to-system or presented to a user by system-to-user interfaces. Data output elements can be linked to data clusters or operational elements using data transfer elements. Data transfer and data output combinations (DO-DT) represent the sending part of a system-to-system interface, which is required to establish information exchange processes.

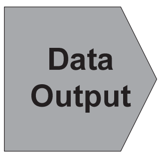


Fig. 14: Data output element

Data Cluster

Data clusters represent collections of specific information. Such data clusters may be realised as technical systems, e.g. information systems, intranets, extranets or electronic data bases in general. Each business information service includes at least one data cluster, which provides content for the business information service.

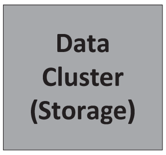


Fig. 15: Data cluster element

Data Transfer

Data transfer elements are connections, representing the transport of data between all other elements for constructing the information flow between information provider and consumer. It requires two elements marking a starting and an end point.

Data transfer can be divided in three types:

- physical data transfer (data attached to an physical object),
- internal data transfer (data transfer between elements within one integrated technical component), and
- external data transfer (data transfer over a communication network).

Physical data transfer is defined as the transport of physical attached data to objects, which are transferred between actors in a supply network. The physical data can be directly attached to the product (e.g. labels, barcodes or RFID-tags) or is distributed with the product (e.g. delivery receipts).

Internal data transfer describes the transport of data between two elements within an integrated technical component. Internal data transfer is the easiest way to transport data between elements, because it is a transfer without media breaches or external data interfaces.

External data transfer is defined as the transport of data between two integrated technical components via defined data interfaces. The external data transport is a complex data transfer, because it requires the transfer of data over a communication network and defined data interfaces as well as data communication standards.

4.1.2 Operational Elements

Operational elements represent basic functionalities required for processing data received from the information flow to provide it to the business information service consumer. Operational elements are separated into filter, trigger, action and data search elements, which prepare received data for decision support and are key elements of the business information service framework.

Filter

A filter element is a basic processing functionality, which compares aggregates or merges received data from different sources with data from existing data clusters or simply filters received data according to predefined rules. A filter always receives data from other data input elements, processes it and forwards it over to other elements. A filter element is always attached to a data output element or a trigger element and at least one data input element. In Fig. 16 an example of a filter element is depicted.

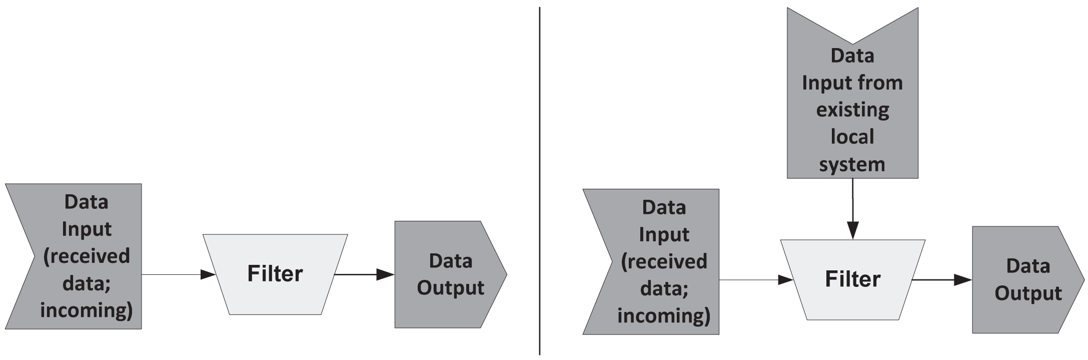


Fig. 16: The filter element with different data inputs and one data output

A generic example for a filter element is the separation of significant data out of a continuous stream of incoming data (left) or the comparison of existing data with received data (right). The way the received data is processed in the filter follows a certain sets of rules.

Trigger

A trigger element represents a basic processing functionality, which selects appropriate actions based on inherent predefined rules and the received data from data input or filter elements. In comparison to the filter element, a trigger does not access existing data for comparison or aggregation. A generic trigger element is depicted in Fig. 17.

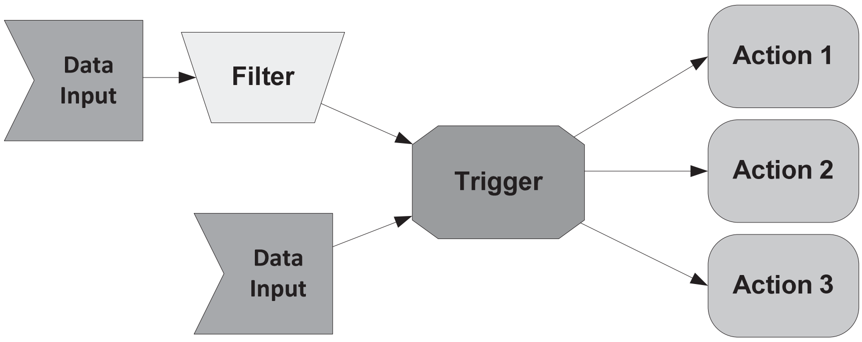


Fig. 17: The trigger element

The trigger element is usually placed at the end of a business information service sequence and proposes appropriate actions, providing the service result to a user or starts a new service sequence. Trigger elements are rule-based decision support functionalities and provide context-specific instructions to the service consumer. Processed data from a filter element or a pre-processed signal are possible inputs for a trigger element.

A generic situational example from the distribution process might be the reception and evaluation of products according to specific rules. The user has different choices to proceed with the products in the process, which are based on rules. The decisions to be taken at this point in the distribution process might include:

- the rejection of a product due insufficient quality (Action 1),
- the product can be distributed to the next actor, because of missing abnormalities (Action 2), or
- the product has to be temporarily removed from the distribution, a sample has to be taken and send to a contracted laboratory for analysis (Action 3).

The action, which is initiated by the trigger element, is depending on the context-specific rules linked to the tasks in the workflow. The presentation of the service result (action) depends on the capabilities of the technological device in which the trigger element has been implemented.

Actions

Actions are specific rule-based activities executed by the trigger element. Therefore, actions are characterised as service results presented to a service consumer as instructions or as an executor for a new sequence of generic elements.

Fig. 18: Action element

Data Search

The data search element is a special type of action. It starts the automated active search for data in existing and connected systems able to provide context-specific information required by the service consumer. The search for context-specific data is followed by a new sequence of elements starting with a data output element, representing the request for information. The search element can be seen as a starting point for initiating a business information services.

Fig. 19: Data search element

Specification of rules

For developing business information services the specification of rules for the rules-based generic elements is inevitable. These rules are closely linked to provided data and requirements related to the operational context within the enterprise as well as external stakeholders. The objective of rules is to adjust and reduce the available and received information to a situation context to disburden the user from evaluating the complete set of information.

The transfer from reference models developed with this framework to specific implementations requires as well the definition of business sector specific and enterprise application specific rules, these rules are elaborated out of the previously presented generic rule depending on the type of data provide and the business rules that can generally be divided into:

- **Domain specific rules**, which vary from business sector to business sector, and
- **Application specific rules**, which are highly specific for the single implementation of the business information services based on the provided data.

4.1.3 Frames

Frames separate the model into different clusters of generic elements according to different objectives in the modelling framework.

Integrated technical components

Integrated technical components are the representation of basic technologies and integrated basic functionalities (i.e. elements). According to their definition, integrated technical components include basic technology as a platform, which provides basic functionalities for a specific business information service (KRCMAR 2005). For modelling business information services based on the previously identified key technologies, these components are marked in a special way to demonstrate and highlight their development in the different technology levels.

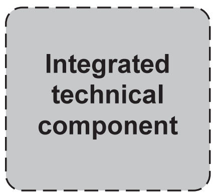


Fig. 20: The frame for marking an integrated technical component

From an information logistic point of view, integrated technical components represent nodes receiving or providing information to establish directed information flows by facilitating available information network.

Basic technology units

Basic technology units are individual and not reusable combinations of generic elements and existing technology in the enterprise IT infrastructure. While they follow the same definition as integrated technological components, they are marked differently in the business information service models. The reason for differentiation is based on the individual and non-generic character of these systems. These units refer to existing technology and existing systems for compensation of missing technological capabilities of the integrated technological components in the focus. Basic technology units require a data input and a data output element to provide or receive data from integrated technical components or other basic technology units.

Fig. 21: The frame for basic technology units

Observation units

Observation unit frames separate the model into business responsibility areas. According to the purpose of the modelling framework, to model inter-enterprise information flows, the need for a separation of the business areas of enterprises is inevitable.

Fig. 22: The frame for marking an observation unit

For developing business information services in an inter-enterprise environment, the separation of responsibilities and the related activities in the business information process between the enterprises is important and represented by this frame.

Physical objects

Physical objects are key elements for the business information service framework. They represent the objects in focus of decision making, such as process-related decisions in distribution. Following the train of thought of the definition of information logistics, the flow of physical objects has to be controlled and managed, which includes the contact with the physical object at a certain point in time and space. Business information services in general provide decision support for this and related management tasks.

Physical objects can be utilized for transferring data as well (see physical data transfer). They represent a special type of data cluster linked to a physical good, which is distributed from one enterprise to another. In the business information services physical objects equipped with identification tags/labels are important elements in the business information service framework. In the framework physical objects are represented through a box with an attached data cluster, which is depicted in Fig. 23.

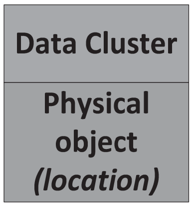


Fig. 23: Physical object with attached data cluster

In each model, physical objects carry identification information and possibly other product- or process-related information, which is required for linking product- and information flow and thus enabling the business information service.

4.1.4 Application of the modelling framework

This chapter provides an insight how to use the generic element for describing the information processes related to the business information service. The application of generic elements for the service description follows a basic input – processing – output scheme. The description focuses therefore on the functionalities of the systems and the data flow between them. It explains how the generic elements are used for description of generic **information and communication processes** with the purpose of mapping the needed data collection, processing and provision process steps for realisation.

In every sequence data input, data processing and data output elements have to be set, to complete a basic description of a business information service. A generic representation of an input – processing – output scheme is elaborated in Fig. 24.

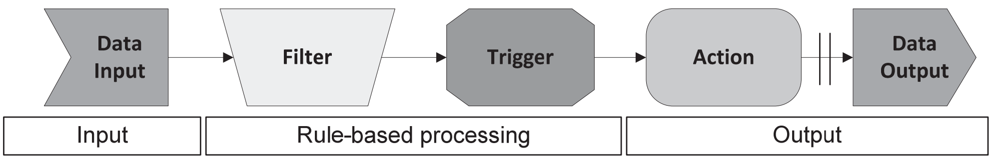
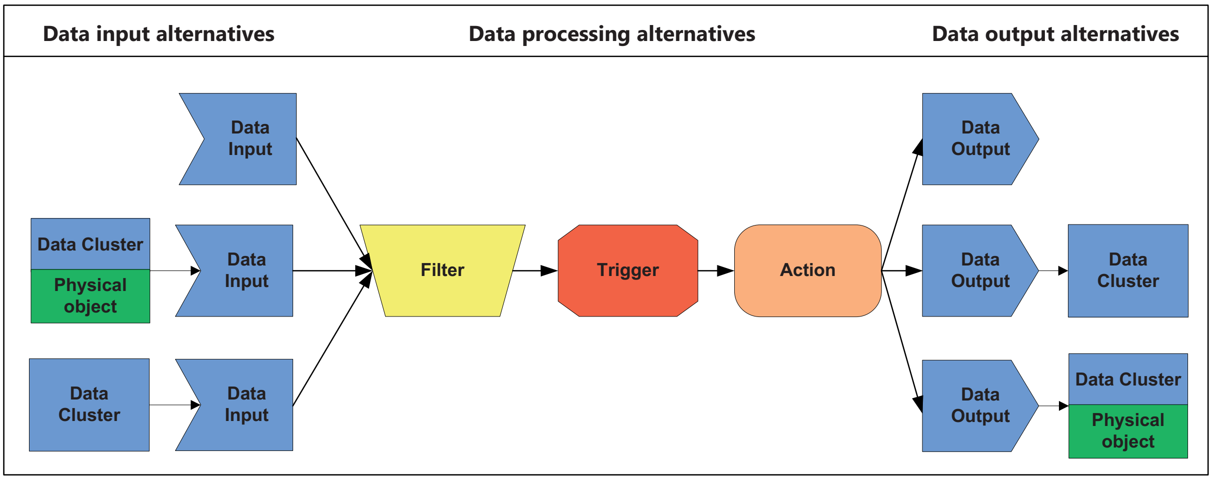


Fig. 24: Basic sequence of generic elements

This basic sequence represents the core of each side of the business information service. In the enterprise, which has to collect and prepare data for the service and in the service consuming enterprise, such a structure can be found. Because of the variety of systems and the individual process design variations of this sequence or other combinations of generic elements are possible. Due to the generic nature of this modelling framework, the feasible combinations are linked to data input, output and processing alternatives in Table 5.

Table 5: Feasible combinations of generic elements



This table shows different feasible combinations of generic elements for describing the data input, data processing and data output in the flow of information between or within enterprises and the business information service linked to this flow. Generic action elements are a special type of output and are closely linked to the rule-based trigger elements. Actions are bivalent elements, which can be used as an output to a user to take appropriate actions or as a starting point for a new sequence of information exchange.

4.2 Modelling of business information services

Following the train of thought presented in Fig. 12, the transfer of the framework for the development of specific application cases requires:

- the definition of the scope and purpose of the information service based on information needs,
- the specification of rules for filter and trigger elements based on data provided by the information service
- the selection of technology for realisation.

As previously discussed and now presented in Fig. 25, the information exchange between enterprises can be realised in two ways:

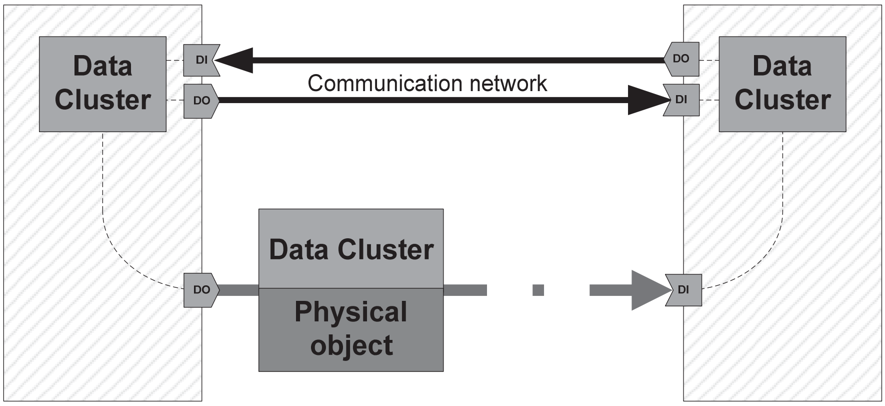


Fig. 25: Options for information exchange

The organisation on the left side of the figure represents the business information service provider, whereas the organisation on the right side represents the service consumer.

Accordingly, the feasible combinations for data input and data output in the business information service sequences can be realised by providing information over a communication network or together with the physical product. The first option of exchanging data between enterprises is via a defined data exchange interface, which is modelled as a data output from a system, while the external data transfer facilitates a communication network and the data input into another system ([DC-DO]-DT-[DI-DC]). The second option of transferring data between enterprises is facilitating a physical object with an attached data cluster as data carrier ([DC-DO]-DT-[DI-DC-DO]-DT-[DI-DC]). This physical object described by [DI-DC-DO] is handed over to another enterprise in the value chain in the distribution process.

These combinations of data input are linked to data processing element such as filters or filters and trigger elements. The provision of data captured from physical objects characterizes the initial event of a business information sequence. Additionally, the data collection represented by those feasible element combinations is an important part in the preparation of data for the provision of information via a business information service. The data output elements provide information to other systems, which are linked to them. In many cases this generic data output is followed by a data input element at another system. These data exchange interfaces are described below. The data output in general starts the data provision to other systems within or outside the enterprise and is usually the end of a business information service sequence.

Business information service provider

As presented in the basic sequence, processing plays an important role in the sequence. An example of the application of the modelling framework for the processing of received data is depicted in Fig. 26 and Fig. 27 .The service provision is based on additional activities which are required to collect and prepare the information for the business information service. This example applies the basic sequence (Fig. 24) and the options of information provision (Fig. 25) in a generic example of a business information provider presented in Fig. 26.

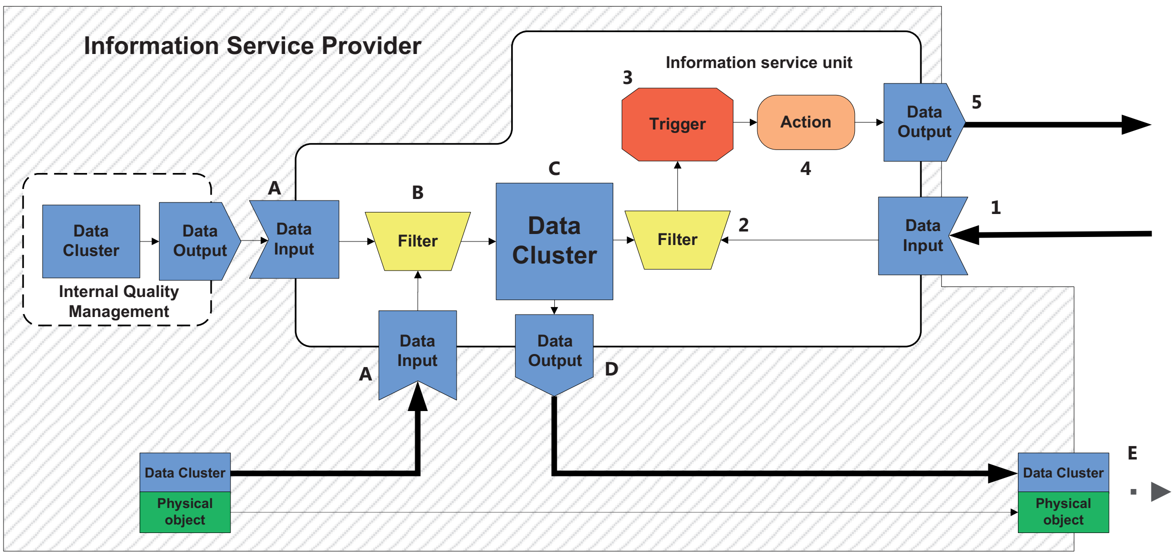


Fig. 26: Generic example for a business information service provider

The additionally required activities include the collection of product information e.g. from the internal quality management, which is linked to the identification information of a specific physical product batch and stored in the central data cluster of the service provider (steps A-C). Following the train of thought presented in Fig. 25, the product information can be provided

- attached to the product (steps D-E), or
- detached using a communication network and defined data exchange interfaces (steps 1-5).

The business information service sequence starts with a request, which is send from the service consumer after receiving the product. This request is based on the product identification information provided with the product. This request is processed and verified in the filter element (1-2). If product information for this specific batch is available, the response is formulated and provided to the service consumer (3-5). Additional rules can be integrated in the filter element evaluating the acceptance of the request and the willingness to share information with the service consumer.

Business information service consumer

In this sequence, which is a feasible combination of elements as well, the filter and trigger element are integrated in the same integrated technical component (e.g. a handheld scanner device). This component supports the user in taking appropriate decisions at the point of the distribution process (=task), where a product is received (= event).

The service consumer has to collect information to establish the information service. Either the product information has been attached to the product or the information has to be requested using the provided information (i.e. identification code from physical product). The rule-based data processing of product- and process-related data for decision support builds the core of this sequence. It represents the evaluation of received information and existing information, its processing and the final decision making.

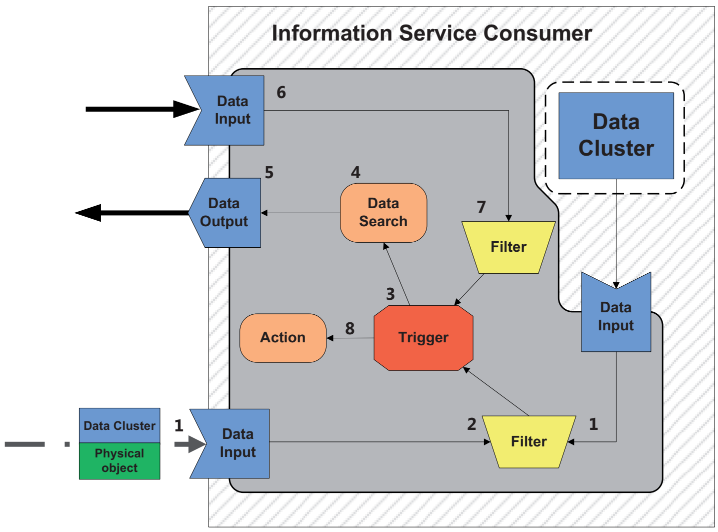


Fig. 27: Processing sequence example (single technical component)

This example includes aggregation of received data (i.e. product identification data) with existing data (1-2), as well as the evaluation of contents provided by the received data from the business information service. The Trigger element (3) evaluates the processed data from the filter element for executing the appropriate action (4) related to a predefined set of rules. This starts a new sequence (5) that results in an information provision (6). The following filter-trigger-action (7, 8, 9) sequence is equivalent to the first sequence. Alternatively, the complete product information set can be provided attached to the product, which makes the steps 4 to 7 obsolete.

The action in the sequence provides the result of the evaluation to a user. These elements represent appropriate actions to support the decisions and activities in the business process layer. The integrated technical component as a whole is closely linked to the technology layer and supportive ICT for the user in the workflow. The different sources of information (i.e. internal data cluster, information service, physical product) refer to the data cluster layer. This integration allows describing the situational context in the business process as well as technical requirements for implementation. The complete model of this example can be found in Appendix D.

Interaction pattern for information provision

The business information services are based on service activation patterns for inter-enterprise information exchange. These patterns support the development of principle reference processes, which support the development of domain specific instantiations of business information services. These information provision interaction patterns are building the core of each business information service.

The regular information provision ("push") is based on the agreement of information exchange between enterprises on a regular basis. This regular information exchange over a communication network can be triggered by specific events, like e.g. the reception of a product. It is based on the generic sequence which is depicted in Fig. 28.

