Transparent_Food

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Transparent_Food

Quality and integrity in food: a challenge for chain communication and transparency research

Coordination and Support Action – CSA

Food Quality and Safety

D 2.1: European tracking and tracing backbone solution requirements analysis

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Executive Summary

A number of information technology supported tracking and tracing and quality assurance systems have been developed during the last few years. Most of the existing solutions focus on a certain production chain or a part of a chain. However, changes in supply chain configurations and interconnections between chains lead to the transformation of the linear structure into a highly dynamic food sector network. Therefore, to achieve appropriate transparency across the whole food sector, different tracking and tracing systems have to be interconnected. There is currently no satisfying solution available that is up to this task. One of the objectives of the Transparent Food project is thus to create a blueprint proposal for a European Backbone Solution that provides basic and simple functionalities to enable integration of different systems.

This report provides an initial requirements analysis for such a solution. Food sector and product characteristics that have an influence on design and architecture of the backbone have been analyzed. Stakeholders expectations have been collected and existing systems and solutions to be networked have been evaluated. The results of this work form the basis from which the project will continue onwards to draft the backbone solution specification proposal.

While building up the stakeholder community during the course of the project, further requirements can turn up. The document collection, for which this report is a summary, will thus continuously receive updates and be filled with new information.

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List of Abbreviations

ASCII	American Standard Code of Information Interchange
CSV	Comma Separated Value
DNS	Domain Name Service
EDI	Electronic Data Interchange
EPC	Electronic Product Code
EPCIS	Electronic Product Code Information Services
HTTP	Hypertext Transfer Protocol
IP	Internet Protocol
ONS	Object Name Service
RFID	Radio Frequency Identification
RPC	Remote Procedure Calls
SGM	Standard Gross Margin
SQL	Structured Query Language
SSL	Secure Socket Layer
TLS	Transport Layer Security
TRU	Traceability Reference Unit
URI	Uniform Resource Identifier
URN	Uniform Resource Name
URL	Uniform Resource Locator
WSDL	Web Services Description Language
XML	Extensible Markup Language

1. Introduction

Due to a number of factors, food safety and quality have been issues of growing importance in the last few years. As a result a number of information technology supported tracking and tracing and quality assurance systems have been developed. Most of the existing solutions focus on a certain production chain or a part of a chain. That kind of setting can currently be handled. However, changes in supply chain configurations and interconnections between chains lead to the transformation of the linear structure into a highly dynamic food sector network. To achieve appropriate transparency across the whole food sector, different tracking and tracing systems have to be interconnected. There is currently no satisfying solution available that is up to this task. One of the objectives of the Transparent Food project is thus to create a blueprint proposal for a European Backbone Solution that provides basic and simple functionalities to enable integration of different systems.

The system proposed has to be up to certain requirements. As IT systems commonly form a certain kind of formalized representation of real world issues, these requirements can generally be derived from properties of the real world objects and topics that it is dealing with and from stakeholders' abilities and expectations. It is thus important to get an overview of the sector structure, of systems already in place and of properties of food products that may have an influence on how certain functionalities can be technically realized. The following document thus aims to analyze these points in deeper detail. It is the outcome of literature review, internet and desk research, and the input of an expert working group setup specifically for creating the Backbone Solution Proposal in the Transparent Food Project. Statistical data on enterprise size distribution in the food sector in the European Union have been collected and evaluated. Stakeholders' expectations have been derived from statements of the respective parties participating in a chain. Existing tracking and tracing systems have been analyzed as to what kinds of products can be handled with them, what functionalities they provide and what methods, standards and technologies they use, to find out, if there is a common ground upon which the proposed backbone solution can settle. The food products themselves and how they are processed in the chain are considered. Finally, there are certain organizational issues to be solved.

First, however, the relevant terms will be defined and the most basic functional requirements will be shortly described in the following section.

2. Basic Functional Requirements

2.1. Tracking

From an abstract point of view, tracking functionality provides the ability to access at any time the current position of a certain object. Although geospatial services gain increasing importance in everyday life, position in this regard does not have to be an exact spatial reference. It may also refer to a position in a number of process steps or to the current holder of an object. If the object simply moves along this chain, tracking can relatively easily be implemented. However, in lots of cases, there are transformation steps, that change the character and/or composition of the object. As such, apart from only position information, there may also be certain attribute changes that are desirable to track along this chain.

2.2. Tracing

Tracing is a process by which the executor may find out how a certain object moved in the past. Tracing information can be gathered by two different mechanisms:

1. Pull approach: Periodically request tracking information and save the information in a kind of log book. This approach is e. g. commonly used in GPS supported logistics systems.
2. Push approach: Whenever an event occurs that goes along with a change in place or a transforming production step, a signal is generated, that is captured at a central place. This approach is e. g. used by the EPC Information Services. It requires to have a clear view of the whole process to be able to derive events, upon which signaling is necessary.

2.3. Backbone

A backbone is the top level of a hierarchical network. As mentioned in the Introduction, a number of tracking and tracing systems in the food sector have been developed during the past few years. However, they focus on different chains or parts of chains and are not or only poorly connected. Thus, the current situation can be depicted as having a number of networks without a common backbone. Therefore, there is only very limited support for dynamic supply chain reconfiguration. The solution proposal to be developed will not strive to replace existing systems. It will rather implement the kind of backbone that is necessary to interconnect existing systems and will provide the top level of a network under which a number of systems can be subsumed.

3. Sector Structure

In more conventional information technology projects, where a single customer orders a certain system or a software company creates an end user application for a broader market, requirements are largely determined by customer demands and can be derived either from an intensive dialogue with the client or market research targeting the potential users. In infrastructure and networking projects a much broader approach is necessary. There is no single customer and the end user of the technology will often never be aware that a certain infrastructure specification forms the basis of the communication upon which delivery of information relies. To be able to derive a technical and organizational architecture and the potential roles of different stakeholders, an overview of the sector with regard to basic data characterizing enterprises like size, work force etc. is necessary. The following section provides this overview of the food sector. A number of representative countries demonstrating different characteristics of the sector have been selected. Data have been obtained from the European statistics office Eurostat and reflect the state of the year 2007. More recent data has been only partly available, was incomplete and thus not suited for a comparative inspection. However newer data indicate that – apart from commonly known trends like the one for slowly increasing farm sizes and less people working on farms per area unit – there have been no significant changes in the overall distribution of the considered parameters during the last three years.

3.1. Primary Production

For the agricultural sector the key variables are given for farm size classes determined by the agricultural area (in ha) (Ref. 1).

In most countries, the number of farms is more or less evenly distributed over all size classes (Figure 1), but in Greece and Hungary more than ¾ of the farms are small or very small (less than 5 ha).

In all countries except for Greece, the small number farms > 50 ha cover roughly half of or more than half of the utilised agricultural area (see Figure 2). This situation is particularly visible in Hungary where farms with more than 100 ha contribute to nearly 70% of the utilised agricultural area.