Fig. 28: Regular information provision

In the generic configuration of this interaction pattern, data is stored in a data cluster and is provided by facilitation of an interface (DO-DT-DI) to a data input element at a foreign actor or system.

The querying for information is a more complex interaction pattern. It represents a two-way communication pattern, where information requests and responses are exchanged. This "pull"-pattern includes functionalities, respectively elements, for data reception and sending (data input and output), data storage (cluster) as well as rule-based elements (filter and trigger) for processing the information request. The generic interaction pattern of querying information is depicted in Fig. 29.

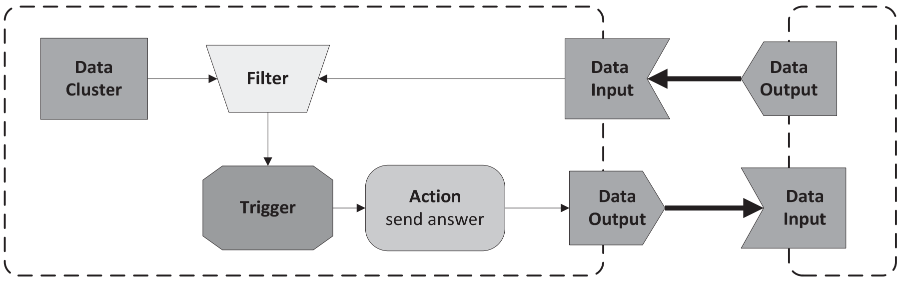


Fig. 29: Querying for information (on demand)

As shown in Fig. 29 the information request (right side), which was transferred via an information network, is received by a data input element. It is forwarded to a filter element, which evaluates and processes the received information request based on the existing information stored in a data cluster and following rules. The result of this request is forwarded to the trigger component, which executes a new sequence, which in turn sends a response back to the requesting actor or system. The sending of a response follows vice versa the reception of a request.

The aforementioned interaction patterns can be linked to an exception reporting pattern, respectively activity service, which evaluates the received information. The activity service is an additional service, which allows the combination with the previous interaction patterns. In Fig. 30 a generic description of this interaction pattern is depicted.

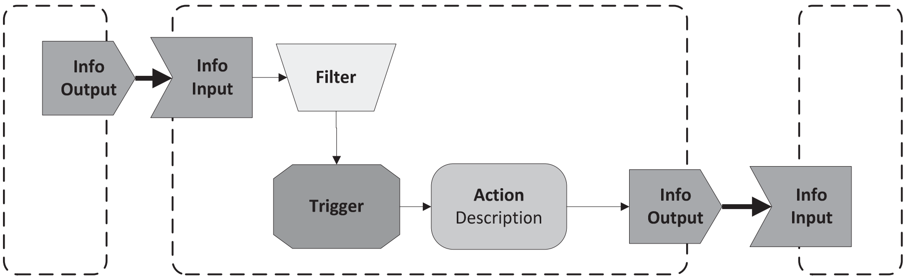


Fig. 30: Information provision on exception (exception reporting)

As shown in Fig. 30, this interaction pattern contains three units. The left unit represents the provision and reception of data, the middle unit represents the activity service itself and the right unit represents the provision of the evaluation result from the activity service. The sending and receiving unit can be situated in the same enterprise or can be provided by a service provider.

Following the train of thought presented in the two previous interaction patterns, the data is received at the data input element and forwarded to the filter element. The filter is of importance in this sequence, because it represents the rule-based evaluation of received data and the discovery of an exception. In this element, data is filtered according to generic pre-defined rules and to whether a deviation from a pre-specified acceptance level occurred or not. If an exception is detected, a notification is forwarded to the trigger element, which triggers a pre-defined information provision (the exception report) via the data output and the information network to pre-defined recipients.

5 Information services for the fresh fruit and vegetable sector

After identifying the general challenges, information needs and barriers in the food sector and the development of the business information service framework, this chapter focuses on the application of the BISF to the fresh fruits and vegetable sector. The objective of this chapter is to transfer the presented business information service and design framework to selected application cases within this scenario concentrating on the identified information needs stated in the research objective and chapter 2. This chapter is based on SCHIEFER ET AL. (2008b) and REICHE (2010b).

5.1 Scenario description

This application scenario focuses on the fresh fruit and vegetable sector, which is part of the food sector. The sector involves a network of enterprises reaching form farmers to retailers. It thereby encompasses various types of companies from microenterprises at the farm- to LEs at the retail-level. In these heterogeneous structures enterprises need to cooperate on an operative level in order to provide consumers with the desired service level.

Fruits and vegetables reach the consumer in form of many different products. Apart from fresh fruits and vegetables, usually referred to as produce, fruits and vegetables may be found in frozen food, in juices or in many varieties of processed food including marmalades or dried foods. However, the basic food chain is based on fresh produce where fruits and vegetables are being produced by farms and delivered to consumers through various trading and packaging stages but without any changes in shape and content. Due to the biological requirements of fruit and vegetable cultivars and the consumer’s preferences, the import and export within the European trading zone and foreign countries are important factors for the supply with these products.

A typical produce chain involves (Fig. 31)

a) the production stage, represented by local and foreign farmers that produce,
b) fruit and vegetable traders that package and bundle farmers’ products in e.g. boxes for sale and further distribution,
c) distribution centres that prepare fruit and vegetable deliveries for distribution to individual retail outlets, and
d) retail outlets that sell fresh produce to consumers.

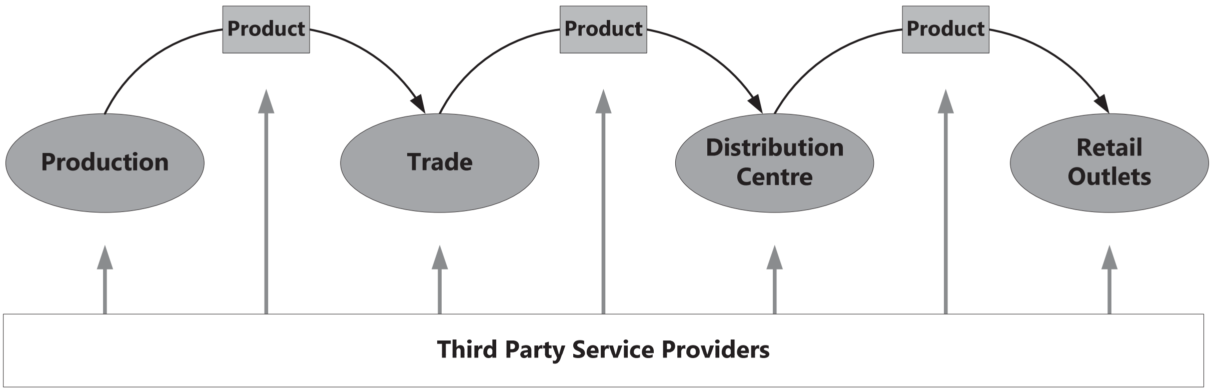


Fig. 31: Generic chain for fresh fruits and vegetables

The fruit and vegetable chain is usually part of a wider supply network where traders or distribution centres might order produce from outside their regular suppliers to provide their own customers with produce, which their regular farmer suppliers cannot deliver. Similarly, traders might deliver some of its produce to customers outside their regular distribution centre customer base. Third party service providers are supporting actors with solutions for production, packaging and transports, but also for quality management and control. Any concepts for improvements need to consider these dynamic linkages and develop appropriate integration approaches and security measures for the protection of all participants' interests.

It is common to package fruits and vegetables in crates (boxes) and especially boxes that are reusable. These boxes usually circulate with the product between production and retail outlets, whereas the provision of fresh boxes to production (via trade) and the collection of used boxes (via distribution centre) can be organised in different ways. This requires managerial engagement which is provided through external service providers (box management) which provide the boxes as well. On the other hand it offers the chance for a chain-wide tracking and tracing system based on these boxes, because the product never leaves the crate until retail.

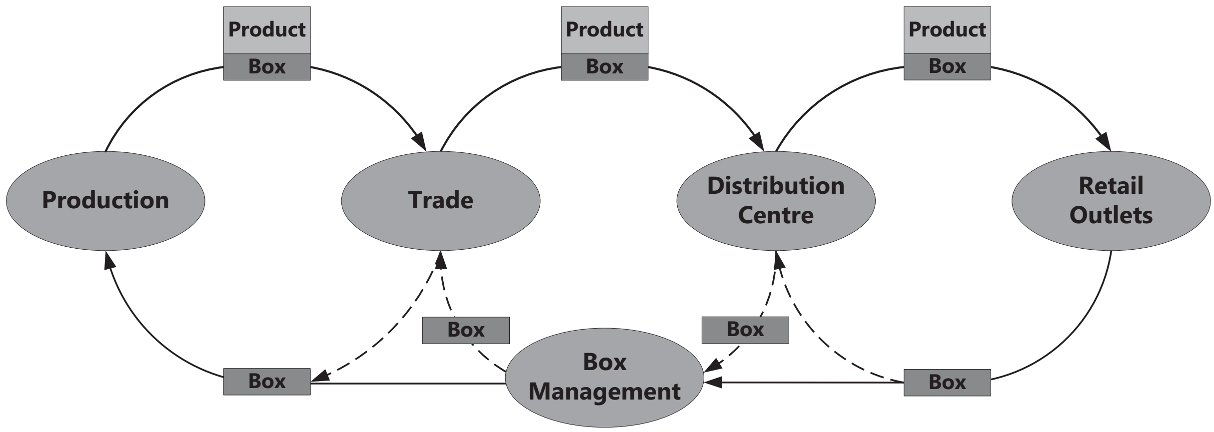


Fig. 32: Possible cycles of reusable crates

The exchange of goods between stages requires communication between suppliers and customers. The involvement of consumers represented retail, which orders produce according to specifications meeting the consumer’s demand for fresh and qualitative products in a high variety and all-year availability.

Information needs

While the fruit and vegetable chain is represented by a straightforward linkage of a few stages in production and trade, the needs for the delivery of trustworthy quality guarantees, quality preservation and organizational efficiency are of paramount importance.

Fruits and vegetables are perishable products where quality is the focus of public and private requirements based primarily on food safety concerns (e.g. EC NO. 396/2005) that require an appropriate control of a variety of parameters in production and logistics. Quality deficiencies cannot be removed and might not only lead to decrease in sales but even to market breakdowns where consequences reach beyond the enterprises and chains that are responsible.

Product quality is primarily dependent on conditions during farm production and, upon harvest, on treatment, temperature control and time to market. For the delivery of quality guarantees to customers, emphasis is put on an appropriate pre-harvest quality analysis and monitoring of quality preservation of products during storage and transport through the supply chain. Trust in the validity of results as well as monitoring information and a trustworthy and timely communication of results towards customers are required.

Critical success factors in efficiency considerations are related to the very early and later stages of the chain. They concern the timely delivery of boxes for packaging of produce and the timely delivery of products to retail. For the delivery of fresh fruits and vegetables, the time of delivery to retail according to agreements is crucial as products cannot be stocked or, if delays occur, have to be sold at other times for which other orders have already been placed. Apart from information on harvest times, the monitoring of inner- and cross-country product movements through the chain and especially of the transport situation in the final stages including delays due to traffic conditions is of high relevance.

Barriers

The provision of trustworthy quality guarantees, the monitoring and control of changes in quality during the product flow between trade and retail, and the monitoring of transport situations builds on "applications" that collect and process the necessary information and on the availability of appropriate network based and flexible communication services that serve the information needs of actors within and beyond the chain and provide the link between production, trade, box management, and retail customers (SCHIEFER ET AL. 2008b).

However, the present communication landscape is dominated by enterprise specific applications and solutions with very limited communication across enterprise borders that reach beyond the exchange of basic business documents as, e.g., bills or product documents.

There is well-established post-harvest quality analysis and product quality analysis at individual stages. However, the linkages between stages and food chain actors that allowed

a) a product based tracking and tracing through the chain,
b) the access to quality information at different stages,
c) the support of trust in product deliveries through the communication of appropriate trust generating parameters like the origin of products or the evaluation of producers and suppliers through e.g., quality certification,
d) the online monitoring of product flows with the identification of changes in quality and of problems in the transport situation that might risk delivery times, and
e) the continuous monitoring of box movements

are poorly developed. Furthermore, customer interaction that reaches beyond the ordering of products is not well established (SCHIEFER ET AL. 2008b).

5.2 Selected application cases for information services

Present trading relationships are not yet prepared for the abovementioned issues. The problem is not the organization of information flows as such, as the exchange is common beginning with information on sales documents. Problems arise from:

- the quantity and diversity of information to be dealt with in collection, processing, and distribution and
- the diversity of customer needs and information rights as determined by the willingness of information owners to share information in more or less trusted relationships.

Empirical studies show that partner relationships building on partner trust are of high prominence in the food (FEARNE AND HUGHES 2000) and especially in the fruits and vegetables sector where quality of products is of high value but sensitive to production and treatment (KADER 2005, KADER 2002, MENCARELLI ET AL. 2005). In the sector, partners had to rely traditionally on suppliers' trustworthiness and product quality guarantees.

This opens the way for the three application cases for information services, which focus especially on the advanced and high quality markets that innovate and lead the way. Expectations of agri-food enterprises in these application cases can not only be met by improvements in information distribution and communication but also by developing an appropriate access control that assures that information reaches the intended recipient but nobody else. Any technological solution needs to respect this limit to find acceptance in the sector. Earlier advancements in technology that tried to bypass this requirement have failed. Therefore, this scenario focuses on the development of a decentralised organisation scheme following the idea of service-oriented architecture and the concept presented in Fig. 5 in chapter 3.2.

The network view builds on general access points that allow network interaction as an alternative to point-to-point communication agreements. Access points allow the activation and utilization of services. Depending on the available levels of technology, such access points could be located at the enterprise e.g. on internet web site implementations, or virtually represented by computer based internet service access opportunities. The network interaction supports flexibility and decentralization in the sense that participation in interaction activities does not need to build on a pre-determined integration in an interaction scheme but offers opportunities to join if needed.

5.2.1 Information Services

The following information and activity services will be elaborated for this scenario:

1. Provision of information (static information service) on the quality status of products on a regular or on demand basis to serving increased information needs along the chain and with consumers without compromising the competitive protection interests of those who provide the information. This service is elaborated in chapter 5.3.
2. Provision of information (dynamic information service) from online monitoring of product quality which, as a dynamic view, might employ all three patterns of information provision (regular, on demand and on exception). This service is elaborated in chapter 5.4.
3. Identification and activation of deficient products (combination of all alternatives) for recalls or elimination from the product distribution process which would build on one of the information service listed above and realise the information provision on exception in analysing quality information at sender's or receiver's end (for this case the sender's view is selected). This service is elaborated in chapter 5.5.

5.2.2 Supportive technology

Focussing on the supportive technology layer, information could travel along the chain through communication networks or through attachment of information to the product (RFIDs). This has consequences regarding the utilization of information services and the devices used. Information attached to the product can be picked up upon product delivery without any link between sender and receiver. Communication through networks requires an information link between sender and receiver. Both approaches, however, could be organized as open information services requiring no specific authorization for its use. If authorization is of interest, both approaches require an authorization link between sender and receiver which could build on the transfer of access codes of whatever kind.

The technology development path focuses on the increasing opportunity to build decentralised communication schemes that make centralized coordination obsolete. This is a critical success factor for the improvement of current practice, since centralised solutions are not accepted for the purpose of broad exchange of product- and process-related information. Due to this lack of acceptance many centralised solutions failed because of data ownership issues and possible negative effects on competitiveness. The visionary level aims at minimizing the required central coordination needs. The elaboration of business information services in this chapter is based on the previously identified key components supporting the collection, processing, transfer and provision of information. To elaborate intermediate and advanced service scenarios, the abovementioned development path is adapted for selected technologies supporting the process. Due to the general technological development the capabilities of the networked devices increase over time. In respect to the emerging mobile technologies, the second and third level emphasises the integration of mobile technologies and related communication networks for mobile communication. The adapted development path of the key technologies is presented in the following overview:

RFID

According to the previously stated advantages, RFID technology is facilitated in this application case for primary for improving traceability by supporting the identification of transport units and secondary to enable a decentralised information provision scheme based on the vision of the internet of things. The assumed generic development path is based on currently available tags and their foreseeable development as well as a visionary scenario, in which RFID-tags are equal to today’s smartphone technology:

TL 1: RFIDs as identification tags with short range passive or active communication capability.

TL 2: RFIDs with data capturing, sensor, and data storage capability, but no opportunity to receive and store data from remote sources.

TL 3: RFIDs which combine advanced capabilities in information collection (sensors and data capturing), storage, filtering, output (audio-visual), sending, and triggering. These capabilities would enable the RFID to participate in the network concept providing an individual access point.

Scanner Technology

The implementation of RFID technology in the application scenario requires scanning technology, for capturing information from the RFID-tags. Due to the capabilities of RFID technology in the different technology levels, the scanner technology has to be aligned to these developments. The development path of scanner technology follows the trend to apply and improve mobile devices for facilitation in business processes. This is considered in the generic development path of scanner devices:

TL 1: Scanners as readers with cable based or short range wireless communication ability.

TL 2: Scanners with advanced information capturing, data storage, and sending capability but limitations in processing and output capability.

TL 3: Scanners which combine advanced capabilities in information capturing, data storage, processing and communication.

Software Agents

The search for information at the different platforms is supported by software agents, defined as a program or software component, which autonomously interacts within its digital environment to automate the collection of information from distributed information sources (FRITZ 2005). This opens opportunities for the business information service organisation depending on the characteristics of these agents. For this thesis, the following generic development path of software agents is assumed:

TL 1: Agents which search pre-defined information clusters according to defined rules.

TL 2: Intelligent software agents which combine information capturing with learning components and appropriate output features and which search pre-defined information clusters according to defined rules.

TL 3: Intelligent software agents which combine flexibility in the integration of rules, advanced information capturing with learning components and flexible and intelligent search components.

Communication networks

The classification of communication networks can be structured by the availability and range of the different networks into three generic technology levels:

TL 1: Local networks (e.g. LAN, WLAN), as a standard network technology,

TL 2: Wide range radio based networks (e.g. GSM), as an emerging technology for ubiquitous access to information,

TL 3: Global range satellite communication networks (e.g. SAT), as a developing communication infrastructure for mass communication in a long-term concept.

These levels of technology are aligned to the previously described technological development path.

5.2.3 Overview

This chapter provides a series of principal reference processes for the selected scenario following the integrated approach of the BISF. The overview on the chapter is presented in the following table.

Table 6: Overview on the dimensions of the reference processes to be developed in this chapter

Services	Technology level		
	TL1	TL2	TL3
Static information service Provision of decentralised product quality information)			
Dynamic information service Online monitoring of product characteristics			
Evaluation and activity service Activation of boxes carrying deficient products			
Decentralisation opportunity		+	++

The combination of service alternatives of the business process layer and the distinguished levels of IT support in combination with the access point approach identify the generic interaction models under consideration.

5.3 Provision of decentralised product quality information

A possible application case for this service is the provision of decentralised product quality information, which is stored at the actors in the supply chain or linked to the product itself. Based on the previously discussed challenges in the fruit and vegetable sector, the need for the provision of product quality information is increasing. Discussions on the safety and quality of food products due to crisis (e.g. the EHEC outbreak in 2011), the environmental impacts of production, and the social background of enterprises involved ask for the provision of appropriate information and guarantees. This leads to market developments towards higher requirements on transparency focussing on:

- **Food safety**, which is defined as the absence of biological, chemical and physical risk factors (PERI 2006, EC NO. 178/2002 Article 2 and 6). Especially focussing on **pesticide residue levels**, which are regimented in EC NO. 396/2005 and recently updated in EC NO. 256/2009. However, fresh produce with pesticide residues or not acceptable plant protection agents are discovered on a regular basis throughout the season (EFSA 2010).
- **Production related attributes** of product quality based on consumer demands, such as e.g. organic or conventional production, the place of primary production (origin) as well as the freedom of genetically modified organisms.

The provision of decentralised information was chosen as an instantiation of this service alternative, because of its importance in the sector. The objective of this application case focuses on the provision of reliable information on the aforementioned issues, which do not change post-harvest and to proof the compliance of public and private requirements of fresh produce. All enterprises in the agri-food sector have to cope with these issues to stay in the market and provide fresh produce meeting the consumers demand. To assure food safety, regular laboratory analysis and other analytic methods are applied with high efforts at different stages in the supply network. However, product quality related information, especially information with competitive value, is usually kept by the originating enterprises. The collection of information about products at each enterprise involved in the production and distribution process as well as the exchange of some of this information within the chain are inherit elements of any regular trading activity with fresh produce. Information exceeding legally required product information is forwarded only on demand. However, the provision of such information would increase trust between trading partners and enable a higher transparency level, which is demanded from agri-food enterprises in the chain as well as the consumer.

5.3.1 Principal service organisation of this application case

The static information service can be triggered either on a **regular** basis or on demand by establishing a query for additional product quality information in the specific context defined by the activities carried out in business processes (e.g. goods inward, order picking or procurement of fresh produce).

Focussing on the distribution process, which is the scenario for implementation, the provision of product identification information can be implemented at the goods inward, where products are checked for their compliance with predefined customer requirements. Due to the time-critical distribution of fresh produce, the generation of laboratory results takes longer then the distribution of the product to the next stage of the supply network. This requires the provision of this information ex post, which is of importance between the two major transition points in the supply network, namely traders/bundlers and distribution centres.

The static information service is based on the connection of physical products and information which belongs to an identified product batch. Today, this information is available for larger batches of products and is not broken down to the box level. This is critical due to the distribution of one larger product batch containing multiple boxes to different customers, which makes tracing a complex task. Therefore, the interaction for the static information service builds on three prerequisites that have to be fulfilled for implementation:

1) the required product quality information has to be collected, which is a standard procedure, carried out by the enterprises in the sector in order to meet different requirements.
2) the collection of product quality information has to be linked to the physical product batch, which is separated into a certain number of boxes. These boxes have to be

marked with a unique identifier (RFID containing BoxID), which has to be recorded as well. This requires standards and protocols for the identification scheme as well as the collection of BoxIDs using scanner technology.

3) box identification information (BoxID) and product quality information have to be linked and provided to the access platform.
4) access details (e.g. address information) to the individual platform have to be forwarded or provided with the product to the customer to enable the request for product quality information related to a specific BoxID.

The BoxID represents a key to the related product information and is an essential part of the security mechanism. Theoretically, only those enterprises in the supply network, who participated in the distribution of a specific box, can provide information in relation to the specific BoxID. Therefore, the BoxID is not only essential for tracking and tracing records, but represents a key for accessing the available product-related information at the platforms. The general interaction principles for the static information service are depicted in Fig. 33.

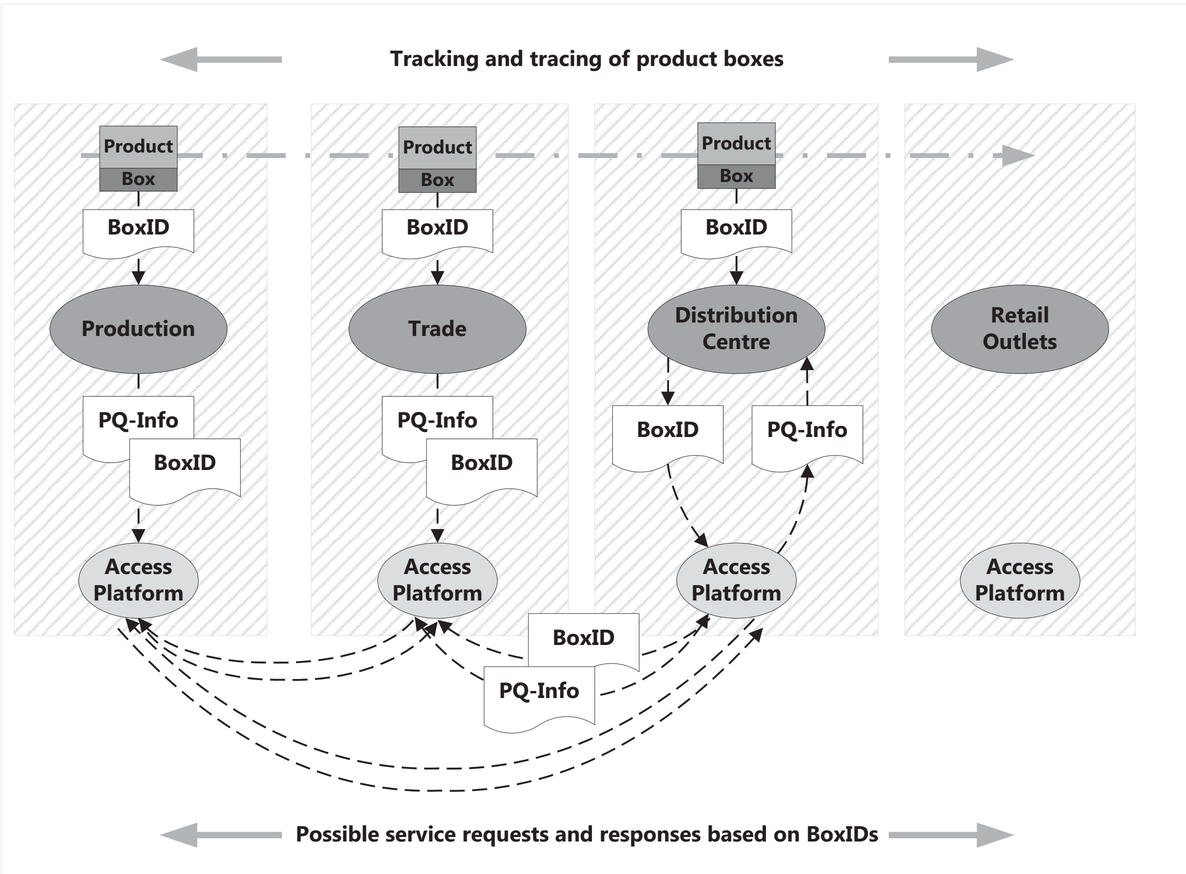


Fig. 33: General service organisation for the provision of decentralised product quality information

The service organisation is developed based on tracking and tracing information available at the different stages, which contains the box identification information (BoxID) and the origin of the product. With this, the movement of the box with the product throughout the supply network allows identification of potential information clusters containing static product quality information (PQ-info). At the different stages, the BoxID is collected and linked to the PQ-info and send to the access platform to be accessed using the static information service. To access the offered product quality information at the different platforms, the specific access details are required. These details are provided from actor to actor using e.g. the RFID-tags on the boxes. However, these access details and BoxIDs can be provided in advance using other communication channels. This enables a controlled information provision. Additionally, the security mechanism of "trust-based access" to the information stored on the access platform prevents loss of data ownership and control over the group of people allowed to access this information.

The processing and evaluation of data received by the static information service requires existing systems and their functionalities. Actors have to evaluate the received information and draw conclusions for their workflow to decide on the appropriate action. To disburden the user from evaluating large amounts of data, specific rule-based filter and trigger mechanisms can be applied to notify users just in case of an exception filtered out of the incoming product quality information.

The realisation of the necessary information flow and information processing for the information service development is presented in the following interaction models for each technology level. These models focus on the application of networked devices in business processes for supporting the users in their tasks. The management and control of the information flow and the processing of information are implemented in these devices. The focus of these models is to integrate networked devices in existing workflows for improvements in service efficiency and quality. A description of the differences between the technology levels and their impact on the organisation of the service will be done in the corresponding model description.

The interaction models for this service are based on a bilateral interaction between a trader and a distribution centre in a sender-recipient relationship (see Fig. 33). The trader enterprise provides the product and product-related information as well as the access point for requesting information. The distribution centre as the receiving actor is representing the generic workflow for receiving products and requesting information from its supplier. However, this setup and workflow can be implemented vice versa because most of the enterprises in the middle part of the supply chain are suppliers as well as customers.

The service organisation for this scenario is based on a generic information model (see Appendix E). The workflow presented in this first reference process contains different consecutive steps and events:

EVENT1: *Product arrival at the Trader (supplier; static data collection and preparation)*

1) Product identification data is collected
2) Product identification data is used to merge available product quality data with identification data
3) a) Update existing product information with new information (e.g. box identification)
   b) During order picking access details are written onto the RFID-tag attached to the box and the box is distributed to the customer.

EVENT2: *Product arrival at the Distribution Centre (customer that receives the specific box; execution of static information service to meet information demand)*

4) Product identification data and access details are collected
5) Product identification data is used to query internally existing product quality information
6) Depending on the sufficiency of the existing data additional product quality information is requested from the supplier via the access point /platform at the supplier *(rule-based triggering of service execution)*
7) Depending on the information received via the information service a rule-based decision is taken how to proceed with the product.

In the food specific context appropriate actions can be:

a) the acceptance of a product and its distribution to the next stage of the supply chain,
b) the rejection of a product due to quality issues like the visible degenerated quality status of the product

c) postponing the distribution of the product and the execution of the static information service as well as the collection of product samples for further analysis
d) the rejection or acceptance of a product due to received product quality information via the static information service.

The interactions between the networked devices, the access platform as well as the different data cluster are elaborated in the following principle reference processes for the different levels of technological development. The modelling follows the previous presented modelling framework.

5.3.2 Service organisation at technology level 1

The technology level 1 is characterised by systems and networked devices with current available capacities, presented in the following table:

Table 7: Networked device capabilities at technology level 1

Networked devices	RFID	Scanner	Software agents
Capabilities	Low storage and short range passive or active communication capability	Single functionality: providing BoxID to other systems (push); Limited range, due to fixed installation;	Agents which search predefined information clusters and access platform according to defined rules

The application of networked devices has to be supplemented and supported by software components and existing systems, such as e.g. middleware for RFID-Scanner gates and attached personal computers to process the received data. The mobility of such devices is very low, because of their fixed installation in the enterprise. Stationary (TL1) RFID-Scanner/writer devices are found at goods inward and outward for scanning the RFID-tag on the box (TL1) and writing the access details onto the RFID-tag of each box that is shipped. The collected product data is processed and stored using product information systems. Due to the variety of systems and the integration of components (i.e. networked devices: Scanner and RFID) various individual interfaces between these systems are required and have to be implemented. The required functionality is implemented in different systems, which force the actor to intervene and replace triggering of appropriate actions. The implementation of the access platform concept requires an adjustment of existing database applications to forward product and box identification information to the access platform. Due to the generic character of the reference processes for this service, these applications are exchangeable and require no further specification.

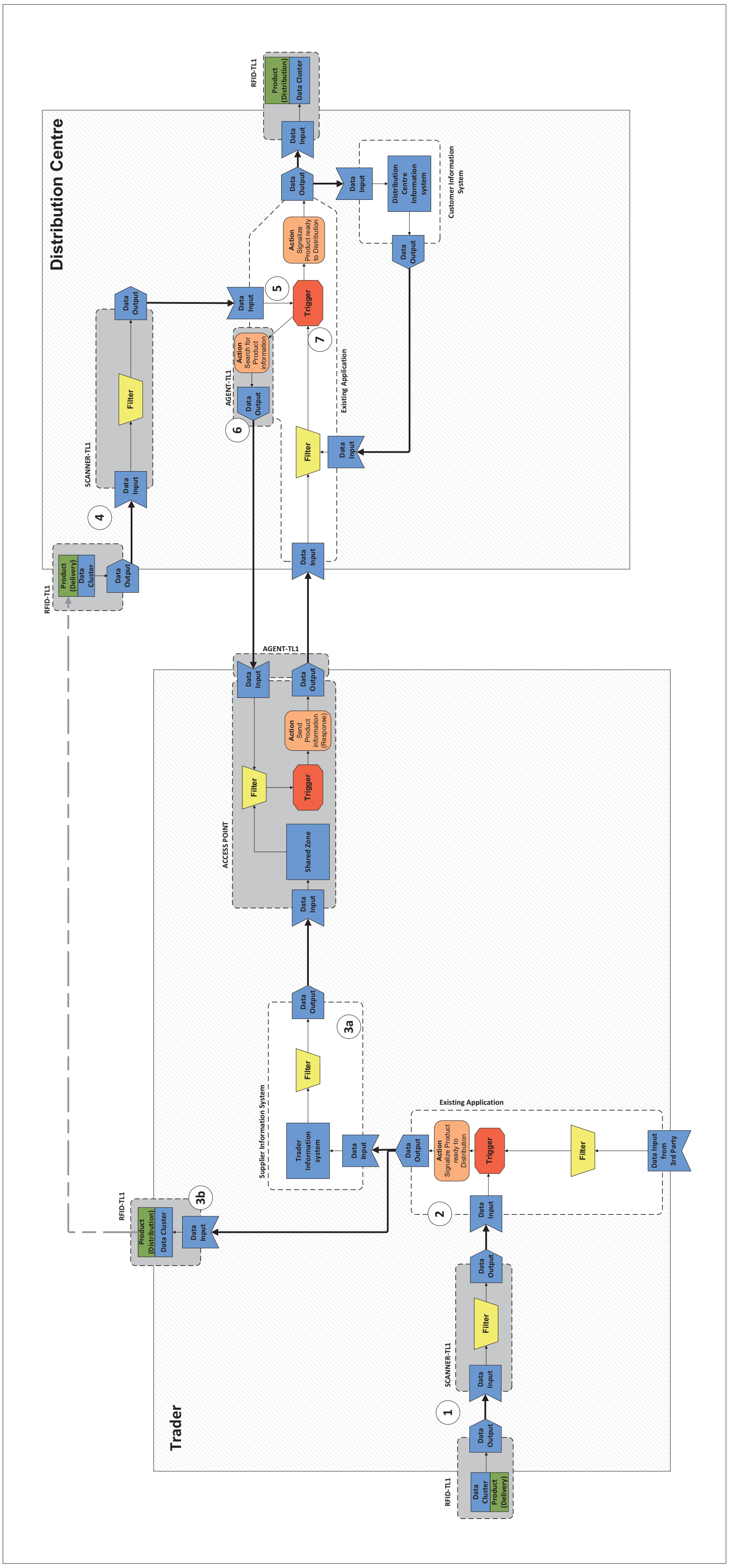


Fig. 34: Static information service at technology level 1

5.3.3 Service organisation at technology level 2

The technology level 2 is characterised by systems and networked devices with extended capabilities in a five year horizon and is presented in Table 8.

Table 8: Networked device capabilities at technology level 2

Networked devices	RFID	Scanner	Software agents
Capabilities	RFIDs with sensors for data capturing and increased data storage capability, but no opportunity to receive and store data from remote sources "on the fly".	Scanners with advanced information capturing, data storage, and sending capability but limitations in filtering, triggering and output capability	Intelligent agents which combine information capturing with learning components and appropriate output features and which search pre-defined information clusters according to defined rules.

In the second step of the technological development path (TL2) the capabilities of the networked devices increase. The scanners' (TL2) mobility and consequently the range of scanner devices increase as well as their ability to connect to existing systems facilitating wireless networks. In comparison to the first technology level, the scanner devices in TL2 are able to establish pull connections to existing systems, whereas scanners in the previous TL were just able to push BoxIDs to a processing application. Mobile Scanners (TL2) are capable of collecting BoxIDs and merge them with existing product information, which increases the filter capacity of these scanner devices.

The RFID-tags increase in their storage capability that allows writing additional information on the tags. Additionally, these tags are equipped with sensors for continuous measurement of the product's ambience. These advanced capabilities enable few but important changes to the workflow of the actors. However these changes are not presentable in the interaction models, because of their marginal influence on the information flow and the necessity of the application of existing systems.

The visible changes in the model, presented in Fig. 35, can be seen in the goods inward of the trader and the distribution centre, where the scanner device exchanges information directly with the different information systems. Product data and distribution data can be accessed by the user directly at the goods inward without a stationary personal computer. This internal information provision has an influence on Event 1 and 2, but there is no change in the generic service principle depicted in Fig. 34. At the reception of products the scanner device forwarded information directly into an attached computer system, which is still the case, but the forwarded information can be processed (Filter) directly on the mobile scanner device. The user at the goods reception can directly access the existing product quality information and can start the search for additional information from the supplier using an existing system with the required capability.

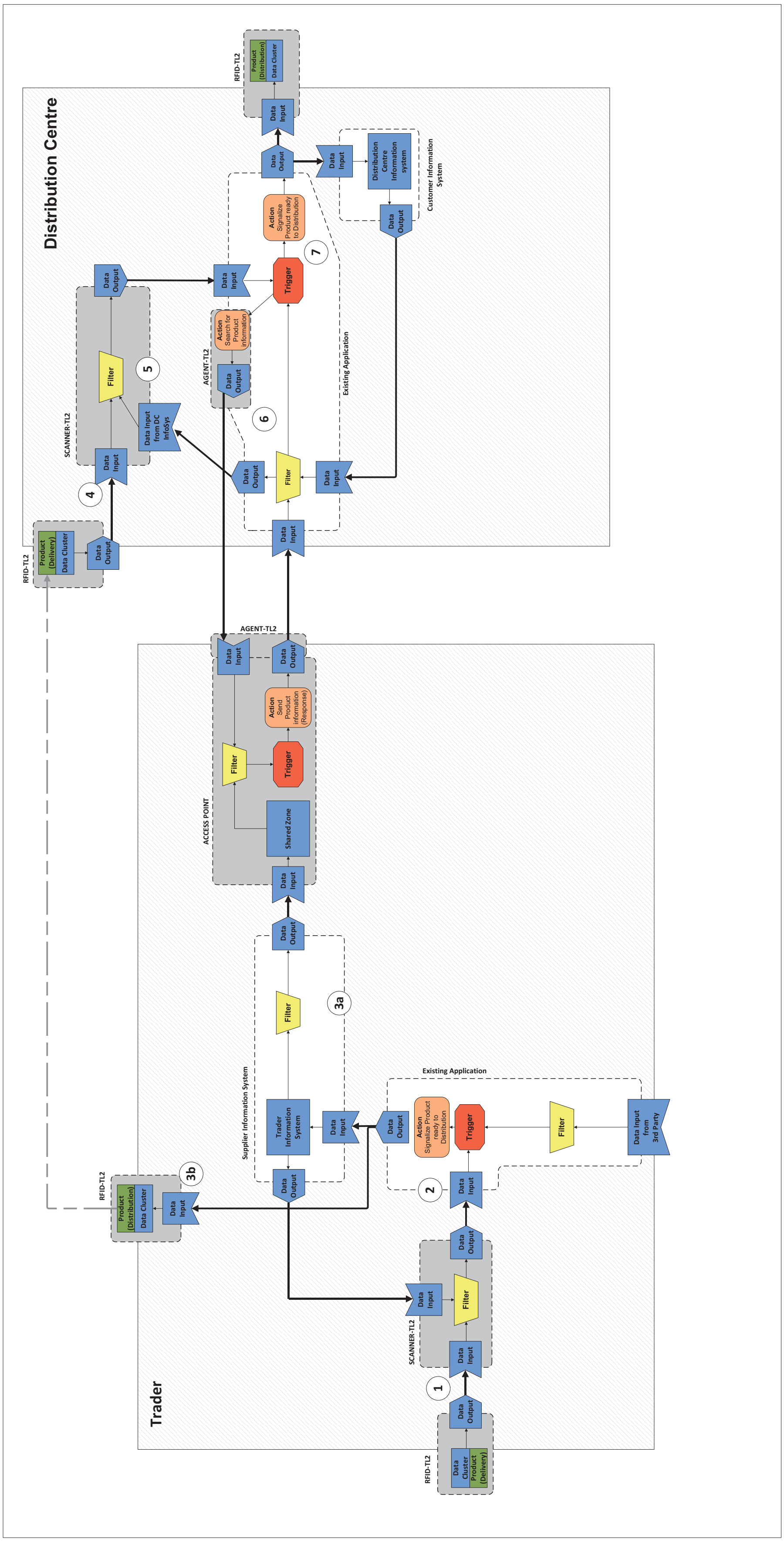


Fig. 35: Static information service at technology level 2

5.3.4 Service organisation at technology level 3

The technology level 3 is characterised by systems and networked devices with visionary capabilities not available today (Table 9). These capabilities have important impacts on the service organisation.

Table 9: Networked device capabilities at technology level 3

Networked devices	RFID	Scanner	Software agents
Capabilities	RFIDs which combine advanced capabilities in information collection (sensors and data capturing 'on the fly'), storage, filtering, output (audio or visual), sending, and triggering	Scanners which combine advanced capabilities in information capturing, data storage, filtering, output (audio or visual), sending, and triggering	Intelligent software agents which combine flexibility in the integration of rules, advanced information capturing with learning components, flexible and intelligent search components, data storage, filtering, output, sending, and triggering

At technology level 3 the advancement of capabilities enables a major shift in the service organisation. In the presented TLs before, the service organisation is depending on existing systems, which have to take over tasks that could not be carried out from the networked devices (e.g. scanners) in focus. With the major increase of RFID capabilities, the platform concept can be integrated into the tag itself. This allows the box to be a fully decentralised information cluster, which collects and provides product information along its way through the supply network. Information that arrives after the shipping of goods is communicated to RFID devices attached to the product box through wireless networks or satellite communication networks and stored on the device for later use. These changes can be observed in the model presented in Fig. 37. The RFID-tag on the box is capable of hosting an access point due to the advanced processing capabilities. This step is crucial for the development of a near to complete decentralised information provision scheme. Fig. 36 presents the major changes in the service organisation for this technology level.

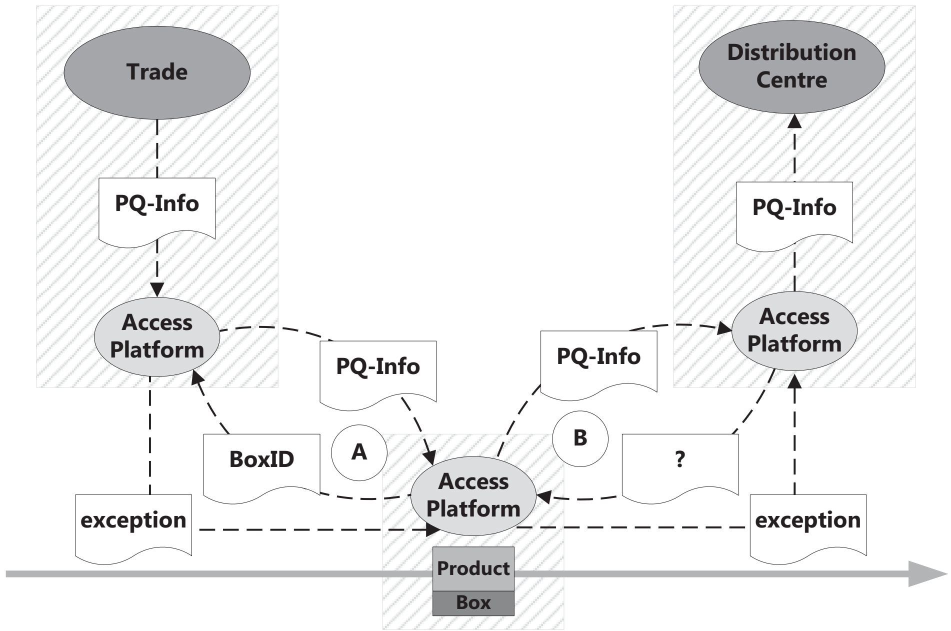


Fig. 36: Box-centric service organisation at technology level 3

In comparison to Fig. 33, the service organisation at technology level 3 shifts towards a box-centric and decentralised organisation scheme, where the box contains distribution related information as well as all available product quality information. The push pattern facilitated to provide information to the box is exchanged by a request-reply pattern (feedback loop A) initiated by the box. At arrival at the supplier, the box registers itself (request) using the BoxID and other information stored on the RFID-tag and collects (reply) product quality information, that is available at this enterprise. In the distribution process, the box can receive additional product quality information (feedback loop A), which was not available at the beginning of the shipping process. In cases of emergency, e.g. the detection of a contamination, the exception signal can be directly communicated to the box, whereas the box can communicate the exception to the customer at the arrival of the product or even earlier using communication networks as well. This enables the communication with supplier and customer during transport facilitating communication networks (feedback loop B).