Considering the labour force the distribution over the size classes is highly variable depending on the country (see Figure 3). In Hungary, more than 50 % of the agricultural labour force is working in farms with less than 5 ha, and nearly 15 % in the largest farms, whereas in Germany and U.K., all size classes employ a significant number of work force.

The economic output (measured as SGM) of the larger farms is relatively greater than that of the smaller and medium sized farms (Figure 4). This is not the case for Greece, where farms of the two highest size classes play almost no role neither in labour force nor in the total SGM.

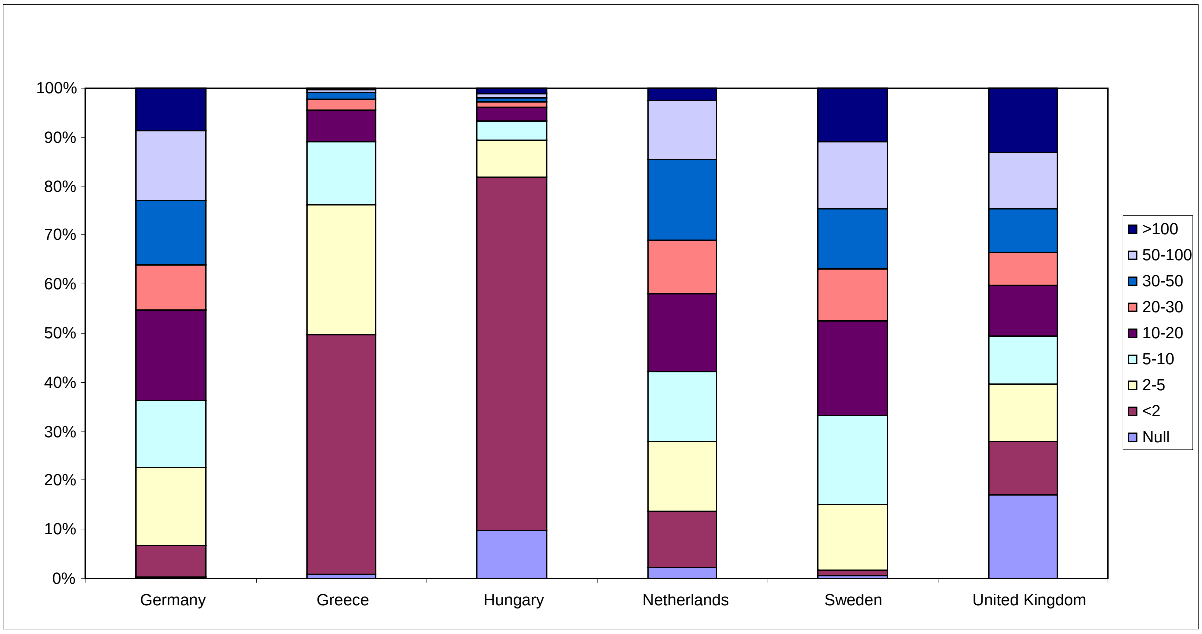

Figure 1: Percentage of agricultural holdings by size classes

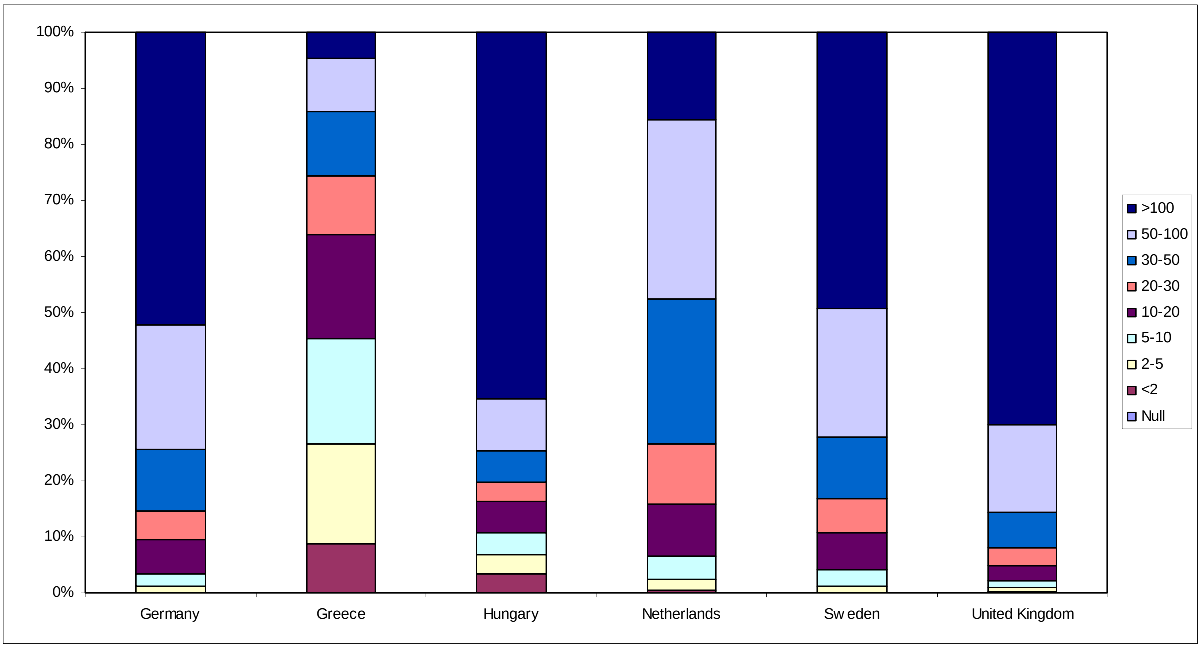

Figure 2: Percentage of utilised agricultural area by size classes.