The most important change in the service organisation is enabled by networked-device-enabled-intelligence (NDEI). This “intelligence” is based on predefined rules, which define e.g. the borders of acceptance for changes in the products’ ambience. Additionally, the RFID is capable of providing audio or visual signals on exceptional events, where direct action is required. These capabilities enable the box to act as an active participant in the distribution process.

The networked devices' capabilities in the technology level 3 enable the implementation of networked device enabled intelligence, due to the increased processing capabilities. The scanner devices (TL3) as well as the RFID (TL3) have the implemented triggering abilities, which build aligned to filtering and triggering rules establishing the base for the development of NDEI. The scanner device is extending its main focus from scanning physical units face-to-face towards scanning local networks for new boxes arriving. In general, the implementation of trigger elements into networked devices disburdens the user/actor from the manual evaluation of received information and can therefore be seen as an important development in business process support.

In the model, the intelligent box is depicted as an entity in the middle. The other instantiations of the box on the left and right side of the model are correspondingly acting as the box in the middle, but are modelled in a simplified way. The number of interfaces decreased significantly due to the increased integration of functionalities to the scanner devices. Scanner devices are able to request information from the information systems as well as providing them to the RFID-tag.

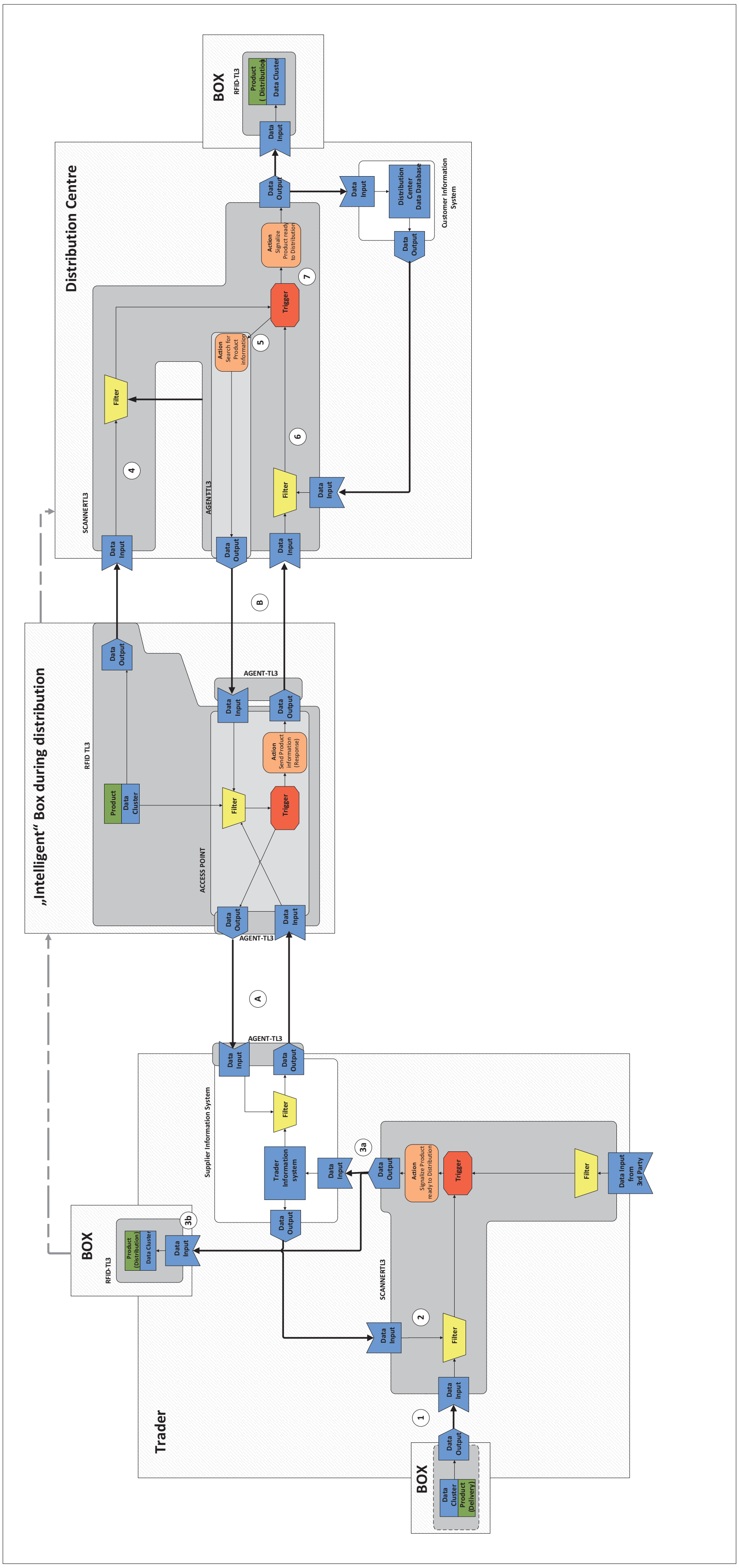


Fig. 37: Static information service at technology level 3

5.4 Online monitoring of product quality

The online monitoring of product boxes during transport was chosen as an instantiation of the dynamic information service, because of its relevance for the distribution of fresh fruits and vegetables. The online monitoring of product quality is a business information service that builds on the dynamic view. It supports the prevention of food losses during transport of products along the chain and the management of distribution at the sender's (trader) and receiver's (distribution centre) end. Dynamic information such as process-related information is as important as static information for the enterprises along the supply chain of fresh produce. Examples involve production indicators like "food miles" or "carbon footprint", which change (increase) during the products lifecycle (SCHIEFER ET AL. 2008b). The increase in information need relates to both, customer enterprises in the chain as well as retail outlets and consumers. There are also tendencies for information requests by policy institutions related to financial subsidies or taxes (e.g. "carbon tax"). The maintenance of a continuous temperature and humidity is important for the shelf-life of fresh produce. The information service serves a general business process that is organized as follows: Distribution centres order products based on sales and planned promotions. The orders may be fulfilled by different traders. This process might be disturbed if products degenerate during delivery, or product delivery is delayed due to traffic or transportation problems. Both scenarios would endanger the supply of fresh products at retail outlets and require actions. The continuous collection of information on the quality status of products or the transportation situation and its provision to the actors involved are therefore of high relevance to business partners and the sector's competitiveness.

Of the two domains of interest, the monitoring of a product's positioning is straightforward with little data communication and processing needs. Technological advances in sensor technology combined with communication technology enable the real-time observation of trucks and their status. However, these technologies are just adopted by first movers and innovative logistic service providers today. These logistic service providers collect real-time monitoring information and are able to provide them to suppliers and customers of fresh produce as a service. Especially distribution process-related information including approximated arrival times and the status of the transport enable improvements in the business organisation of distribution centres (e.g. assignment of a dock for a specific transport in advance). These improvements reduce time that is needed to arrange the reception of goods and the shipping of goods from distribution centres.

The situation is different regarding quality monitoring which makes it a communication and processing challenge. Successful monitoring of food quality requires sophisticated sensor and data communication technology. Fresh produce is sensible to changes in its environment. The most important factors for preserving food quality that need to be controlled and communicated within the information service are temperature and humidity throughout the distribution process from harvest to retail outlets. Future interests in monitoring could reach beyond direct product related quality characteristics and include more complex information from the environment (e.g. CO_2 emissions).

5.4.1 Principal service organisation of the online-monitoring service

The central aspect in the service organization is the forwarding of monitoring information to a service provider for aggregation in order to get a complete picture of the product handling and possible negative influences on the product quality. Today, the degeneration or wrong handling of fresh produce leads to quality degeneration from mildew to major product spoilage, which increases opportunity costs for the enterprises along the chain. The collection and aggregation of monitoring information can improve the product handling and enable the prediction of the remaining shelf-life.

Different products have different requirements which need to be observed and if pre-defined deviations occur, trigger a decision on how to proceed. From an information service point of view the trigger elements might involve a "*call for action*" by human actors or it might initiate an action autonomously. Independent from the actor, decision alternatives could involve e.g.

1) the redirection of deliveries (by sender) to other outlets to reduce time to market,
2) the assurance of additional supplies (by sender or receiver) to avoid product shortages at point of sale (POS) or, in the food quality scenario,
3) the direct contact with transportation units to assure a better control of environment and avoid further product deterioration.

The identification of *critical deviations* depends on the establishment of a link between observation and requirements, their comparison and the evaluation of results. This requires processing power either in the monitoring device itself or at the recipient's end. The first option builds on higher levels of technology which combines sensor capability with data storage and processing capability. It contributes to the autonomy of the product with its monitoring device attached and supports the realization of a **decentralized monitoring scheme** where the centralization is restricted to the availability of a communication network based on e.g. satellites that allows to informing actors in case of need. It avoids the need for continuous information flows towards actors in the chain as would be necessary in the second option where the identification of deviations requires continuous data communication. This decentralized approach opens monitoring to all potential trading partners without the need for any central management service.

However, as discussed in the static information service, the adoption and broad based acceptance of the decentralized scheme depends on the organization of an appropriate access control to data directly delivered from the product through basic networks without central data management service involved. Present technology does not yet favour the decentralised approach. Furthermore, a continuous wireless communication of a data stream is still hampered by technological and financial problems. If established today, central systems or application providers for single objectives (e.g. GPS tracking of trucks) are bound to one provider, which is the baseline towards the development of the decentralised approach. The monitoring of products is still a very rare exception. As a result, the technology developments discussed in the following service models should have a major effect on improving quality assurance and process efficiency in trading processes in the food sector and specifically the fruits and vegetables sector.

The challenge in the development of this service is the collection of monitoring information along the chain and the aggregation of this information. Especially, dynamically changing information requires the continuous collection of status information for further aggregation. A central independent monitoring application, which collects, aggregates and provides this information to authorized actors is an important part in the service organisation on the first technology levels and is depicted in Fig. 38.

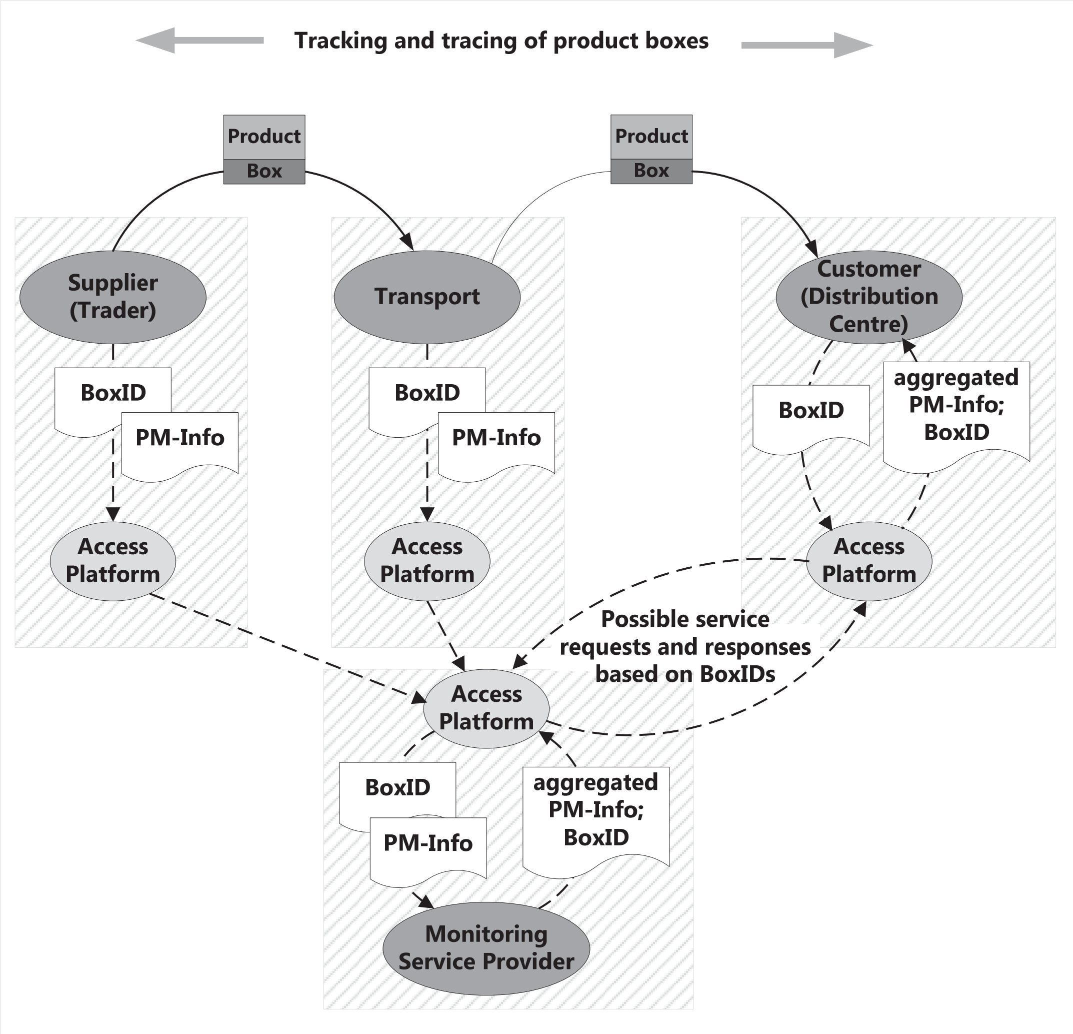


Fig. 38: Generic service organisation for online monitoring

The service organisation requires the box-specific information provision of product monitoring information (PM-Info). This information is provided from the participating actors to the central monitoring application.

The presented service organisation follows a general workflow including generic process steps in the information flow, which are triggered by certain events:

EVENT1: Product departure at the Trader (first enterprise in the distribution chain; dynamic data collection and preparation)

1) Product identification data is provided to the monitoring application (start monitoring) and to the distribution centre as delivery announcement
2) a) Product identification data is used to merge with available local monitoring data, b) and is provided to the monitoring application (push).
3) Handing over product boxes to transport

EVENT2: Collection of monitoring data during transport (time-related event)

4) Product observation during transport (continuous collection of monitoring data) and uploading of monitoring data to monitoring application.

EVENT3: Product arrival at the Distribution Centre (every subsequent enterprise in the chain that receives the specific box; dynamic information service execution)

5) Product identification data is collected and merged with existing data.
6) A request for aggregated monitoring information is send to the monitoring application. This step can also be executed on a regular basis, independent from the arrival of the product, because access details to the application and this specific monitoring session are already available.
7) Depending on the monitoring information received via the information service,
8) a rule-based instruction (action proposal) is provided to the user how to proceed with the product.

In the food specific context appropriate actions can be:

a) The acceptance of a product and its distribution to the next stage of the supply chain
b) The rejection of a product due to quality issues like the visible degenerated quality status of the product or deviations from contractually agreed conditions
c) Direct procurement of product from an alternative trader, because of the time criticality, the products that are expected are already scheduled for different deliveries to the retail outlets – change of planning

The service organisation for this exemplified scenario is based on a generic information model (see Appendix F).

5.4.2 Service organisation at technology level 1

The online monitoring service at technology level 1 is characterized by systems and networked devices with current available capacities. The local collection of monitoring data at the enterprises is organized in different ways which reach from hand-written control sheets up to digital observation of warehouses. In our models we assume, that monitoring data is already available in a digital format. For this reference process, networked devices of technology level 1 are assumed to be implemented. The capabilities of the networked devices in this TL are presented in the following table.

Table 10: Networked device capabilities at technology level 1

Networked devices	RFID	Scanner	Software agents
Capabilities	Low storage and short range passive or active communication capability; no embedded sensors for monitoring	Single functionality: providing BoxID to other systems (push); Limited range, due to fixed installation	Agents at the monitoring application search pre-defined access platforms for monitoring information

The service is initiated by the collection of product (box) identification information for a certain delivery, which is about to be distributed to the distribution centre (Event1). A delivery notification is send to the distribution centre to announce the delivery (Event2). The box identification information and a monitoring request are provided together with local monitoring information to the monitoring application. Stationary (TL1) RFID-Scanner/writer devices are implemented at goods inward and good outward for scanning the RFID (TL1) of each box. The collected local monitoring information describes the temperature and humidity during the process between the reception and the distribution points in the process. The truck which transports the products to the distribution centre uses a local device for monitoring the products ambience during transport. This monitoring information is provided to the monitoring application for aggregation. During the transport the distribution centre is able to execute the online monitoring service to observe the status of the products and evaluate the appropriate action alternatives (Filter and Trigger; Event3).

The organisation of the online monitoring service including these assumptions is depicted in the following model.

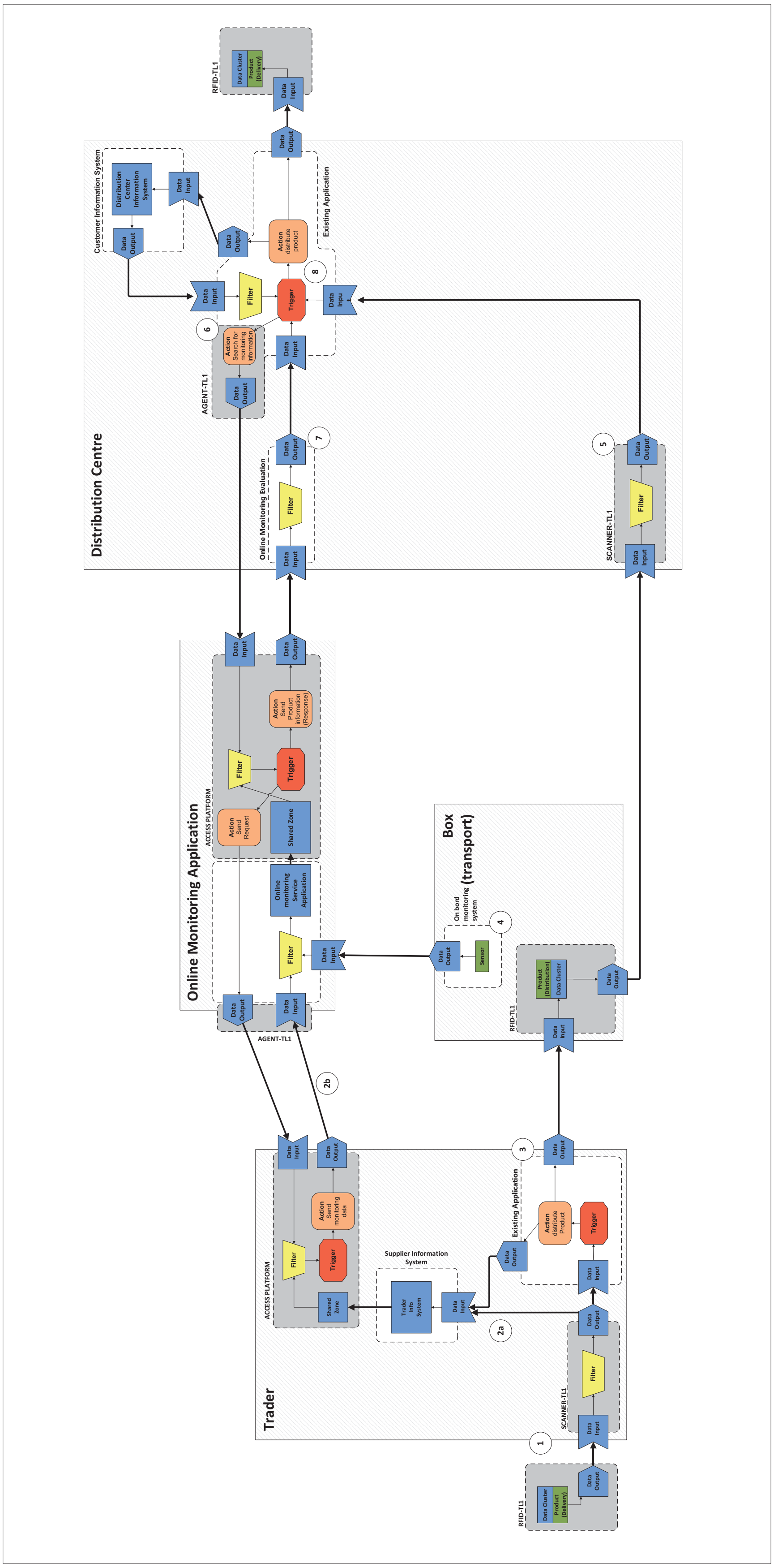


Fig. 39: Dynamic information service at technology level 1

5.4.3 Service organisation at technology level 2

At technology level 2, the collection of monitoring data is more flexible due to the increasing capabilities of RFID-tags. The technology development paths in the monitoring scenario show more variability than in the static information service depending on information interest and use. The basic development builds on RFIDs with sensor technology that allows the storage of monitoring data. This enables small changes at the service organisation (see Fig. 38) by adding boxes collecting PM-Info. At the receiving end, monitoring data could be read and utilized with similar variations in technology as described for the static information service. The lack of network communication capability of RFID-tags necessitates a central communication device in the truck, for sending the monitoring data to the monitoring application. The capabilities of the networked devices in the corresponding TL are presented in the table below.

Table 11: Networked device capabilities at technology level 2

Networked devices	RFID	Scanner	Software agents
Capabilities	RFIDs with sensors for monitoring data capturing and increased data storage capability, but limited communication capability and not able to collect monitoring information from other sources "on the fly"	Scanners with advanced information capturing, data storage, and sending capability but limitations in filtering, triggering and output capability	Intelligent agents at monitoring application, which combine information capturing with learning components and appropriate output features and which search pre-defined information clusters according to defined rules

The increased capability of the scanner devices enables the integration of the evaluation of monitoring data stored on the single RFID-tags. Based on the filtering capability the received monitoring information can be separated into critical and uncritical monitoring information, so that a specific product evaluation is possible.