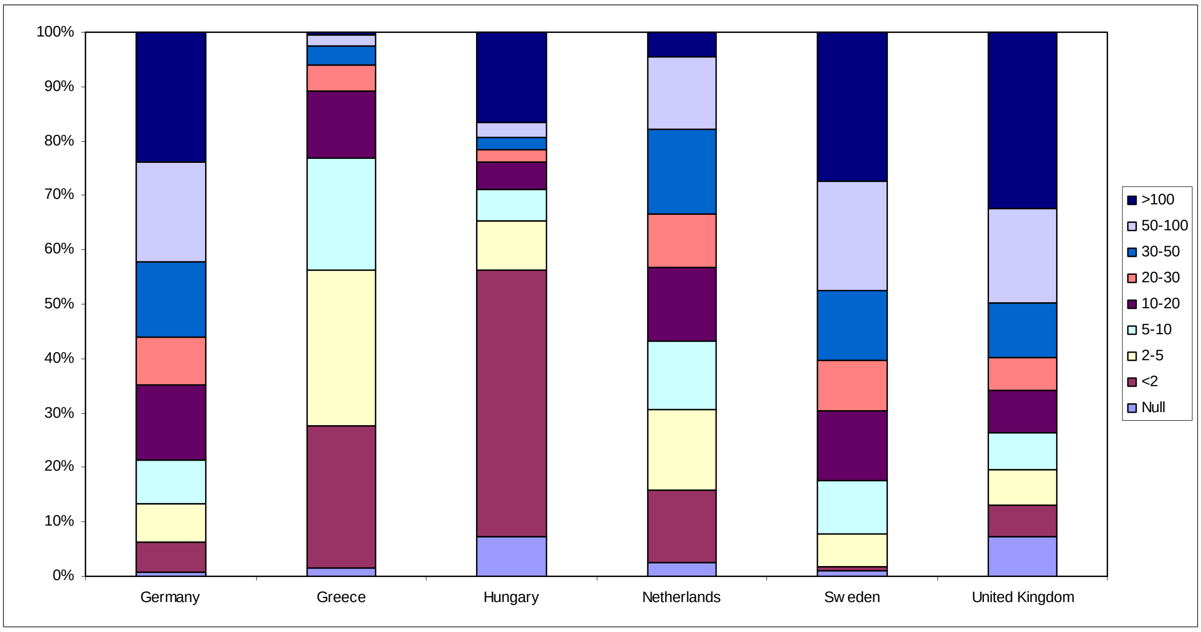

Figure 3: Percentage of bound labour force of agricultural holdings by size classes.

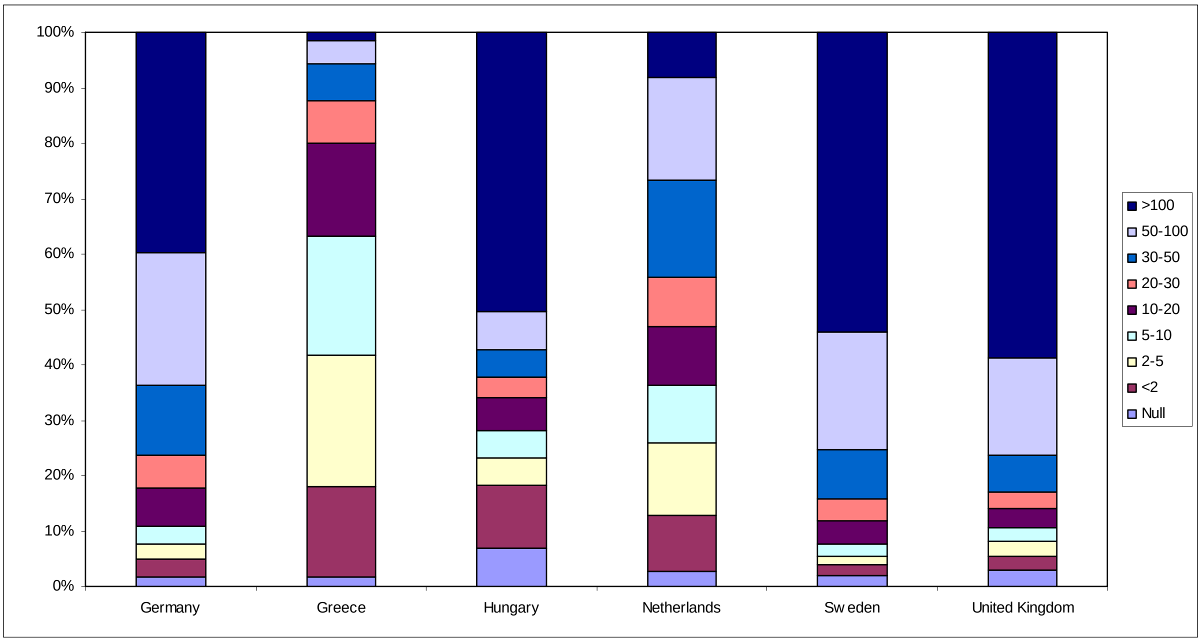

Figure 4: SGM of agricultural holdings by size classes.

3.2. Food Processing Stage

Figure 5 shows that in the food and beverage manufacturing industry in the European Union (Ref 2) there is a large number of small enterprises (almost 80%). Even medium sized enterprises are only represented to a minor degree and very large enterprises are a minority. Considering the economic output (as turnover) or the labour force (as number of persons employed), the large enterprises account for a larger share of the market. However, roughly 20 % of the overall turnover of the food industry in the E.U. is covered by enterprises with less than 50 employees. In this case, data are presented in aggregated form, because parts of the country-wise statistics were incomplete. However, also these numbers do not differ much between the different countries, so that layer of the food chain shows mostly constant distribution across all of Europe.

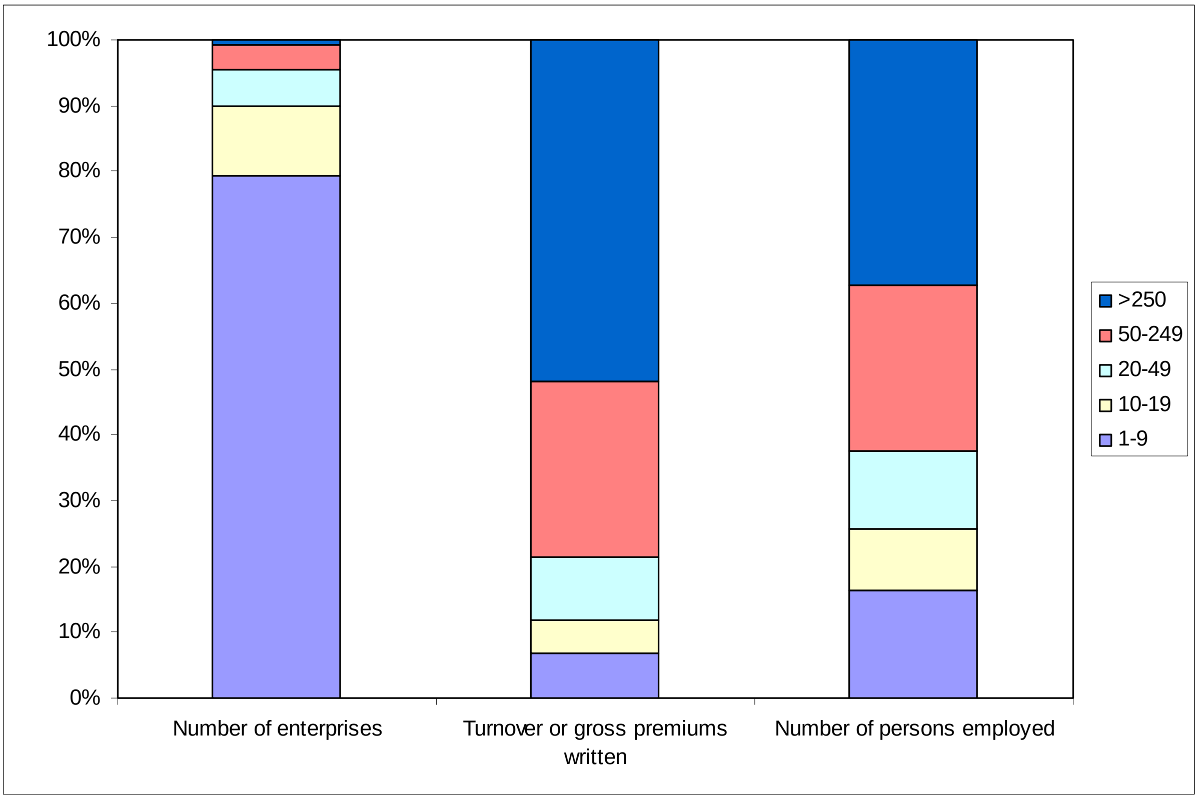

Figure 5: Key variables of manufacturers of food and beverages in the EU27 by employment size classes.