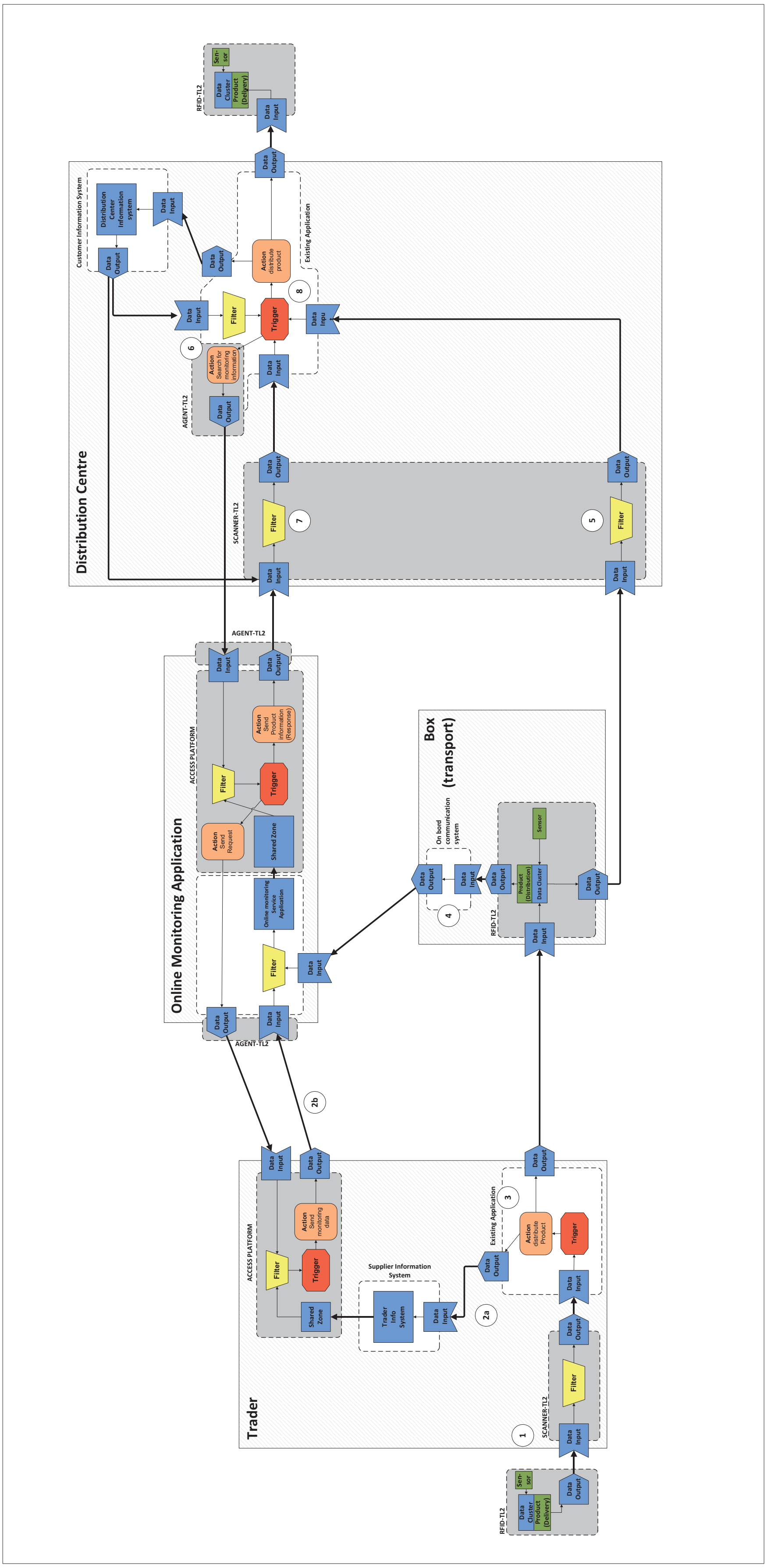


Fig. 40: Dynamic information service at technology level 2

5.4.4 Service organisation at technology level 3

At technology level 3, major changes regarding decentralization and technological development occur. Following the development path, a big step in the decentralization is enabled by the increased capability of filtering and triggering as well as network communication abilities of the RFID-tag. The corresponding capabilities are summarised in the table below:

Table 12: Networked device capabilities at technology level 3

Networked devices	RFID	Scanner	Software agents
Capabilities	RFIDs which combine advanced capabilities in information collection (sensors and data capturing "on the fly"), storage, filtering and triggering, output (audio or visual) and sending monitoring data facilitating communication networks	Scanners which combine advanced capabilities in information capturing using a.o. communication networks, data storage, filtering and triggering, output (audio or visual), sending	Intelligent software agents which combine flexibility in the integration of rules, advanced information capturing with learning components, flexible and intelligent search components, temporary data storage, filtering, output, sending

As depicted in Fig. 41 the monitoring application software and the access platform are integrated into the RFID-tag. This leads to major changes in the model. The RFID-tag observes the product boxes ambience continuously and informs the environment with visual signals (red display) of negative influences on the product in the box. Moving to network and RFID technology allows communicating monitoring data and especially deviations from requirement directly at the time of occurrence.

The advanced capabilities of scanner devices enable network communication with the boxes during transport. With advanced scanner technology at distribution centers and retail outlets, complete online transparency would be feasible without any central management scheme.

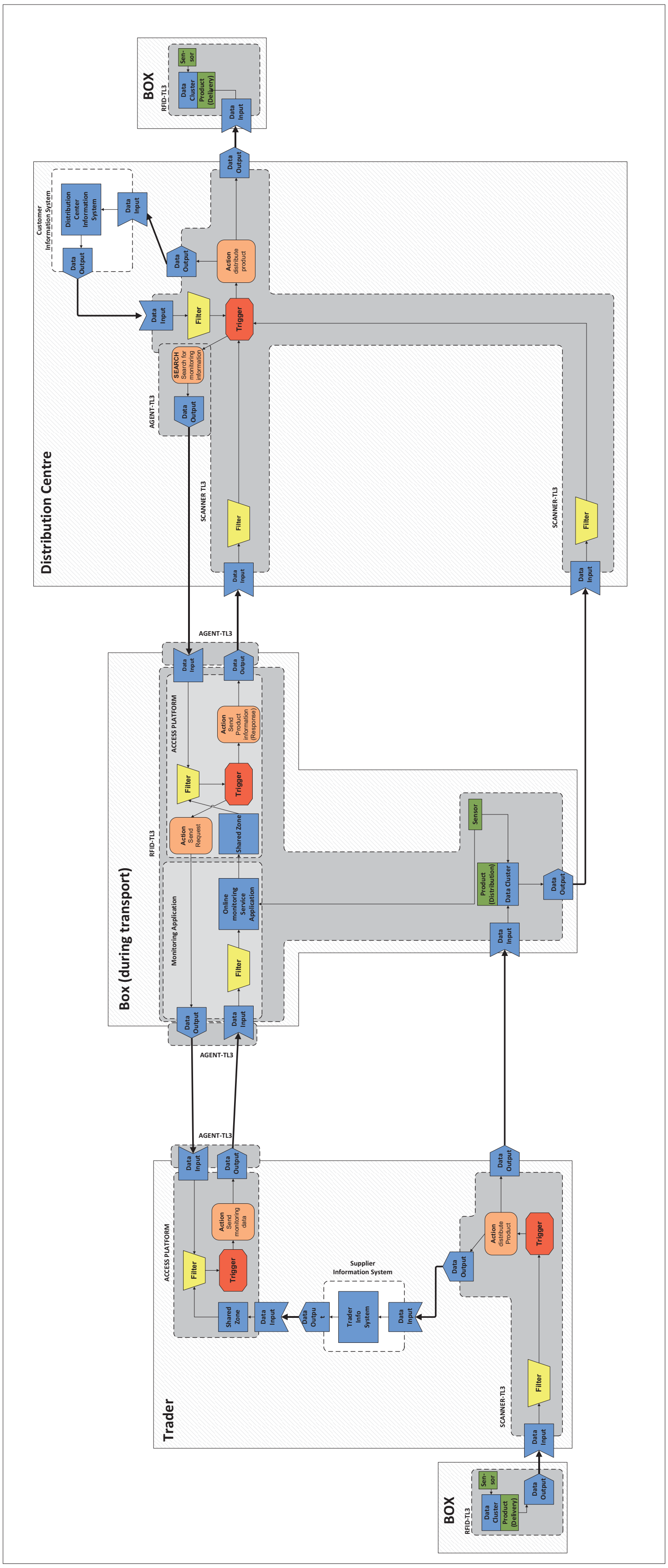


Fig. 41: Dynamic information service at technology level 3

5.5 Activation of a box containing a deficient product

The previously presented static and dynamic information service application cases provide information to service consumers in business processes on a regular or on demand basis. Considering the large amount of data linked to larger product deliveries containing a high number of boxes increases the need for a service that evaluates this data and provides active decision support to the responsible person in the business process. The identification of exceptions supported by rule-based evaluation as well as the rule-based triggering of appropriate actions are core functionalities of this service. Such filtering mechanisms focus on software supported identification of valuable information meeting the personal information demand (EDMUNDS AND MORRIS 2000, SARWAR ET AL. 2001). These filter mechanisms are discussed in literature (HIPPNER 2002, SARWAR ET AL. 2001) and can be distinguished according to HIPPNER (2002) in:

a) Content-based filtering, defined as the filtering of information according to the content,
b) Economic filtering, defined as the filtering of information according to cost and benefit related aspects, and
c) Collaborative filtering, defined as the collaborative recommendation of specific information of interest to other users.

In this application case, the focus is on content-based filtering based on specific pre-defined rules to identify deficient products in the distribution process by evaluating received information provided by the static and dynamic information services. Product deficiencies of food products are defined in this context as the non-compliance of products with agreed product quality and safety parameters such as e.g. pesticide residue levels or the presence of harmful bacteria. The identification of deficient products might be a complex task, because deficiencies in respect to food safety and quality relevant parameters are not always directly visible. While the direct analysis of any individual product allows a clear information link between analysis and product item, there might be other products with similar deficiencies (e.g. based on similar origin) that have not been analysed. They might even have been distributed in boxes through other distribution channels and mixed with other non-deficient product boxes. This task is supported by an appropriate organization of tracking and tracing systems, which are not part of this case scenario, but present an essential prerequisite.

Product deficiencies could be detected by the production as initial source or the trader as well as the retail distribution centre as recipient. From a system point of view there is no principal difference between the actors as the detection by recipients would just require an additional information exchange. However, if deficiencies are being detected at later stages in the chain, the time to react is being further reduced which requires system design to place high emphasis on system efficiency. In the case scenario, this is the rule and not the exception. Excluding failures in initial quality control at trader’s end, deficiencies in products might be detected at later stages of the distribution channel due to the following scenarios:

a) some quality tests need to be performed by laboratories which need time to get results, time fresh produce cannot afford to stay at trader’s end.
b) Products may have been deteriorating due to insufficient conditions during distribution.

The marketing of fresh produce builds on short time-to-market distribution schemes. This limits the time to react in case of product deficiencies. Reaction would involve:

1) the identification of deficient products,
2) the identification of their location in different distribution channels, and
3) the activation of an action that asks for action by a human or autonomous actor.

The principal action is quite straightforward, as it involves the identification of deficient products based on provided information as well as the separation of these products for elimination from the distribution process.

5.5.1 Principal service organisation of this application case

The service organisation in this application case focuses on the distribution of notifications on product- or process deficiencies in a supply network environment. A prerequisite for this “exception reporting” is the identification of product- and process-related information provided by the static or dynamic information services. The identification of exceptions is supported by the EAS, which filter received information to discover exceptions and trigger appropriate pre-defined actions which have to be taken in case of detection of a deficient product.

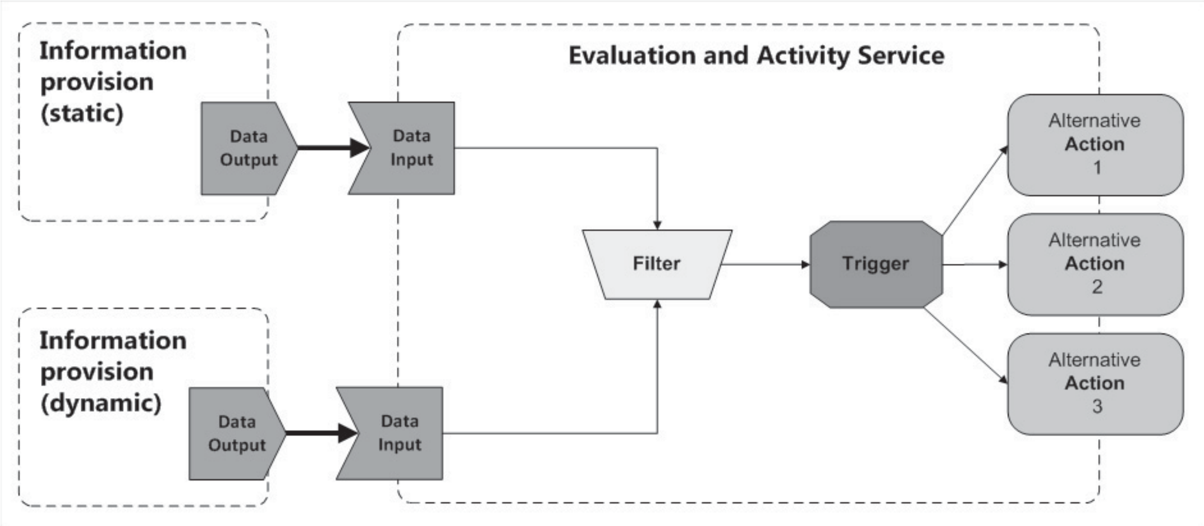


Fig. 42: EAS service sequence for exception identification

Exceptions in general are perceptible deviations from acceptance levels regarding product and process parameters, which require human guidance (actions) to prevent negative impacts on a process. The definition of acceptance levels for static and dynamic parameters (Filter) can differ between enterprises. The definition of appropriate rules and classifications for exceptions is done by experts such as quality managers in the food sector, who establish them up on the general and specific food legislation as well as company guidelines. After discovering a deficient product, this exception notification has to be communicated to the upstream and downstream actors in the chain to prevent further distribution of the product. This communication can be realised using a

1) push concept, by providing BoxID and exception notification together directly to involved actors in the supply network, or
2) pull concept, where exception notifications are published to the actors' access platform and can be requested on demand on a regular basis.

Fig. 43 illustrates the general inter-enterprise service organisation.

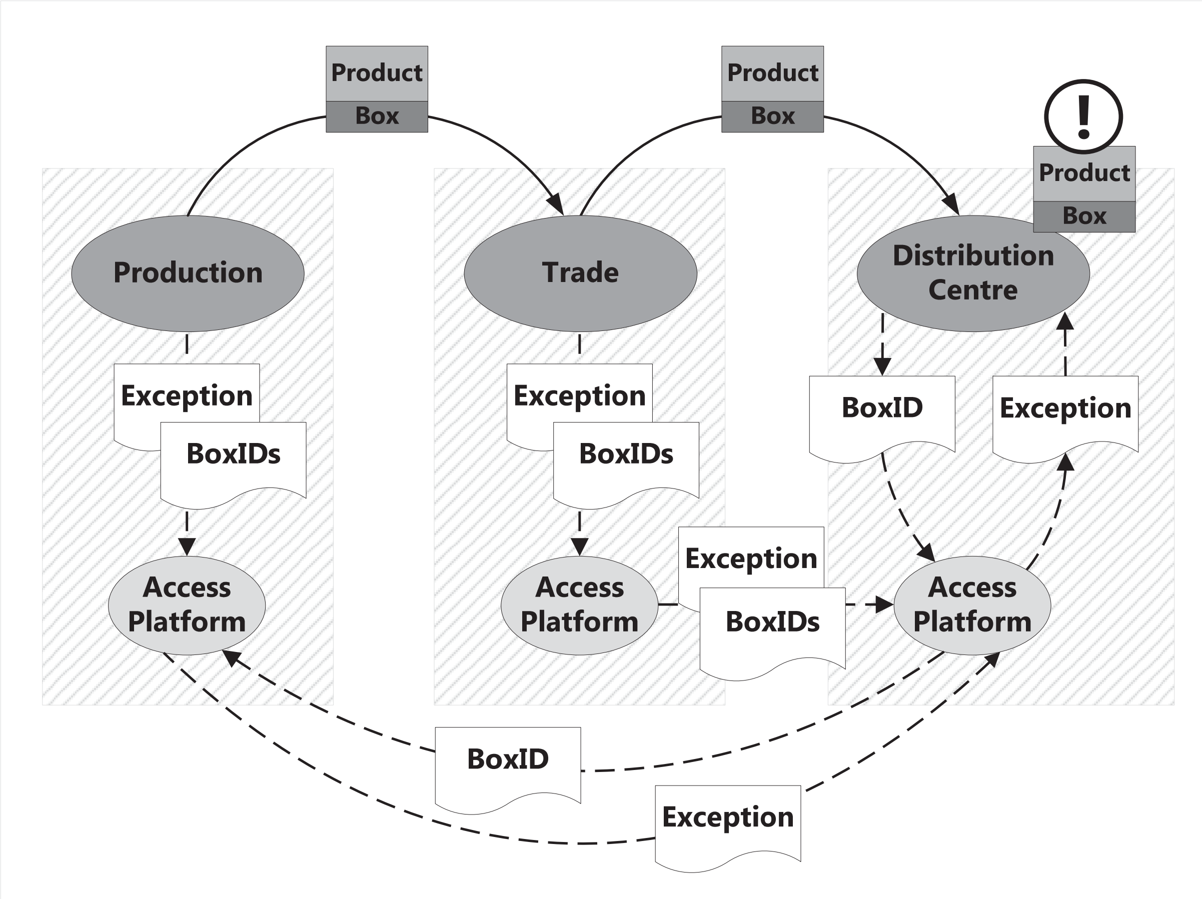


Fig. 43: General service organisation for this case

The objective of this application case is the identification of deficient product batches. This requires the unique identification of boxes as well as linking product- and process-related information to a specific box. The principal reference processes for this application case focus on the integration of the EAS into different components depending on their technological capabilities. However, the identification of exceptional information in a continuous stream of information (filter) and the triggering of an appropriate action including the notification of other chain members is in focus of this application case.

5.5.2 Service organisation at technology level 1

Based on the technological capabilities available at the first technology level, the identification of an exception cannot be carried out by the described components (Scanner, RFID). This requires the implementation of existing systems to receive information from other actors or service providers and identify exceptions, link this information to a specific product box and forward the exception notification to involved actors in the distribution process. The identification of a deficient product is based on the BoxID, which is collected at the transfer points in the distribution between supplier and customer.

If information on a product deficiency is discovered, the tracking and tracing records provide the related BoxIDs as well as the related trading partners in the chain, which enables the identification of affected boxes and actors handling these boxes in the distribution process. The exception notification can be realised as a directed message send by an existing application or can be published to the access platform. In both cases, the BoxID and the exception notification reach the participating actors and the deficient product boxes are discovered at the next scanning point.

However, agri-food enterprises are able to identify the supplier of the product and the customer, who received the product. This increases the complexity for forwarding the exception notification and requires an additional process step, where the IDs of product boxes in stock have to be compared with the BoxIDs provided with the exception notification. If the product boxes carrying the deficient product have already been forwarded to the next actor or actors in the supply network, the exception notification has to be distributed as well.

The interaction model of the activity service (TL1) is depicted in Fig. 44.

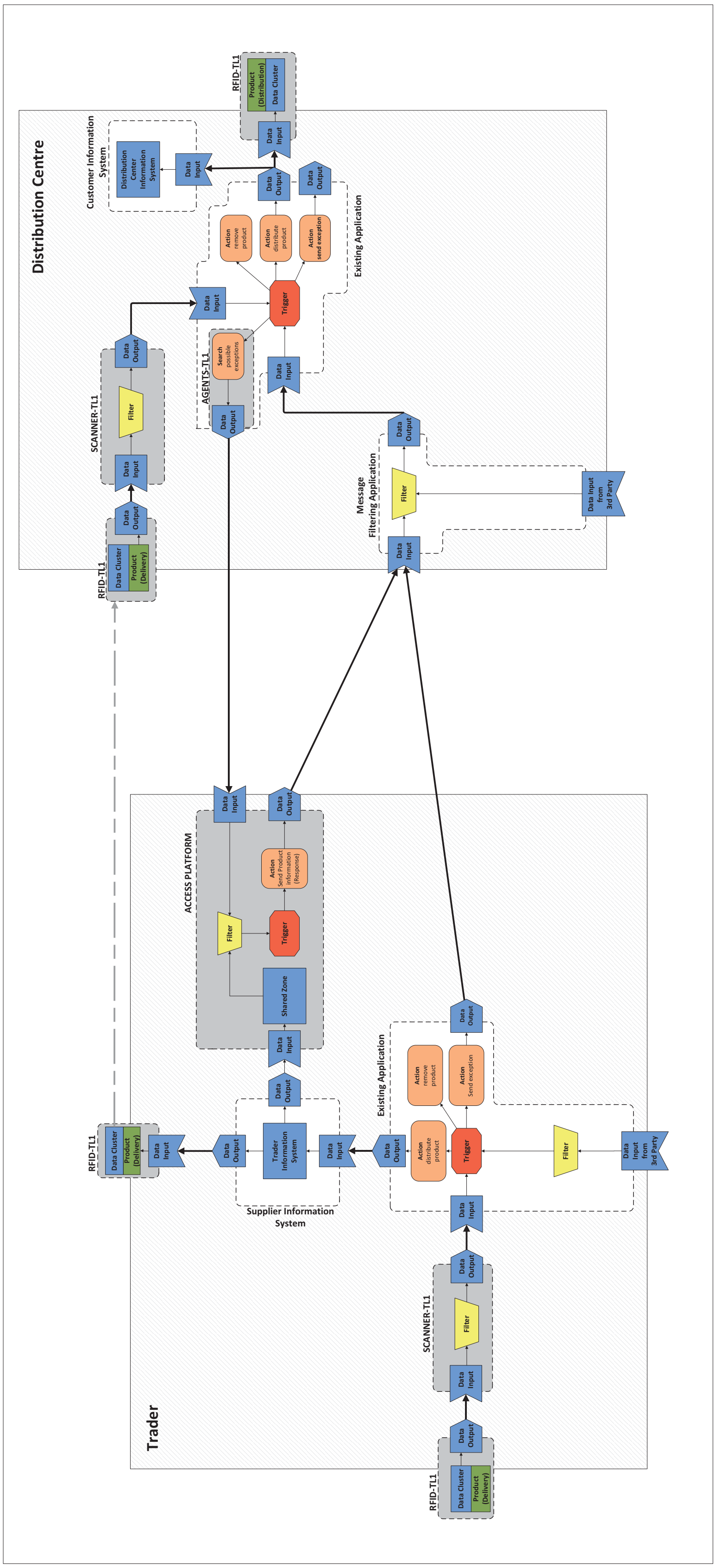


Fig. 44: Service at technology level 1

5.5.3 Service organisation at technology level 2

At the second technology level, the capabilities of data collection for RFID-tags are increasing due to the integrated sensor components. These sensors continuously collect monitoring data from the product box ambience. The identification of exceptions, leading to deficient products, can be realised in this scenario based on the comparison of collected monitoring information and pre-defined acceptance levels. This evaluation directly takes place at the scanner device. However, this filtering capability is limited and requires manual assessment of appropriate actions. Additionally, the previously defined mechanisms for discovering an exception are still valid and implemented in the interaction model.