3.3. Wholesale

In the wholesale area of food, beverages and tobacco, the structure of the market is highly variable between the examined countries (Ref 3, Figure 6 - Figure 8).

In Sweden, about 70 % of the number of wholesale enterprises fall into the lowest size class (only 1 employee), but contribute to less than 10 % of the market (as total turnover). On the other hand, companies with more than 250 employees provide more than 60 % of the labour force and more than 40 % of the turnover while constituting only 0.3 % of the total number of enterprises. In Greece, the vast majority of enterprises in this sector also has less than 10 employees, but they still contribute to about 40 % of the market. In all countries, less than 50 % of the labour force in wholesale work for enterprises with more than 250 employees.

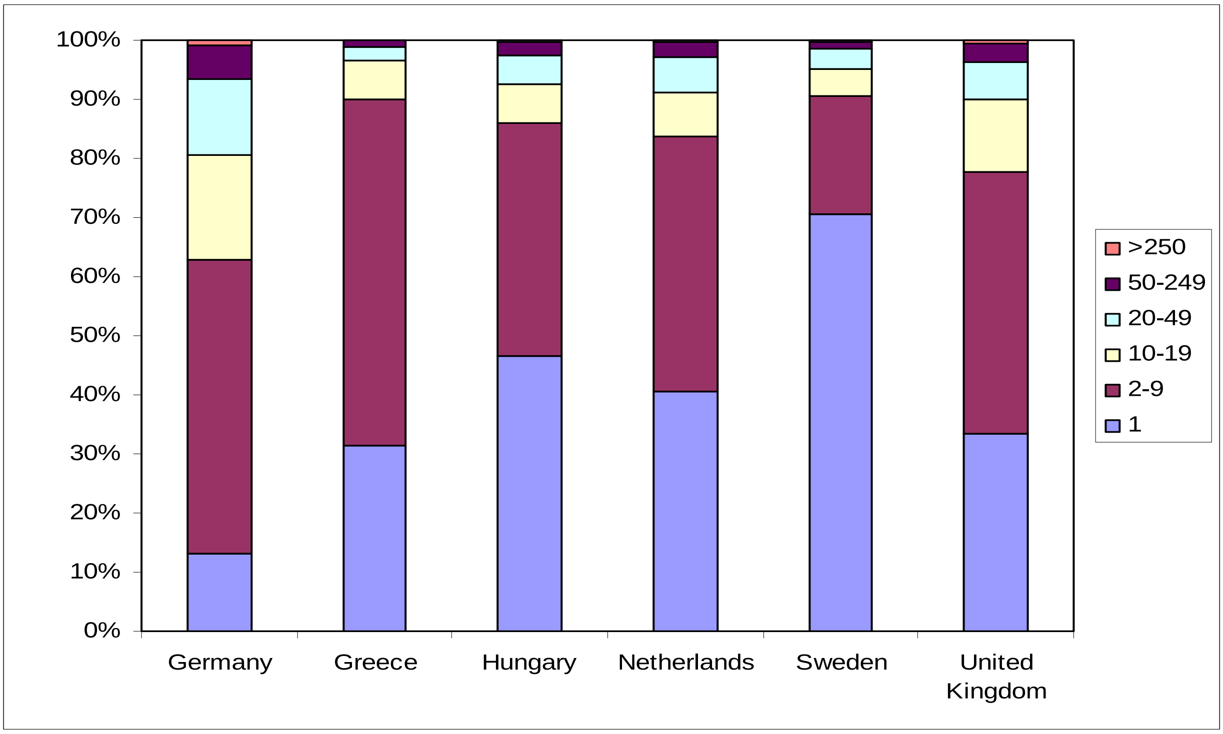

Figure 6: Number of enterprises in wholesale by employment size classes.

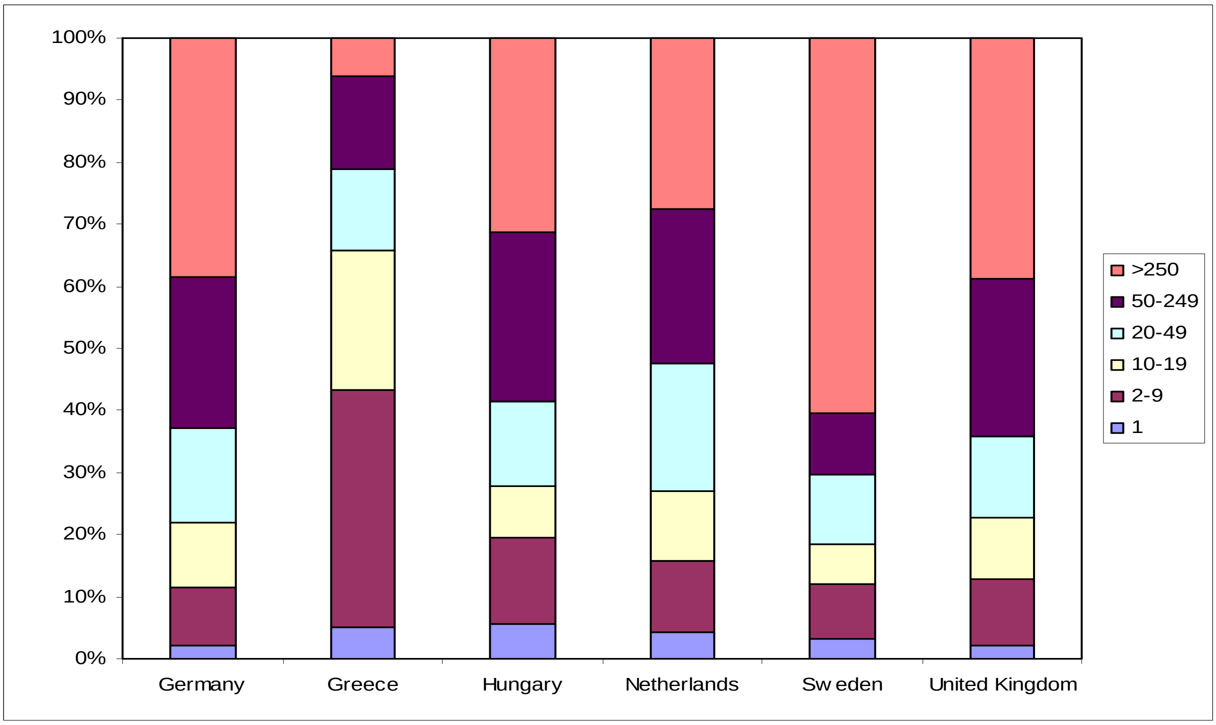

Figure 7: Number of persons employed in wholesale by employment size classes.

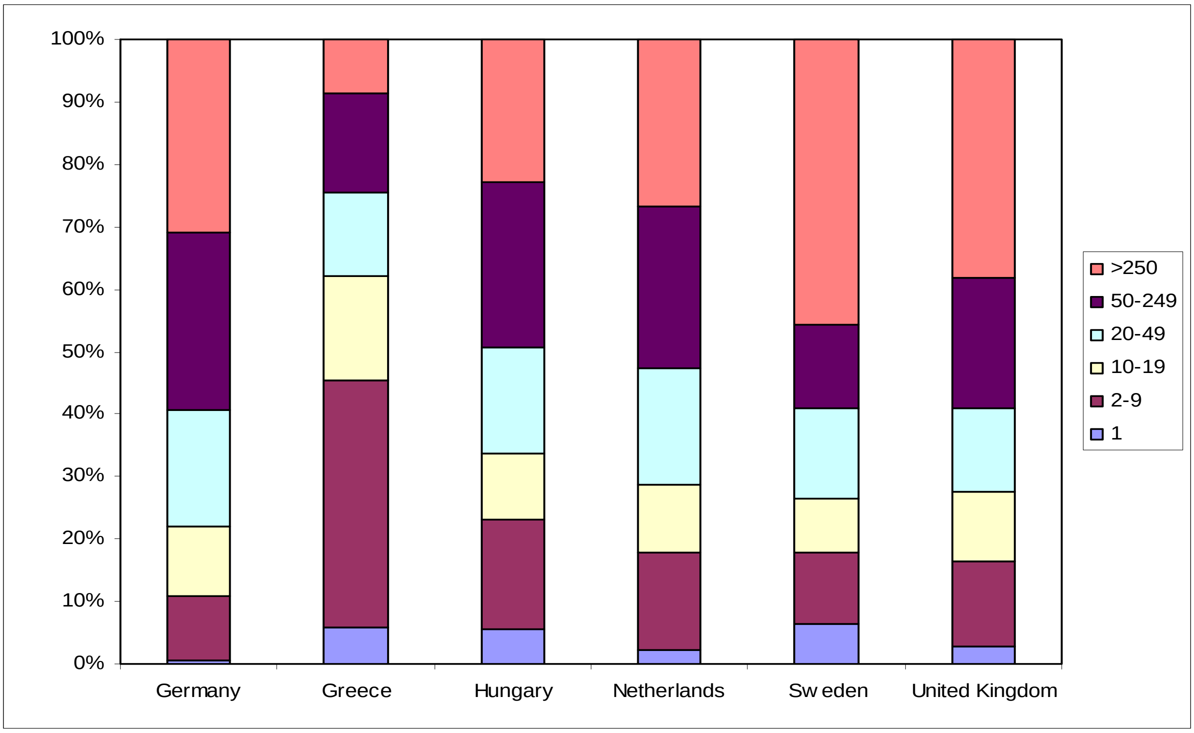

Figure 8: Turnover or gross premiums written in wholesale by employment size classes.

3.4. Retail

Food and beverages are sold both in non-specialized stores (e.g. supermarkets) and in specialized stores (e.g. bakeries, groceries etc.). In all countries, the situation is vastly different between the two.

It can be observed for the non-specialized stores that a few very large enterprises cover the largest share of the turnover and the labour force (Figure 9 - Figure 11). This is especially the case in Germany and the United Kingdom, whereas in the other countries, small enterprises still cover between around 30 and 60 % of the market share.

Most of the specialized stores for food, beverages and tobacco in all examined countries (data are missing for Greece and Sweden) have less than 20 employees, and these stores employ not only the majority of the labour force, but achieve also the largest part of the total turnover (Figure 12 - Figure 13).

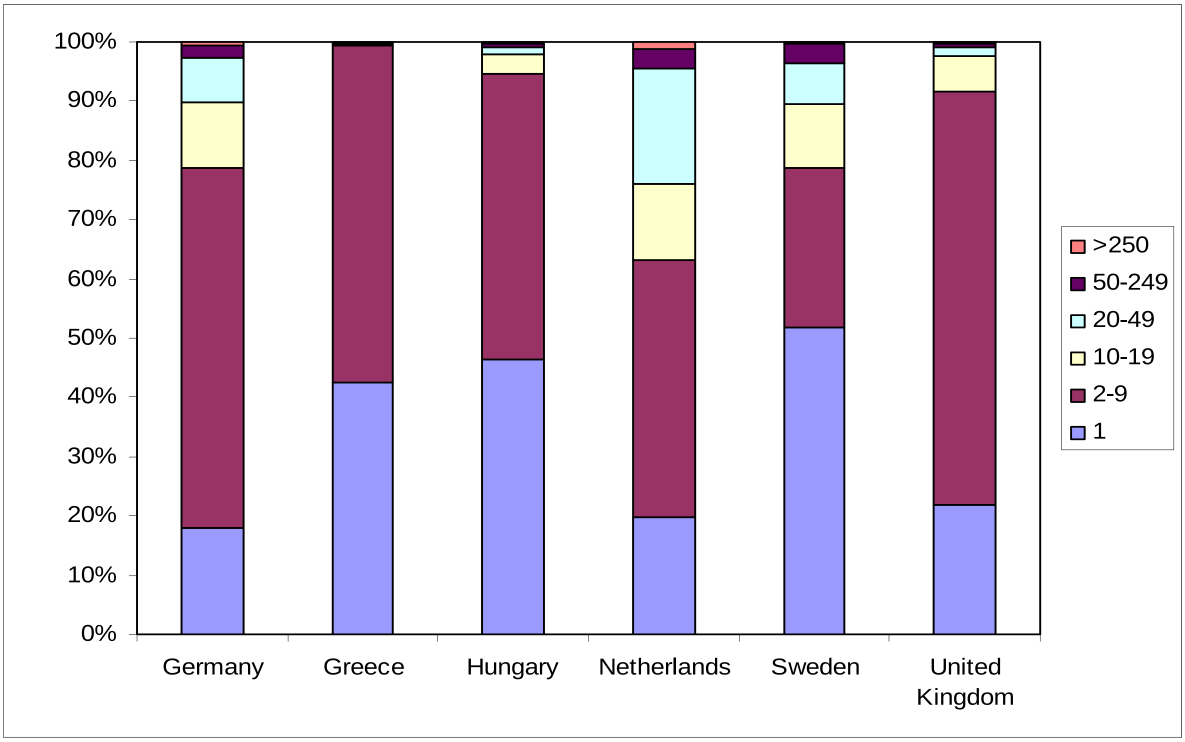

Figure 9: Number of enterprises in retail, non-specialized stores, by employment size classes.