The identification and elimination of deficient products is facilitated by the advanced mobility of the scanner component. This enables the identification of deficient products at all stations that the product box is passing through and where no stationary scanners are available (e.g. warehouse, point of sale).

The interaction model is depicted in Fig. 45.

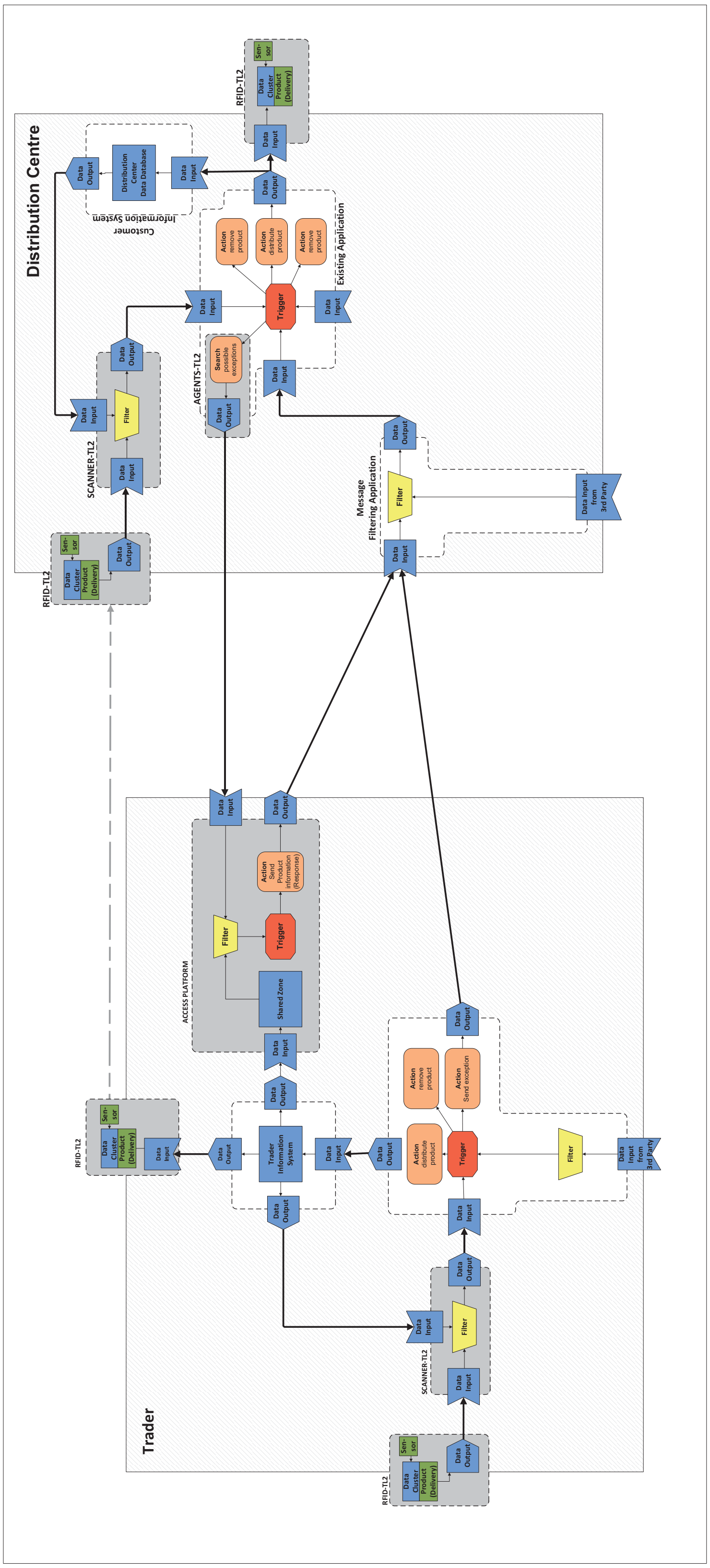


Fig. 45: Service at technology level 2

5.5.4 Service organisation at technology level 3

At technology level 3, the possibilities for the service organisation are increasing tremendously due to the advanced technical capabilities, which enable a direct evaluation of received information on the box.

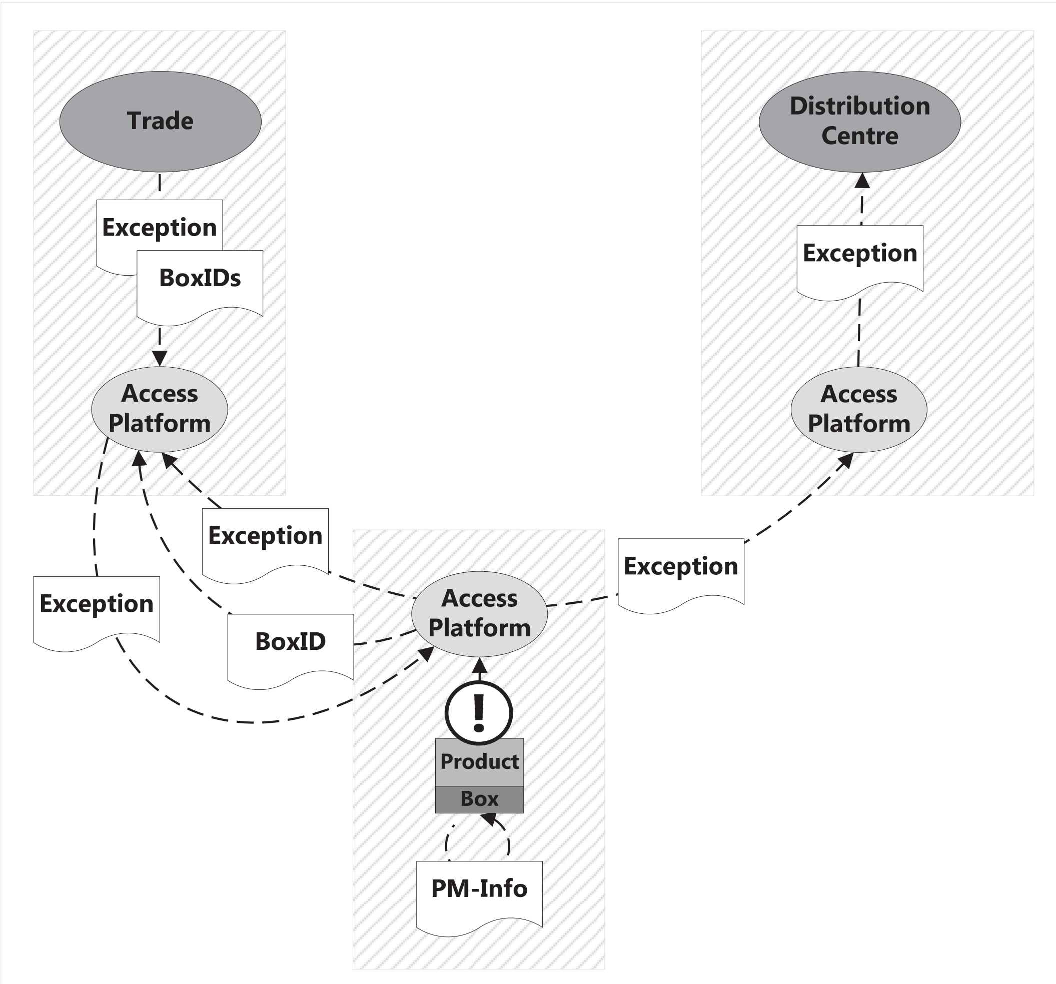


Fig. 46: Box-centric service organisation

Based on the advances capabilities of the RFID, the collection of monitoring information (dynamic) and its evaluation by the EAS takes place directly on the box. The advanced communication abilities enable collection of exception information from the product supplier as well as the provision of exception information directly from the box to the potential recipient. In case of an exception, the box is additionally capable to activate audio/visual signals, to signalise an exception.

The advanced technology development of scanner devices allows to bypass any organizational infrastructure and to scan product boxes directly wherever they are facilitating global communication networks (e.g. satellite based communication networks). Scanners can mark a deficient product by providing exception information to the RFID. The scanner devices range is increased by the ability to connect to those networks.

If the components (especially the trigger) of the network scanner are integrated into the RFID device, the device itself is enabled to evaluate incoming information and propagate exceptions. Examples could involve changes in colour, vibration or any other signal that could be identified by humans or devices that are responsible for eliminating the product out of the distribution channel. In this last scenario, the integration of several functionalities into a single device (RFID-TL3) separates the location of the deficient product completely from any technological infrastructure, making it easy to use wherever the product might be, even in households with consumers.

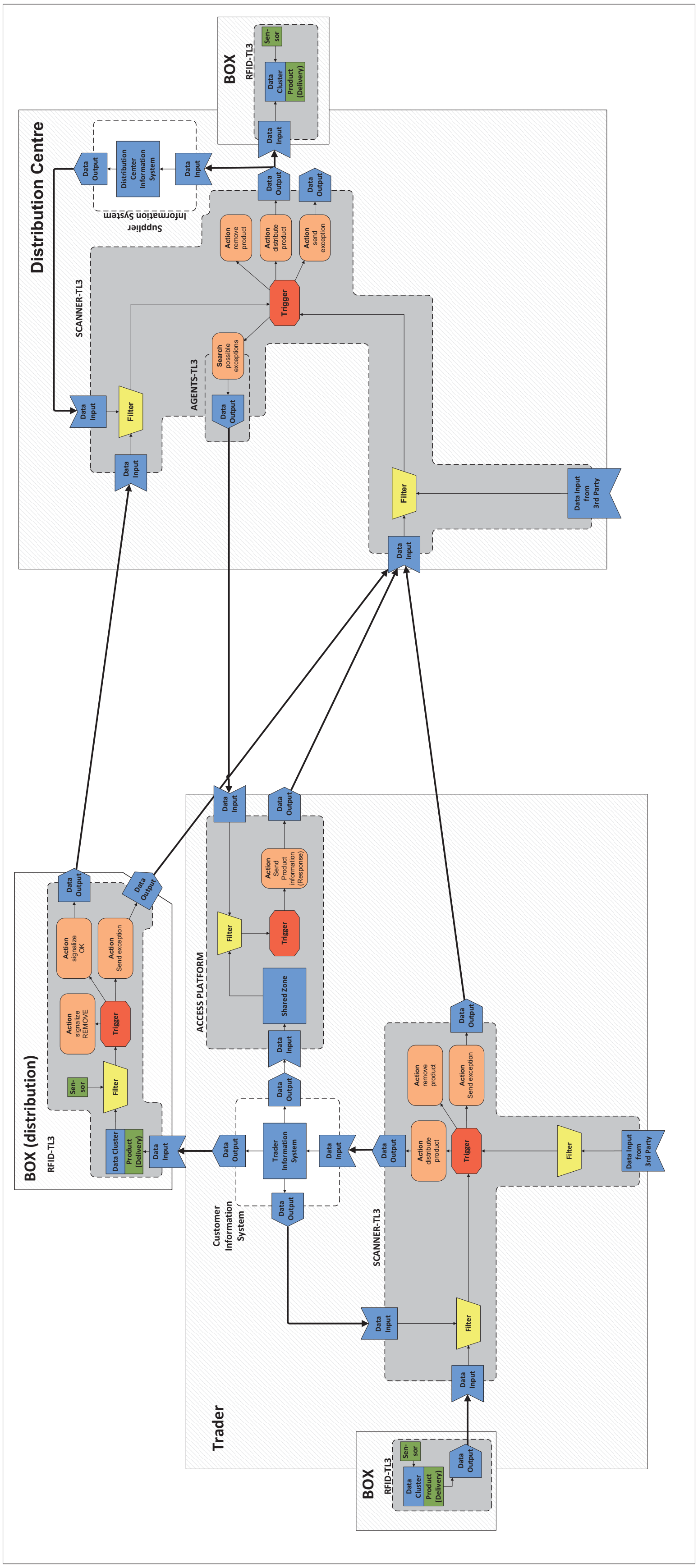


Fig. 47: Service organisation at technology level 3

5.6 Elaboration of generic integrated components

Based on the service models for the different technology levels presented in this chapter a series of generic integrated components can be elaborated focussing on the integration of technology for business process optimisation. The focus of this sub-chapter is therefore to compare the models of different technology levels and extract generic integrated components. These generic components are understood as guidelines for implementation of the different principal reference processes.

5.6.1 Scanner

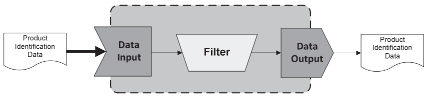
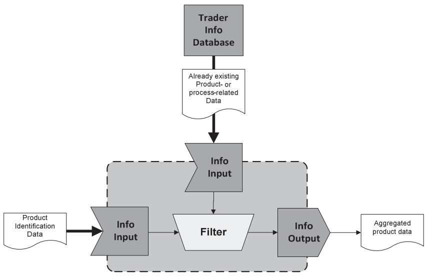
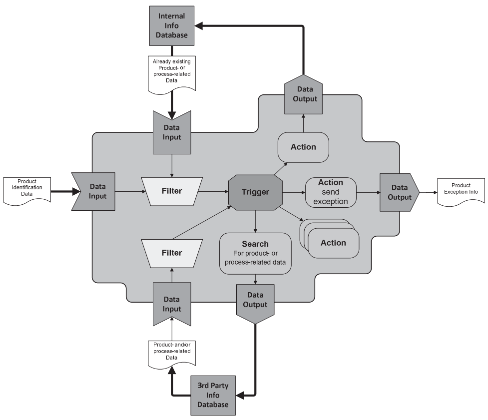
In the previously presented service models, the scanner devices are required for extraction of identification information from RFID-tags attached to the boxes as well as the communication with existing systems for further information processing. The integration of functionalities throughout the different technology levels lead to an increase in service efficiency by reduction the number of required systems and therefore the reduction of complexities in the information flow (e.g. media breaks or required interfaces). The different scanner capabilities are summarized in the table below.

Table 13: Summary of scanner capabilities in different technology levels

	Infrastructural elements				Operational elements		
Technology Level	Data Input	Data Output	Data Cluster	Data Transfer	Filter	Trigger	Data Search
1	X	X			X		
2	X	X		X	XX		X
3	X	X	X	XX	XXX	X	XX

As presented in the table, the capabilities increase throughout the emerging technological development. The service quality increases tremendously by the integration of rule-based filter and trigger elements, which are core functionalities for networked device enabled intelligence. The definition of appropriate rules for data analysis and the adaptation of these rules to business process activities are a major improvement for business process support. The development path and the description of the identified generic scanner devices is presented in the following table.

Table 14: Generic integrated components (scanners) at different levels of technological development

TL	Graphical notation in the service models	Description of the networked device
1		Scanners at this level are described as readers with cable based or short range wireless communication ability for providing the received data. Due to their limited capabilities they just provide data without significant processing.
2		Mobile scanners with advanced information capturing and sending capability but limitations in filtering, triggering and output capability. They are able to connect to internal communication network for receiving product- or process-related data from a local information system. The advanced filtering functionality enables linking product identification data to existing product- and process-related data.
3		Scanners at this level are complex devices which combine advanced capabilities in information capturing, filtering, output (audio or visual), sending, and triggering. They are able to connect to different communication networks for external information collection facilitating the business information services. The triggering capability allows evaluating received information and requests of actions to the user according to an inherent set of filter and trigger rules (networked device enabled intelligence).

5.6.2 RFID

In the previously presented service models, the RFID-tags are required for the unique identification of single trading units (=boxes). The presented service models are concentrating on the different capabilities provided by the RFID-tag. The realisation of the previously presented services depends on the capabilities of RFIDs. In the early stages the RFID (TL1) enabled the unique identification of product boxes, which is a major requirement for establishing business information services. The sensor equipped RFID in TL2 enabled the collection of monitoring information, but was limited in the communication capabilities. To achieve a real-time online monitoring of product boxes, this deficiency was compensated by the central monitoring service and existing communication systems in transport. In TL3 the RFID was capable of collection all available PQ-info by interaction with existing information systems of actors along the distribution process.

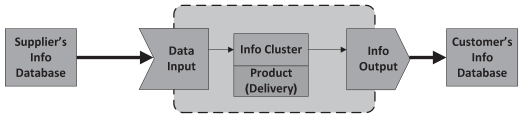
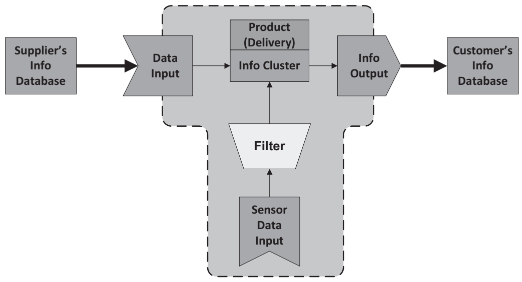
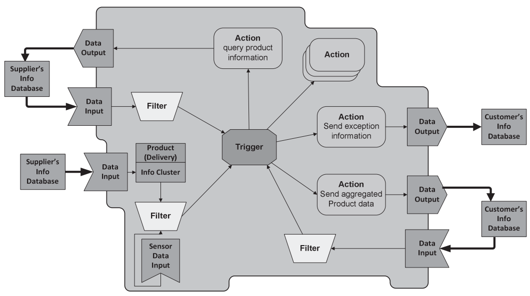
Especially in the visionary service models, the advanced capabilities of RFID-tags enabled a fully decentralised information organisation based on the vision of the “internet of things”. The integration of functionalities throughout the different technology levels lead to an increase in service efficiency by reduction of required central data aggregation systems (online monitoring applications) as well as redundancies in the storage of data at different points in the supply network. The different capabilities are summarized in the table below.

Table 15: Summary of RFID capabilities in different technology levels

	Infrastructural elements				Operational elements		
Technology Level	Data Input	Data Output	Data Cluster	Data Transfer	Filter	Trigger	Data Search
1	X	X	X				
2	XX	X	XX	X			
3	XXX	X	XXX	XX	X	X	X

The integration of specific functionalities enabled the collection of data that had to be collected with huge efforts or was just not available before. The increase in data input capabilities, e.g. of sensor data, has a tremendous impact on service quality. The different generic RFID components are presented below.

Table 16: Generic integrated components (RFID) at different levels of technological development

TL	Graphical notation in the service models	Description of the networked device
1		RFIDs at this level are simple identification tags with short range passive or active communication capability. They are able to receive data via scanner/writer devices at the supplier, store it and provide it to the next scanner device at the customer's end of the distribution process.
2		RFIDs at this level are capable of simple data capturing from included sensors. The storage capability is increased. Due to their short range active communication range, they can provide data and capture data from local information databases via scanner/writer devices, but have. no opportunity to receive and store data from remote sources „on the fly". Due to their limited filter capability they are able to aggregate received sensor data. They are able to receive data via scanner/writer devices at the supplier, store it and provide it to the next scanner device at the customer's end of the distribution process.
3		RFIDs which combine advanced capabilities in information collection (sensors and data capturing „on the fly"), storage, filtering, output (audiovisual), sending, and triggering. Due to their broad communication capability, these tags are able to receive requests from customers, or send requests to the supplier ("call home") on a regular basis. The included trigger capability enables networked device enabled intelligence and therefore rule based exception calls to the customer, whenever the parameters of the tag's environment are out of limits. Rule-based triggering and filtering allow a broad range of action requests to users by facilitating audio-visual signals.

6 Economic decision model for adoption

The transfer of results of the previously presented application scenario requires economic decisions, which include the adoption of technology as well as changes in the organisation of processes. This chapter is part of a discussion, which was carried out in FRITZ ET AL. (2010), and is part of REICHE ET AL. (2011b).

Due to the dynamic character of technology developments, the economic decision model builds on a circle of continuous process improvement and adoption to new technologies to stay competitive and to be on the same e-readiness level as the enterprise's environment. With reference to the strategic advancement of enterprises and sectors towards improvements in the utilization of ICT support in business processes the circle of continuous improvement builds on a process with three phases.

The first phase deals with improvements in the utilization of levels of technology. The decision scenario links developments in technology captured in reference processes with the characteristics of the implementation environment in enterprises and the sector captured in levels of e-readiness. It involves the (Fig. 48):

1) analysis of the current level of e-readiness with the situational conditions of the enterprise and the sector with its trading partners,
2) linkage of the current level of e-readiness with the provided reference processes,
3) selection of a reference process which bests fit the implementation environment, and
4) analysis of cost-benefit gains an enterprise could realize through its adoption.

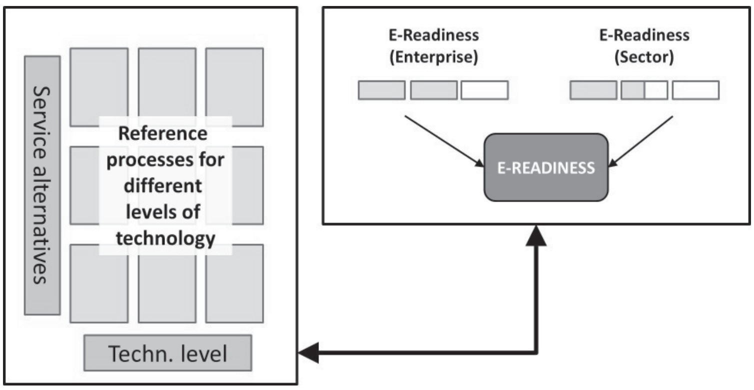


Fig. 48: The decision scenario, phase 1 (adapted from FRITZ ET AL. 2010 and modified)

The second phase deals with the adaption of selected reference processes to the variations in e-readiness observed within an enterprise and with potential trading partners as discussed before. As the stage before, this stage concludes with an analysis of cost-benefit gains an enterprise could realize through its adoption. A typical example for differentiation in technology utilization involves the implementation of a higher level of technology within an enterprise with high level of e-readiness. Meanwhile the communication with trading partners within a sector of generally lower e-readiness would still need to build on traditional paper based communication schemes. This scenario is quite common in

- trading activities between countries with different levels of development,
- sectors with enterprise groups of different investment capabilities, e.g. involving larger groups of small and medium sized enterprises,
- sectors where individual enterprises might show high levels of e-readiness but where the lack of agreements on data exchange and standards between enterprises prohibits the utilization of higher levels of communication technology.

The *third phase* deals with development dynamics and the potential cost-benefit gains through improvements in e-readiness within an enterprise as well as within a sector which allowed the

- integration of higher levels of reference processes and
- elimination of implementation deficiencies by the necessary adoptions of reference processes or the development of functionalities that balance these deficiencies.

This stage is based on a GAP analysis that identifies the gaps between e-readiness and reference processes of higher levels of technology which enterprises and/or its trading partners might be interested to reach in efforts to improve service efficiency or service quality. The complete decision process is outlined in Fig. 49.

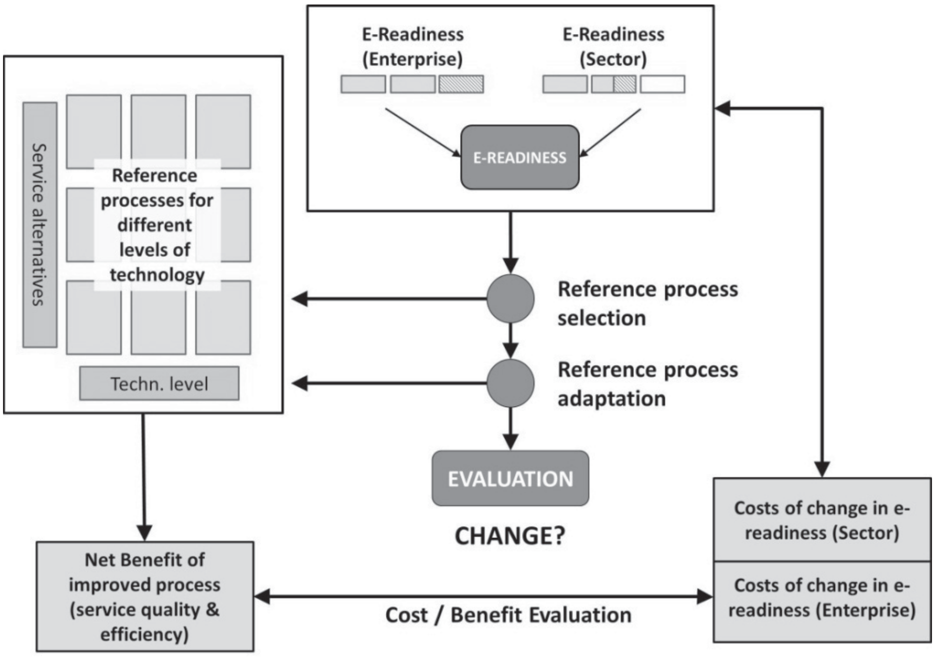


Fig. 49: The complete decision scenario (adapted from FRITZ ET AL. 2010 and modified)

The cost and benefit evaluation is based on the relation between the improvement potential which arises from the adaption to a reference process at a certain technology level and the adoption costs. The evaluation of the improvement potential is based on the comparison of the present technology and the technology to adopt.

6.1 Evaluation of benefits by reference process selection

For adopting ICT, the cost benefit relation is an important factor for decision making. Generally, the improvement potential (benefits) is based on the improvement of service quality and efficiency in respect to the existing process, which has to be improved technologically and organisationally.

However, the benefits of technology and organisational changes cannot always be measured numerically. The **service quality** is related to the integration of software and networked device functionalities that support carrying out tasks within a process. Therefore, improving the service quality is related to the generic optimisation dimensions time, costs, data quality as well as the quality of work-life (DAVENPORT AND SHORT 1990).

The **time-related improvement** includes a.o. target outcomes, such as

- required time to fulfil tasks within a process, such as e.g. the documentation of the incoming and outgoing product flow (WAMBA ET AL 2008),
- the optimisation the distribution process by reducing delays (SUBRAMANI 2004),
- the reduction of time to discover deficient products, which is an important risk management factor.

The **cost-related improvement** includes a.o. target outcomes, such as

- the reduction of transaction costs by improved inter-enterprise information exchange,
- the reduction of failure costs by improved product and process evaluation,
- the reduction of process costs by improved process observation and evaluation.

The **data quality improvement** includes a.o. target outcomes, such as

- the consistent documentation of product flows (SUBRAMANI 2004),
- the provision of aggregated and rule-based evaluated pre-processed data for decision making,
- the reduction of risks and uncertainties by provided product quality information (SUBRAMANI 2004).

The **quality of work improvement** includes a.o. target outcomes, such as

- the empowerment of individuals by ICT, which ensures a better control of process outcomes and the ability to make decisions (Davenport and Short 1990),
- the reduction of time to access task- and context-specific information as well as better context-specific decision support (POUSTTCHI AND THURNHER 2005),
- increasing the automation of tasks in processes (WAMBA ET AL. 2008).

These dimensions influence the decision by characterizing the improvement potential deriving from the difference between current process performance and anticipated performance after adopting the reference process. The **improvement of service efficiency** is described in general by the relation between applied information- and communication technology and the service quality level. **Improvement of service efficiency** includes the reduction of complexities regarding:

- information technology management by increasing the number of functionalities in a reduced number of networked devices,

- the reduction of the number of media breaks,
- the minimisation of the required implementation of data exchange standards,
- the inter-enterprise information exchange by reducing interfaces.

Especially these benefits are hard to measure and can only be assessed in the general utility value of benefit and improvement potential tendencies. Conclusively, both dimensions have to be taken into consideration for evaluating the reference process benefits which are referred to in Fig. 49. Different methods can be applied by measuring and aggregating the improvement potential and identifying the individual optimization goals. Such methods may include scenario development for comparative simulation experiments or a multi-variant analysis (BULLINGER 1994). Because of the complexity of these methods, expert advice may be important for defining the improvement potential for decision support.

In addition, the feasibility of adopting a reference process has to be taken into consideration. An example for the general impact assessment of reference processes in different levels of technology and the business process improvement potential is presented in Table 17.

Table 17: Impact of reference process adoption in respect to service quality and service improvement potential (example for a linear relation)

		Reference process (TL1)	Reference process (TL2)	Reference process (TL3)
Service quality	Process time reduction	+	++	+++
	Process costs reduction	+	++	+++
	Data quality gains	+	++	+++
	Access to data	+	++	+++
	Quality of work	+	++	+++
Service efficiency	Process efficiency gains in relation to required ICT	+	++	+++
Total value of benefits		**+**	**++**	**+++**

The depicted evaluation of the improvement potential is based on the linear coherence presented in Fig. 11 in chapter 3.3.4.2. Because of the highly dynamic technological development and the diversity of networked devices, these categories can provide guidance for the decision maker. The real improvement potential can only be evaluated in the individual context. The final adoption decision is complex and challenging because of the wide range of implications and uncertainties. The participating stages of the supply network and the related agrifood enterprises in the business environment determine the facilitation of a technology in the business sector and are an important factor in the adoption decision. The more enterprises in a sector participate in a certain network application of a technology the higher the pressure on the individual company to adapt to this situation. Especially in a supply network environment the adoption decision can have an influence on the competitiveness of an enterprise.

6.2 Optimization

The adoption of the elaborated reference processes and the included technology as well as the integration into currently existing business processes can enable the previous discussed improvement potentials. However, the adoption of a complete reference process might be not feasible due to the previous discussed issues evolving out of the e-readiness of the sector.

In general, the match of reference process and e-readiness is based on a general fit between the requirements of the specific technology level in the reference process and the fulfilment of e-readiness criteria. For implementation, reference processes are selected which fit a certain implementation environment captured in the level of e-readiness. However, this basic approach of introducing reference processes of certain technology levels might limit the full utilization of technology potentials or face resistance by potential users as the e-readiness level does not explicitly consider variations of e-readiness within an enterprise or within a sector scenario. A more detailed view regarding individual functionalities (e.g. control at point of sale or monitoring inventory conditions) and the existing technology realising these functionalities can relate to reference processes in different technology levels. This might allow mixing elements of reference processes related to different levels of technology into a new process design that takes account of variations while technology breaks. However, technology breaks of acceptable dimension might still be considered within the process as a whole. An exemplified decision is presented in the following figure.

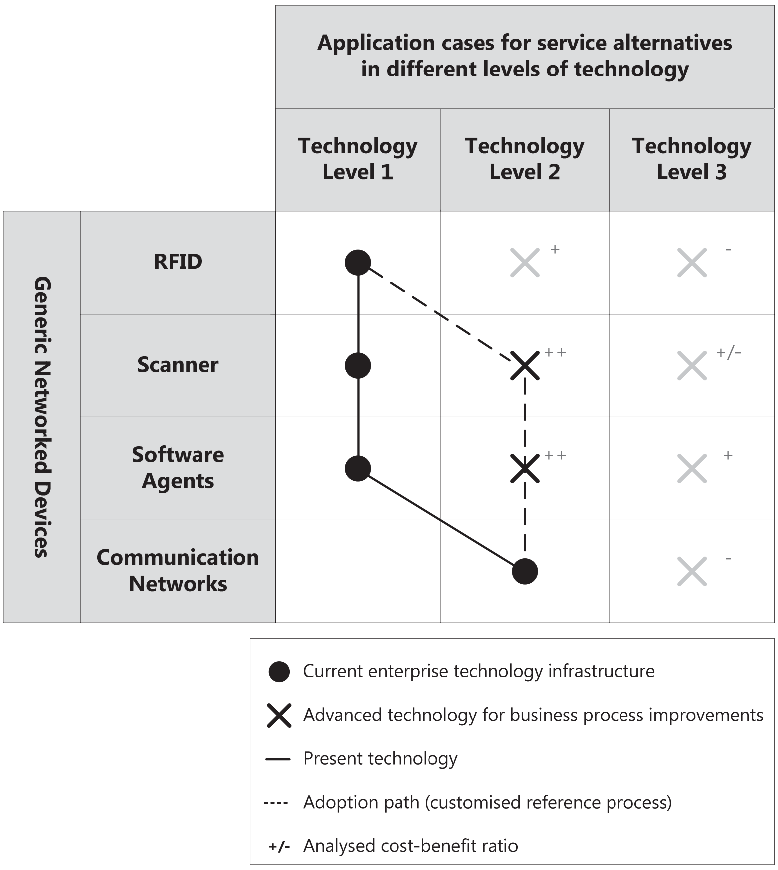


Fig. 50: Optimised adoption decision (example)

The selection of networked devices for process improvement depends on the integration of functionalities, the match with the existing IT-infrastructure as well as the required functionalities for establishing the inter-enterprise information exchange. However, the business environment has an important influence on the selection of network technology as well. The technical and organizational feasibility of the reference has to be customized meeting the requirements from the supply network as well as the individual business process requirements.

7 Discussion

In the first chapters of this thesis, the increasing need for transparency regarding product quality characteristics and inter-enterprise business processes was highlighted as a field of research with high relevance for the food sector. This thesis concentrates on the development of a framework for developing business information services and the integration of new technologies to improve the information exchange and thereby improve product- and process-related transparency between agri-food enterprises. The framework was adapted to the fruit and vegetable sector to show its applicability and give an overview on possible service organisation schemes based on technological devices in different levels of sophistication. The gradational progress of this thesis ended in an economic decision model aiming at the initiation of the transfer of the results to real application cases. The following discussion concentrates on the applicability of the framework, the developed application case in the fruit and vegetable sector, as well as the further required measures to adapt this framework in the food sector.

7.1 Business information service and design framework and its applicability

The business information service framework developed in this thesis concentrates on the organisation and orchestration of existing ICT and the reasonable complementation with supportive technologies to establish business information services in a dynamically changing business environment. Due to its generic character, the facilitation of this framework is not bound to a specific product or business domain. Although this thesis focussed on agri-food supply networks, the framework has been successfully facilitated to develop business information services in the construction business domain (see CUTELOOP 2011). Experience that has been made during the project and the transfer of the framework to another business domain showed that this transfer BISF is feasible due to its generic character. Especially the classification of services (static, dynamic) and the rule-based decision support by EAS are transferable with low efforts. However, the generic character requires different measures to analyse and further define the scope, the content and the context in which this framework can be facilitated in the business environment.

The transfer of the presented framework to specific application cases requires a preliminary analysis of the

a) organisational fit: by evaluation of the e-readiness levels of the participating enterprises and the organisation of inter-enterprise business processes,
b) technological fit: by identifying available information sources and their possible role in the concept (e.g. traceability systems and quality management systems), as well as
c) a clear definition of the service scope related to both domains,

in order to identify gaps between the as-is and the to-be situation that need to be closed in the development phase. An important point in the present thesis and in both works is the complexity of application cases with the increasing number of participating enterprises.

The presented decision framework supports the identification of investments that are necessary to reach the service level promised by more advanced reference processes than those implemented currently. It captures investments in technology as well as in necessary organizational transformations, both in enterprises as well as in sector environments and relates them to benefits from improvements in process efficiency and process capability. The determination of costs and benefits of adopting a specific reference process includes the analysis of predicted changes related to the change in the business process regarding service quality and service efficiency as well the costs for adoption.

The development phase needs to include a.o. measures to make information technically available by standards, protocols and the identification technology (e.g. RFID or barcodes), alignment of existing ICT and information systems as well as the development of information reference models for information exchange. These are major pre-requisites for a successful service development. A comprehensive example for information reference models in the pork sector can be found in the work of LEHMANN (2011). Due to the generic character of the presented framework, these issues have been left to be discussed in specific projects and application cases.

7.2 Information services for the fresh fruit and vegetable sector

The transfer of the framework to the fruit and vegetable scenario showed different possibilities for improving transparency and food safety by enabling product-centric information provision. The service cases are discussed in the following part of this chapter.

The presented "provision of decentralised product information" scenario refers to the requirement to provide quality and safety guarantees for food products to stakeholders in the food supply network. This service scenario describes the provision of product quality information from distributed information sources to meet this requirement. The presented service organisation concentrates on the exchange of this information in a 1-to-1 business relationship between the major nodes in the fruit and vegetable supply network (traders and retail distribution centres). The data search functionality facilitated by software agents in combination with access platforms, implemented at the participating enterprises in the supply network, increases the flexibility of information collection and provision. The presented process can be transferred to a network scenario based on the access platform approach (see Fig. 5). In the early technology level, this data search represents immobilised and fixed interfaces due to the minimal capabilities of software agents. In the visionary technology level (TL3) these agents are capable of collecting information for a specific box by querying all platforms in the supply network. With the current practice this would require tremendous efforts to build up interfaces between all participating enterprises for realising this functionality. The development of such a coordination scheme in the fruit and vegetable sector is feasible, because of the short chain and the existence of powerful players, such as agricultural co-operative societies integrating data from their members and retail distribution centres coordinating the supply of retail outlets. However, the integration of agri-food enterprises outside a coordinated supply network requires a fixed entrance point e.g. the import company, which gathers and clusters product-quality information to make it accessible to the network. This reduces the required nodes in the network and increases the potential for adoption. For establishing a sectorial coordination scheme to identify deficient products in the process, this integration is an essential prerequisite towards increasing transparency.

The presented online monitoring service concentrates on the improvement of transparency in the distribution process of fresh fruit and vegetables. Transparency in this context refers to three issues:

a) identification of critical situations in the distribution process by monitoring the products' ambience, in order to
b) enable the ability to react in critical situations to prevent food losses, and therefore
c) improve distribution planning by provision of reliable data.

The online monitoring service for observation of the products' ambience refers to the high amount of food losses during transport. If all technological measures for prevention of decay fail, information about the position and the status is urgently required in order to prevent food losses. The previously mentioned concept of Supply Chain Event Management includes the opportunity to simulate possible impacts of an event in order to support decision making in these situations (HELLINGRATH ET AL. 2008). In the case of fresh fruits and vegetables such simulation setups for forecasting the development of product quality during storage and transport already exist for specific products (see e.g. GIANNAKOUROU ET AL. 2001, VAN DER VORST ET AL. 2005b) and can be embedded in the evaluation process of the information service.

The impacts of technology, especially the improvement of RFID capabilities along the described development path, enable new ways of monitoring information capturing. Active RFID-tags with temperature sensors already exist and are offered on the market; however, this technology is extremely expensive compared to passive EPC-RFID-tags. Even if these tags are implemented into the service organisation, the provision of real-time information on the products' ambience would require additional communication systems for information provision. The development of the RFID capabilities in the visionary level would make such additional systems obsolete. From an information logistical point of view, the provision of transparency information about the distribution process would increase the responsiveness and therefore the possibility to react in order to prevent food losses. The availability of process-related information has not only implications for food quality, but also for the organisation of logistic services. During the expert interviews for investigating possible service ideas for the application case, a logistic service provider pointed out that this information leads to major savings and improves flexibility of planning the allocation of his resources enabled by a tremendous amount of sensors and ICT in his trucks. Conclusively, this offers potential for synergies, because process-related information is already collected for other reasons and can be transferred to stakeholders in the food sector to satisfy their information needs. The presented online monitoring service facilitates these synergies by integrating the online monitoring application in the first two technology levels.

The last presented service alternative concentrates on the identification and activation of a box carrying a deficient product. Crises in the food sector challenged agri-food enterprises tremendously by a breakdown of sales caused by an increased uncertainty of consumers and an increasing refusal to procure crisis-related food products. Not only such severe crises with medial presence, but also regularly occurring cases of exceeded pesticide residue limits throughout the season require a preventive solution that allows identifying deficient products and their separation from innocuous products. The implemented measures for quality control based on laboratory analysis as well as company specific measures for assuring food safety and traceability systems represent valuable information sources for identification and separation of a deficient product, if this information is communicated. On the other hand, this information allows providing guarantees and proof for the safety of products based on laboratory analyses. The presented service alternative concentrates on the provision of exception information on affected product batches to prevent their distribution to the consumer. The possibilities of technology to support this objective are related to two domains:

a) communication of information along the distribution path of a deficient product along the supply network, and
b) the possible ways the product boxes are discovered.

The presented service organisations in the different technology levels show major differences in the coordination scheme. In the first and second technology level, the communication and identification requires technical support by scanners and existing systems at different points in the process. The visionary technology level, especially the advanced capabilities of RFID-tags, enables a completely decentralised coordination scheme, where the product box captures information along its way through the distribution path. Based on the increased processing capability the box is capable of drawing conclusion out of this data and activating of a visual signal (e.g. a red screen) to signalise that it contains harmful products. This enables the direct discovery of affected product boxes without further technical support. The range of captured information by the box in this scenario covers all presented service alternatives. However, this service alternative is still depending on the proper and timely identification of the cause for the deficiency that require intensive laboratory analysis. Conclusively, the presented approach for identification of deficient product boxes requires the cooperation of participants inside and outside the supply network.

The application cases for the provision of decentralised stored product quality and safety information, the monitoring of products during transport and the resulting activation of deficient products developed in this thesis, show significant improvement potentials gained by a new way of organising product- and process-related information and the capabilities of new technologies. However, their realisation requires at least two agri-food enterprises. An effective application in the sector requires tremendous efforts in aligning existing systems as well as adoption and implementation of commonly used technology, strongly depending on the e-readiness level of the sector. The decentralisation by new coordination schemes offers an improvement potential by the establishment of flexible connections between enterprises in the supply network to provide information, or from a different perspective, by the direct provision of static and dynamic information directly by the product box.

7.3 Incentives and barriers for adaptation

The operative optimization of intra- and inter-enterprise processes and the improved transparency level are important benefits related to network technology such as RFID and business information services. The adoption of new network technologies increases the readiness for new business relations and new business perspectives in agri-food supply networks. The willingness to adopt new technologies is highly driven by internal as well as external factors. Incentives for sharing information between actors have to be elaborated co-operatively and the adoption of required network technology has to be aligned. The highest beneficiary level of such identification technology can be reached only with a high diffusion rate in the supply network around the company (TAMM AND TRIBOWSKI 2010). Another important aspect of selecting the reference process at an appropriate technology level is the diffusion of a certain technology in the business environment around the enterprise. The implementation of network technology (e.g. RFID) driven by dominant actors forces suppliers to adapt to the arising requirements. To keep up the interoperability between systems of different actors is challenging and a basic requirement for every adoption decision. In agri-food supply networks suppliers have to be able to adapt to different technological requirements of different customers. The integration of customers for the establishment of feedback loops is supported by the framework and the technology, capable of connecting to different systems in the agri-food supply network.

The dominant internal factors are the ability to adopt (e-readiness) on the one hand and the benefits arising from adoption on the other hand. For internal process improvement the individual decision is based on these factors. The adoption of network technology for inter-enterprise process improvement strongly depends on external factors such as the supply chain integration and diffusion of the technology and the complexities arising from the adoption regarding the system interoperability. These external factors are challenging to anticipate and increase the uncertainty especially for SME's in the agri-food sector. Even dominant actors such as agricultural cooperative societies and retail groups delay their adoption decision because of the risk of lock-in effects. To overcome this situation the foundation of a sectorial initiative from different actors from different stages to develop strategies and visions for reducing uncertainty would be the most feasible. These foundations already exist and have an increasing acceptance in the sector However, these foundations are mostly driven by dominant actors.

Incentives for participation, especially for SMEs, are an important pre-requisite to enable the technical development of the sector and with that an increase in competitive advantage of the sector. While the enterprises' ability to adapt to new technological developments depends on internal and external environmental factors, the overall benefit from adoption strongly depends on the willingness to share information between actors in the different stages. This situation is particularly challenging for all actors in agri-food chains, because the dominant actors would benefit more from the provided information by improving their processes, than the enterprises providing the information. Especially the protection of data ownership is crucial for SME's in agri-food chains and decreases the willingness to share. On the other hand, sharing information can increase the ability to open new business opportunities (see e.g. PORTER AND MILLAR 1985, BEULENS ET AL. 2005). However, this benefit has to be monetary to compensate the process optimization potential at the dominant actors. The balancing of this problem is one future challenge the agri-food sector has to compete with.