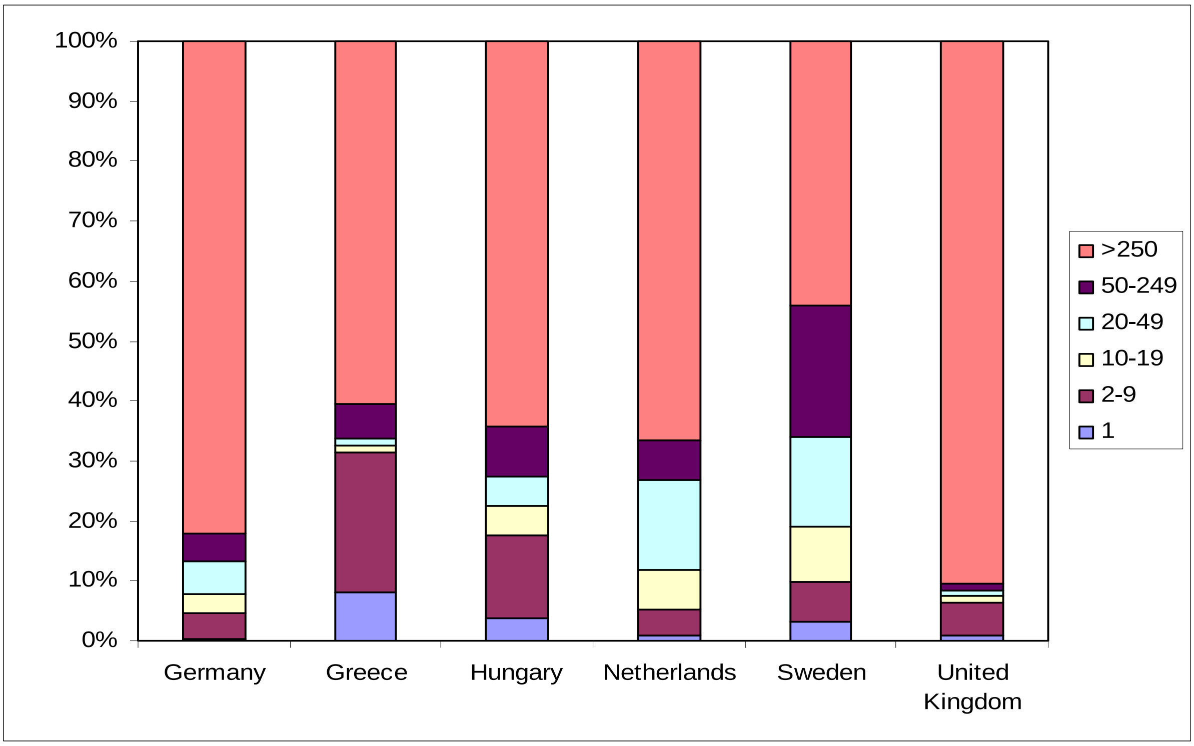

Figure 10: Turnover or gross premiums written in retail, non-specialized stores, by employment size classes.

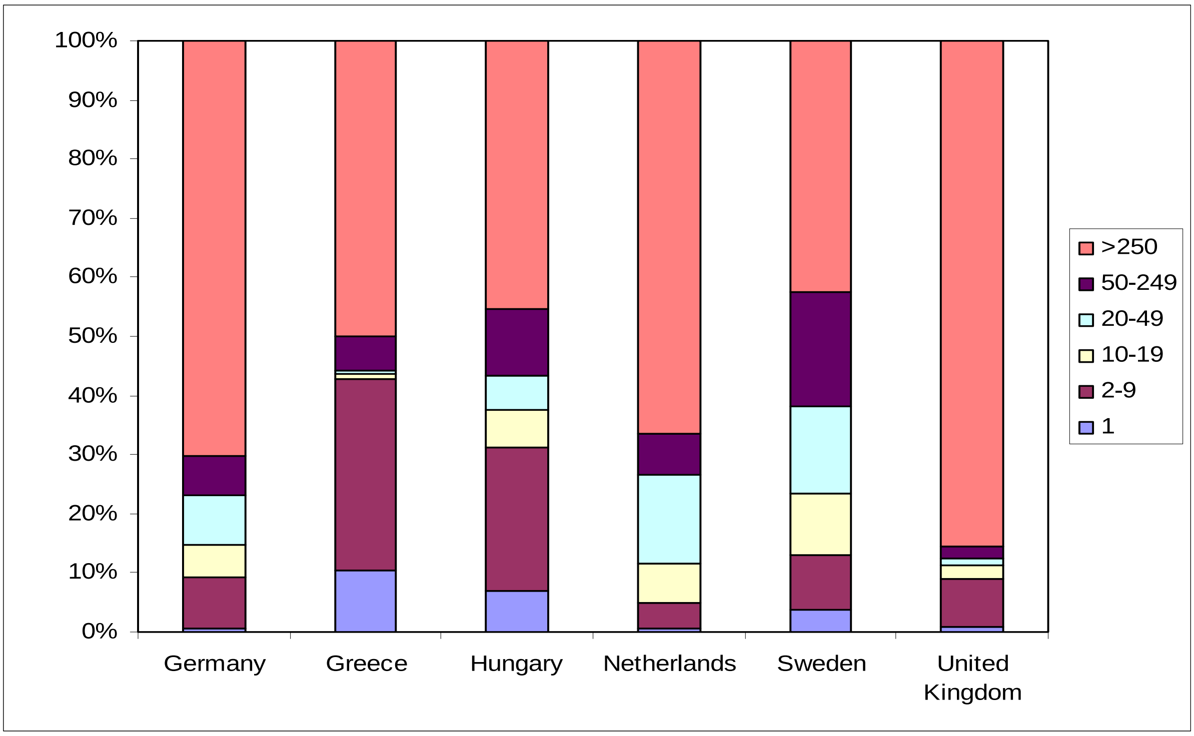

Figure 11: Number of persons employed in retail, non-specialized stores, by employment size classes.