8 Summary and conclusion

Agri-food enterprises are challenged by a multitude of complexities. The globalisation and increasing international competition in the food sector, the high degree of small- and medium-sized enterprises, as well as national and cross-national food crises and related uncertainties for consumers and agri-food enterprises lead to different public and private requirements.

Public requirements are determined by the values of society, including consumers as individuals, and legislative initiatives. The society's perception has changed in respect to the impacts and consequences of global food production and therefore also on the sustainable development and facilitation of resources, including social, environmental and economic issues (see AIKING AND DE BOER 2004). This is reflected in consumer demand, which is determined more by concerns on the safety, quality and integrity of food products. On the other hand, consumers are more demanding in respect to the diversity and availability of food products and the associated information in order to better select the products and comprehend the impacts of their buying decisions (see also BEULENS ET AL. 2005). Especially food crises, but also the consolidation of food legislation in the European Union, lead to a multitude of regulations formulating requirements for agri-food enterprises and the marketability of food products. These regulations are continuously aligned to emerging and relevant issues in the food sector, leading to dynamically changing challenges.

Private requirements primarily originate from difficulties of agri-food enterprises to cope with public requirements, but complexities also arise from the division of labour, the sector structure and the need to guarantee food safety and the quality of provided food products. These issues lead to different standards, such as BRC, IFS, ISO 22000, as well as the foundation of initiatives for chain-focussed quality assurance (e.g. Q+S). Meeting the abovementioned requirements has become a pre-requisite for participation in relationships in the food sector. Additionally, the globalised markets and the increasing competition lead to the need for agri-food enterprises to optimise current business practice in order to stay competitive. Transparency of products and inter-enterprise processes have become an important factor for competitiveness and trust in agri-food enterprises and their provided products.

Transparency within a supply network is defined as *"the extent to which all network's stakeholders have a shared understanding of, and access to, product and process related information, that they request, without loss, noise, delay and distortion"* HOFSTEDE (2002). However, improving transparency requires a clear identification of the information needs of stakeholders and the identification and access to information sources (FRITZ AND SCHIEFER 2010). Due to the extensiveness of transparency information, two major fields are identified with relevance for this thesis. The first field concentrates on product characteristics and food safety related issues, whereas the second field focuses on the organisational transparency of the product distribution. The provision and exchange of relevant information represents an unresolved challenge for the organisation of inter-enterprise communication.

The objective of this thesis is to develop a generically applicable framework for the provision and aggregation of relevant product- and process-related data by so-called business information services in order to satisfy the information needs of different stakeholders in the food sector. These services build up on the concept of information logistics in order to timely provide necessary and reliable information to meet the information needs of actors in the agri-food supply network. The framework comprises of four layers, which take as the starting point the information needs based on events and interactions in the business process layer. To meet these needs, the second layer defines service alternatives based on generic types of information (static and dynamic) as well as an evaluation and activity service (EAS) to process and evaluate the received information and to support decision making in critical situations.

The second layer defines patterns for integrating these services into business interactions, represented by regular information provision attached to the product or detached over a communication network as well as information on demand. Furthermore, to meet the objective of the framework, the third service activation pattern is based on the discovery of exceptional situations, caused by e.g. contaminated products or deficiencies in the distribution process, and the required information provision on exceptional situations (exception reporting). To establish the technical connection between information sources and information recipients, the framework considers a supportive technology layer. This supportive technology layer consists of so-called networked devices based on integrated components, which provide infrastructural functionalities to establish the information flow as well as operational functionalities to observe, process and evaluate this information flow according to pre-defined rules and to detect exceptional situations that call for action. The last layer of the framework contains available external and internal information sources based on systems that keep the recorded product- and process-related information. These sources are divided into network/sector focussed information systems, with focus on traceability or quality management, and intra-enterprise information systems.

The framework is adapted to an application scenario in order to show its applicability. The focus of this application scenario is on fresh fruit and vegetable networks and present information needs. Due to the high perishability and sensitivity of fresh products, the time-criticality of the distribution process (SCHIEFER ET AL. 2008) and regularly occurring violations of pesticide residue levels (EFSA 2010) as well as recent crises (e.g. EHEC), this application scenario offers potential for improvement by business information services in order to reduce uncertainties by providing information on product- and process-related conditions.

The presented service alternatives concentrate on different aspects aligned to this issue. The static information service is demonstrated by the provision of decentralised stored product quality information for specific product boxes, whereas the dynamic information service is demonstrated by online monitoring of product characteristics during transport. Both service alternatives provide product quality- and process-related information that allows identifying exceptional situations. The third service focuses on the individual identification and activation of product boxes carrying negatively affected products. The service alternatives are applied to business interactions between agricultural cooperative societies, representing a large number of farmers, and retail distribution centres organising the supply with fresh fruits and vegetables for a large number of associated retail stores, representing the most important interface to the consumer.

For the supportive technology layer, four promising new technologies were selected:

- RFID technology, enabling chain-wide tracking and tracing of reusable product boxes carrying fresh produce from farm to retail, and enabling the digital provision of information attached to the product.
- Scanner technology, capturing information from these boxes.
- Software Agents, searching for data related to a specific box at distributed access points in the supply network along the path of the product, and

- Communication networks, facilitated for the provision of detached product- and process-related information.

The developed service alternatives were demonstrated at three different levels of technological development concentrating on:

- current available technology,
- technology which might be available within a five years' timeframe, as well as
- a visionary technology level.

The different capabilities of networked devices in the different technology levels enable different organisation patterns for the establishment of information services. Based on an evaluation of the resulting models, generic technological components were summarised for RFID and scanner technology in order to compare existing ICT with the required ICT for establishing business information services in the different technology levels.

To enable the transfer of results from the application scenario to existing business processes, an economic decision models is discussed in the last part of the thesis. This decision model is based on a cost-benefit analysis, which is presented in a generic way in order to trigger an adoption discussion at agri-food enterprises. However, these adoption decisions are dependent on the individual ability to adopt ICT (e-readiness) and to use it efficiently. Therefore, the provided decision model intents to show a way to combine different networked devices in different levels of technology in order to optimise and improve the existing organisation with technology at the best cost-benefit ratio, which has to be calculated for the individual adoption case.

The business information framework has proofed its generic character by its successful application in the CuteLoop project to two different business domains, namely the presented fresh fruits and vegetable scenario as well as a scenario in the construction domain to provide craftsmen with necessary information on their tasks (see CUTELOOP 2008 AND CUTELOOP 2011). The discussion of the application scenario with experts from this sector highlighted different barriers for adoption. The adoption of RFID technology, which is a key requirement in the presented scenario, is an issue that involves all actors in the supply network and not only one company. The provision of product quality and process-related information depends on working traceability schemes in a chain-wide context and therefore on technology that is commonly accepted in the sector. However, barcode technology is currently still state of the art in the sector; it does not inhibit the establishment of services, but makes them less efficient due to the time that is required for scanning every box in a time-critical distribution process. The adoption of scanner devices is clearly related to the applied identification technology (barcode or RFID).

The results of this thesis cover different aspects. The first and most important aspect are key requirements for establishing business information services based on the presented framework. These key requirements for developing information services in order to improve product-related transparency identified in this thesis are:

- the identification of information needs and possible information sources,
- the alignment of product identification schemes, in order to develop information services providing product-related information on a high level of detail,
- the organisational and technological fit of applied technology to the e-readiness level with the focus on SME's,
- the protection of rights and ownership for provided data.

Business information services, as they are described and elaborated in this thesis, have the potential to improve business interaction between actors as well as to improve the planning and organisation of distribution processes by applying new technologies and mechanisms for information provision. However, the effects of provided information on competitiveness are still unclear and require carefulness in order to protect data ownership. This point is especially critical for the acceptance of business information services.

The provision of product-related information on a high level of detail is dependent on sophisticated tracking and tracing as well as documentation of production concentrating on measures for product quality and safety. For establishing product-centric information services, the unmistakable identification of products and the linkage between this identification information and the previous stated documentation is evident. Current technological developments in the standardisation of RFID technology as well as the reduction of RFID costs may open the way for chain-wide implementation of this technology and the potential to realise the presented service examples on the first two technology levels. Especially the usage of reusable packaging in the case of fruits and vegetables reduces the costs for adopting RFID technology for all actors in the fresh fruit and vegetable supply chain and leads to a fast amortisation of investments (see also MARTÍNEZ-SALA ET AL. 2009). Initiatives, such as the EPCglobal initiative, provide a broad knowledge-base based on the experience of enterprises in the food sector. However, to benefit from the adoption of RFID technology, further cooperation of major stakeholders in the sector is required to solve remaining issues in order to increase the acceptance of RFID in the food sector.

Further research has to be conducted in the field of standards and organisation of information exchange practice as well as on the impacts of the ability of enterprises to provide additional product- and process-related information on the competitiveness.

In order to realise service concepts based on the elaborated framework, further research has to be carried out in this field to develop information reference models and product-specific vocabularies to enable the product-related information exchange. Standards are needed for establishing flexible connections between devices and systems as well as systems-to-systems. Additionally, further standardisation of RFID technology and technical network interface (see Fig. 5) is required as well.

From an organisational point of view, the impacts of implemented business information services have to be investigated. This includes the real improvement of food safety and process optimisation in order to answer the question of whether the investments pay off for the participating enterprises or not. The question that remains, concentrates on the willingness to pay for necessary technical and organisational investments and necessary incentives for participating enterprises in order to increase the willingness to share the previously discussed information. These aspects have not been discussed in this thesis and research in these fields is urgently required to overcome present issues in the food sector.

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Appendix

Appendix A: Detailed overview on EC No. 178/2002

Regulation	Reference	Requirement
EC No. 178/2002 general principles and requirements of food law	**Article 6 Risk analysis and management**	Exclusion of hazards represented by biological, chemical or physical agents in, or condition of, food with the potential to cause an adverse health effect. Agri-food enterprises have to implement and maintain measures for risk analysis and management.
	Article 8 Protection of consumers' interests and Article 16 Presentation of food products	Protection of the interests of consumers by providing reliable and true information on offered food, to maintain informed choices for consumption. The focus lays on the prevention of fraud or misleading information regarding the products condition. (see also LFGB §11)
	Article 14 Food safety requirements	Food shall not be placed on the market if it is considered to be injurious to health or unfit for human consumption.
	Article 18 Traceability	The traceability of food, feed, food-producing animals and all substances incorporated into foodstuffs must be established at all stages of production, processing and distribution. To this end, business operators are required to apply appropriate systems and procedures.
	Article 19 Responsibilities for agri-food enterprises regarding food	Responsibilities include: The immediate withdrawal of food, which is not in compliance with the food safety requirements, from the distribution process or the market. Agri-food enterprises "shall participate in contributing to the safety of the food by passing on relevant information necessary to trace a food, cooperating in the action taken by producers, processors, manufacturers and/or the competent authorities."

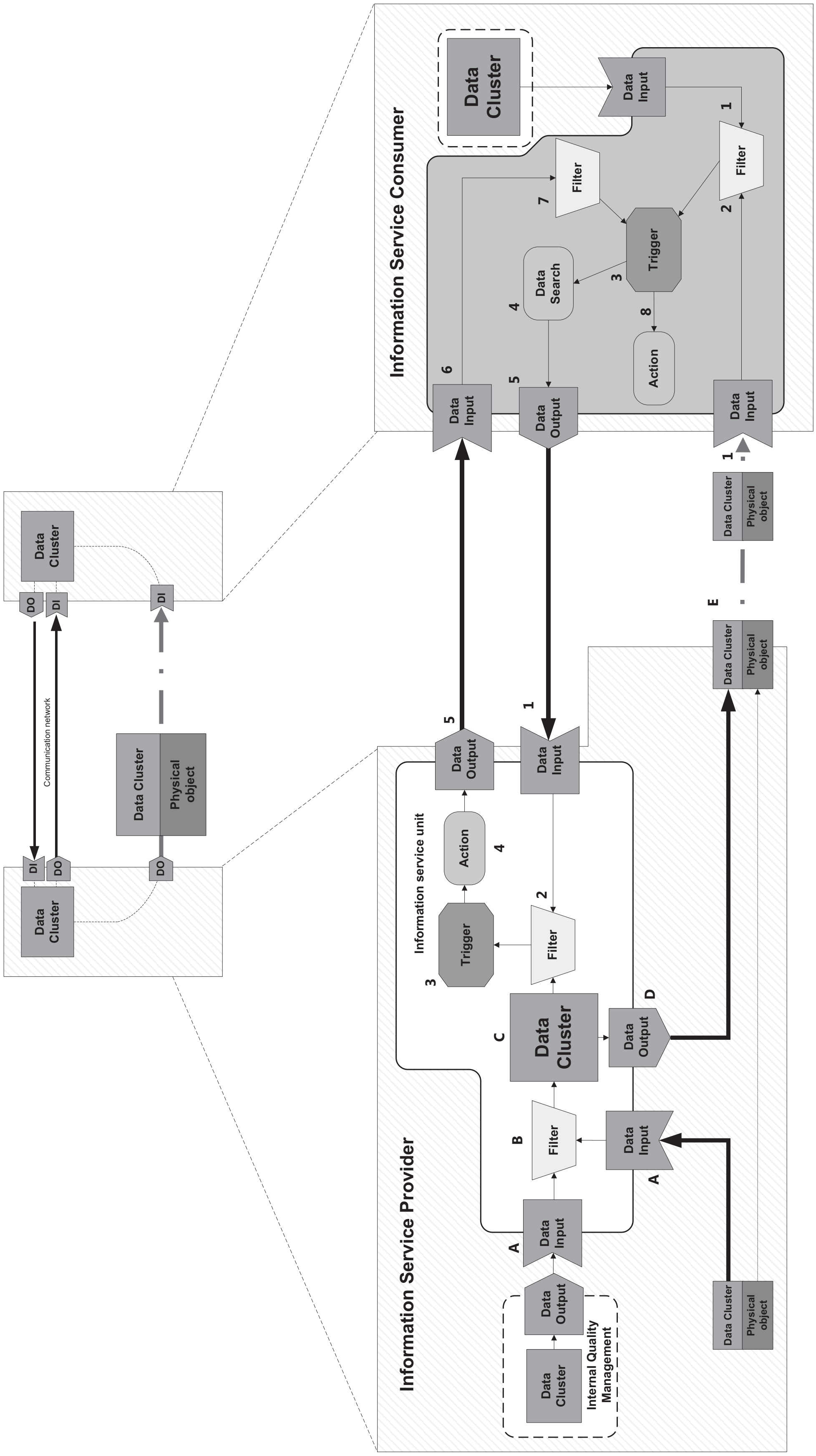
Appendix B: RFID Case Studies from Literature

Author, year	Case study	Focus		Improvement potentials for								RFID Technology	
		Supply Chain	Enterprise	Chain's end-to-end visibility	Traceability	Automatisation of logistic processes	Product-based information sharing	Supply Chain Management	Product monitoring	Process control	Warehouse management	Passive	Active
Wamba et al. (2008)	Impact of RFID and the EPCglobal network for retail industry	x	x	x	x	x	x					x	
Martínez-Sala et al. (2009)	Tracking of returnable packaging and Transport units	x		x		x		x			x		x
Jedermann et al. (2009)	Temperature monitoring in transportation of perishable food	x	x				x		x				x
Regaterri, et al. (2007)	Traceability system for traditional cheese based on RFID		x		x				x		x	x	
Kelepoulis et al. (2007)	RFID-enables traceability in food supply chains	x		x	x		x	x			x	x	
McFarlane and Sheffi (2003)	RFID in supply chain operations	x		x	x	x		x		x	x		
Kärkkäinen (2003)	RFID tagging for short shelf life goods	x			x			x			x	x	
Angeles (2006)	RFID in supply chains	x		x		x		x		x	x	x	

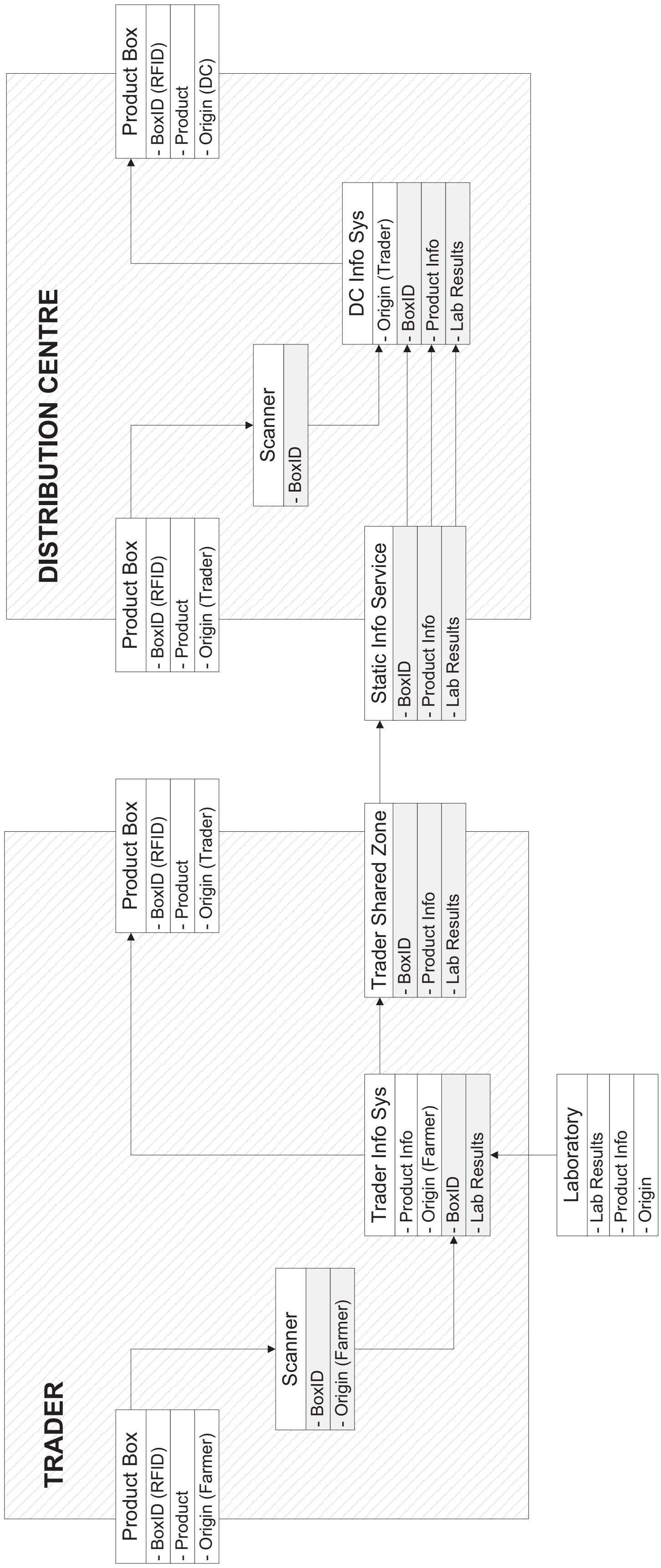
Appendix C: RFID Case Studies from the Food Sector

Author, year	Case study	Focus		Improvement potentials for								RFID Technology	
		Supply Chain	Enterprise	Chain's end-to-end visibility	Traceability	Automatisation of logistic processes	Product-based information sharing	Supply Chain Management	Product monitoring	Process control	Warehouse management	Passive	Active
METRO GROUP (2006)	Distribution of products from suppliers to retail	x	x		x	x		x			x	x	
SACHSENMILCH (2006)	Cheese production and raw material management		x		x				x	x	x	x	
SCHMIDT LEBKUCHEN (2006)	RFID in food production		x		x					x	x	x	
MIGROS (2006)	Distribution management	x	x		x	x					x		x
EURO POOL SYSTEM (2011)	Automatisation of order picking in retail distribution centre	x	x		x	x			x	x	x	x	
NORTURA (2008)	Chain-wide traceability of meat products	x	x	x	x				x	x	x	x	

Appendix D: Modelling of Business Information Services (generic example)



Appendix E: Information Model for the provision of decentralised product quality information (example)



Appendix F: Information Model for the online monitoring service (example)

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Robert Reiche works as a research associate at the Institute for Food and Resource Economics in the Department for Business Management, Organization and Information Management at the University of Bonn, Germany. He is also part of a research team working on different European research projects in the field of food chain information management. In addition, his teaching activities involve lectures and presentations on this topic for diploma and master students in the departments' master programme.

Project participation

2008-2011	CuteLoop	Customer in the Loop - Using Networked Devices enabled Intelligence for Proactive Customers Integration as Drivers of the Integrated Enterprise
since 2011	SmartAgriFood	Smart Food and Agribusiness - Future Internet for Safe and Healthy Food from Farm to Fork

Thesis related publications

Reiche, R., Fritz, M., Schiefer, G. (2009). Interaction models in the fresh fruit and vegetable supply chain using new technologies for sustainability and quality preservation. In: Bregt, A.; Wolfert, S.; Wien, J.E.; Lokhorst, C. (eds.), "EFITA conference '09. Proceedings of the 7th EFITA Conference", Wageningen Academic Publishers (pp. 667-674).

Reiche, R., Lehmann, R. J., Fritz, M., Schiefer, G. (2011). Business process support using RFID-based information services in the distribution of fresh fruits and vegetables. In Clasen, M., Schätzel, O. and Theuvsen, B. (eds.), Qualität und Effizienz durch informationsgestützte Landwirtschaft. LNI-Proceedings, Bonn, Germany. ISBN 978-3-88579-275-8.

Lehmann, R. J., Reiche, R., Fritz, M. and Schiefer, G. (2010). Integrated Production and Information Process Modeling for Decision Support in Quality Management. In: Manos, B., Paparrizos, K., Matsatsinis, K. and Papathanasiou, P. (eds.) "Decision Support Systems in Agriculture, Food and the Environment: Trends, Applications and Advances" (pp. 270-286), Information Science Reference, Hershey, USA.