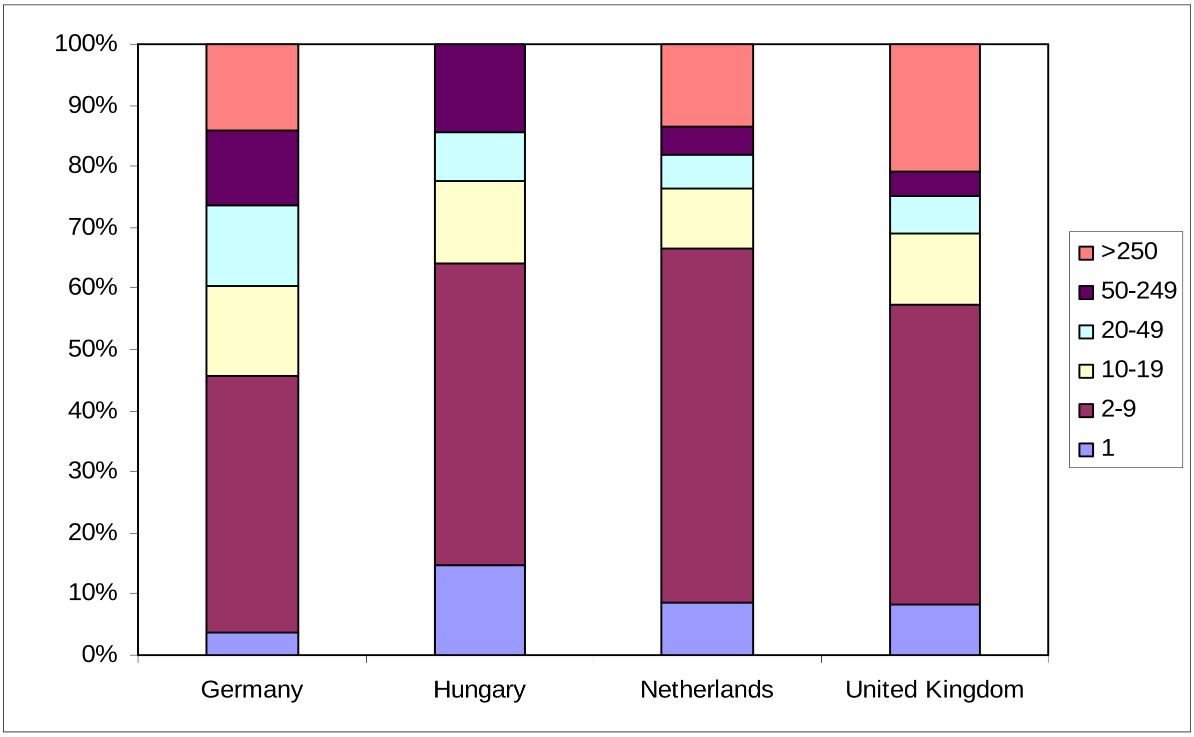

Figure 12: Turnover or gross premiums written in retail, specialized stores, by employment size classes.

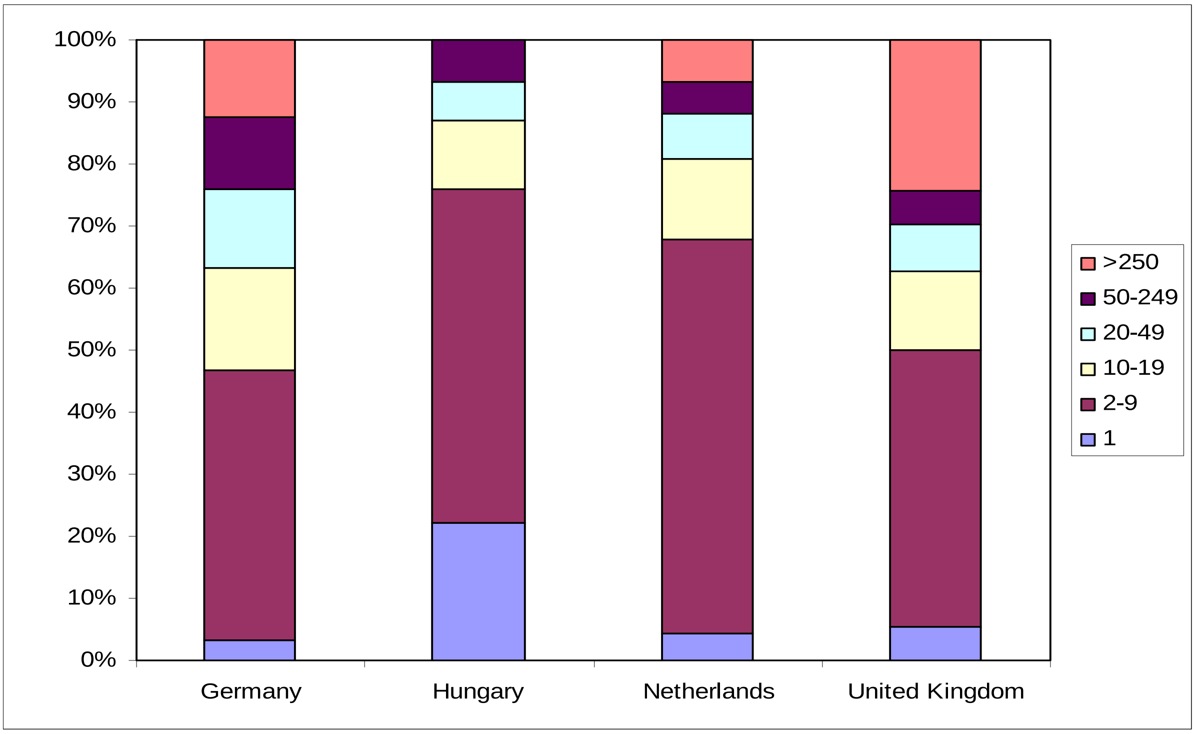

Figure 13: Number of persons employed in retail, non-specialized stores, by employment size classes.

3.5. Conclusions

Overall, the analysis shows a broad diversity of enterprise size distribution characteristics across countries and across different stages of the food chain. While the larger enterprises commonly are small in numbers but contribute a relatively large part to the economic outcome and to the percentage of bound labour force, small enterprises still play a major role in various stages of the food sector, especially in primary production and specialized retail stores. With this regard, the sector differs from other industries like e. g. the electronics sector, where there are almost no small enterprises present in the supply chain or the automotive sector, where there are lots of medium sized enterprises in the pre-production parts deliverer stage of the chain and a small number of very large corporate enterprises doing final assembly. The picture given of the sector has a number of consequences as to requirements of the envisioned backbone solution to achieve sector-wide transparency. First of all, small scale enterprises will neither be able to run their own information technology department nor be able to afford running their own systems at expensive IT outsourcing companies. The solution to this problem may be to deliver access to the tracking and tracing solution backbone by mechanisms like "software as a service" (SAAS), where external providers offer a common interface to a large number of clients, usually using the Internet. However, the financial outcome of running SAAS depends on a certain critical mass of clients that may be interested in participating from the beginning on. Therefore, currently most companies providing these kinds of services to individuals and enterprises of all size classes focus on very general infrastructure services like common storage (e. g. Amazon S3, Rangboom) or Email (various enterprise class webmail providers). An important aspect to consider when evaluating the feasibility of that kind of solution is thus the question of a suitable business model and future legal boundary conditions. By a decision of the working group this work package will not focus on these aspects but rather only work on technical issues. For future directions in providing a backbone solution however, these questions will have to be dealt with.

Another issue with regard to providing access to the backbone to small and medium sized enterprises as software as a service is the question of internet connectivity. Although broadband internet connectivity is becoming more and more common in every country in the EU, the percentage of reliable internet connections is constantly decreasing. This comes from the fact that on the one hand more connectivity options today rely on wireless technology (UMTS, satellite modems etc.) – especially in rural areas – and on the other hand there is an increasing number of connections without having throughput and availability guaranteed by either technical measures or an appropriate service level agreements (cf. DSL lines with variable bit rates vs. various incarnations of ISDN multiplexed lines like E1-E5 with guaranteed bit rates). How to deal with these changing boundary conditions in the face of increasing importance of communication across the Internet and reliance on networked applications going from simple SAAS provision to complex cloud applications has led to a slow but steady revival of distributed operating systems and system architecture research (cf. e. g. Ref 4) as the currently available systems provide only unsatisfactory solutions to the resulting problems.

For future work in building the tracking and tracing backbone solution, the consequence is that thought has to be given on how to deal with temporary outages. Available internet service architecture design patterns allow for simple caching of requests. While certainly not suited to overcome long-term connectivity outages, it has to be evaluated if these mechanisms can at least be used to allow for bridging short term gaps.

Another aspect to consider is the large number of potential participants to the network. Solutions available in other industries like e. g. RosettaNet in the electronics industry which is based on web services built around ebXML are thus not easily transferable to the food sector, as – due to their design as RPC services – they will not scale to stakeholder numbers that large.

4. Stakeholder Expectations

To understand clearly the needs for tracking and tracing throughout the food chain it is highly important to discuss in depth the expectations of all involved stakeholders. Globalization of the food industry has introduced the need of various intermediates between production and consumption of goods. Almost every stakeholder now implements some kind of quality scheme in order to meet legislation needs, including traceability, and manage quality and safety of the products. All implemented protocols have been designed in order to facilitate the commerce of food establishing the minimum requirements any intermediate stakeholder would ask from all its suppliers. Therefore one of the primary expectations of all the chain node stakeholders is a common effort to be appreciated from the final consumer. In detail every stakeholder expects different information to support its activities. To most parties in the food sector tracking and tracing would be mostly useless if not answering the questions as to ‘how’, ‘when’ and ‘why’ besides to only ‘where food is produced’.

4.1. Consumers

The new model of the European consumer is characterized by more specific demands on food production, a higher disposable income and increased life expectancy. Consumers are demanding convenience foods, a good quality/price relation, dietary value and confidence in safety and quality of food production. Therefore traceability information, should – apart from the exact area of production – always be accompanied by dietary factors. Also, the possibility of having access to information regarding safety of food should be provided.

4.2. Stores and Dealers

Being the final destination before the consumer, stores and dealers expect due diligence from the whole food chain. Quality and safety should be guaranteed in order to create a positive consuming attitude. Retailers need to have the ability of backwards risk assessment trials for evaluation and improvement. Information should be available from every node of the chain to allow control of their creditability. Mass balance should be accompanied by information about how food is produced. No food alerts can be issued if the only item known is where it has been produced. From the stores' and dealers' point of view, a proactive approach to food safety is demanded that not only allows reaction to problems but also to enforce proper procedures necessary to prevent incidents from happening.

4.3. Processors and Transport

Standing in the middle of the food chain, processors and transporters have the responsibility to ensure that products reach retailers in the best possible state. Tracking and tracing for them is crucial to manage control of raw materials risks in order to produce safe and high quality food. It is though the link with the highest difficulties in documenting all factors for the creditability of traceability. Participating in such procedures, they expect improvement of their services to be followed by easier access to the markets. Methods to facilitate documentation of all handling activities that might possibly create any risk to food safety would allow processors to feel more secure and improve their services.

4.4. Farmers

Farmers, having to operate in a highly uncontrolled environment, are the ones who have to undertake the most risky practices in food production. They should be in the position to document all cultivation practices that are applied onto the quantities delivered to the next chain step. Creditable data from growers is the most crucial point for giving proof of due diligence in tracking and tracing. Being the link with low or no opportunities to apply enterprise grade information technology in order to provide data, they need to be supplied with a simple, multipurpose tool. In recent years, growers have been obliged to comply with various criteria (e. g. cross compliance, good agricultural practice, integrated crop management etc.) in order to have access to subsidies and the markets. They can be persuaded to present data if these would be collected in user friendly environments with low required investments and if tools are compatible with their existing documentation needs. Data according to farmers needs to stay strictly privacy protected but yet has to be available upon request. Farmers would be assiduous if they could gather data in an easy and secure way and when they feel confident that this information would never be used against their interest. One thing they expect is the appreciation of their contribution. Being able to be referred in the final product, at least as point of origin, would make them feel that their own production has safely been handled and good traceability practices followed. Moreover, a consistent tracking and tracing system would allow growers to check mass balance produced and delivered to the consumers.

4.5. Conclusions

Stakeholders expectations and needs and also motivations to use a tracking and tracing system differ depending on their position in the chain. A demand that obviously has to be considered in designing the backbone solution is the possibility to trace backwards and forwards. Having access to more information than just bare tracking and tracing data is a common requirement to all stakeholders. This aspect will also be discussed in more detail in the next section.

5. Food Properties and Handling

IT systems for food traceability face problems distinctive of the food sector. The computerized management of traceability information must take into account several processes that food undergoes mainly in long chains. The information storing and retrieving routines have to ensure the lots tracking and allow for plausibility checks like providing the mass balance along the transformation steps from field to table. Those steps may include processes that change the material characteristics (e. g. from solid fruits to liquid juice) implying changes of units of measurement and attributes of the lots. Easier to be managed are the short chains e. g. for fresh products. In this case a strong requirement is the timing of information storing that can be enhanced by bar codes or RFID labelling.
The main kinds of properties of food itself and the processes that the food chains may include and that have an influence on design requirements of a tracking and tracing backbone solution are described in the following paragraphs.

5.1. Mixability

Lots of mixing is present in most food chains. Usually at least one or two main ingredients directly traced right onto the farm, field or stable are found. Besides that, minor ingredients that come in from other chains play a role as well. Where possible the lot ID of minor ingredients is stored but in many cases (i. e. water) this is not available. For biological products or products having a quality insurance it may be required to store a chemical analysis for a fixed timing (i.e. monthly for the water) in the system. A more complex situation arises in the restauration (canteens, fast foods etc.) where dozens of lots are assembled by the operators to be consumed in short time. Usually they have no time to measure the weight of each lot used. A pre-defined “recipe” can speed up data entry. The operator is asked to choose the recipe name and enter the lot numbers of the ingredients and the system automatically deducts a fixed quantity of the entered lots on the basis of the recipe rules. Mobile and water-proof devices are strongly required in such an environment.

5.2. Divisibility

Making many smaller lots from a larger lot may cause a dramatic drop of traceability precision in chains with continuing processes. In the bread or pasta chain wheat seeds are stored in large grain bins after the trucks come into the storage centre. Usually a truck load is a single lot with a single origin (field(s) of a single farm). The storage process may last for a long period and at the same time, for the same grain bin, there is an in- and outflow of material as lots are refilled and lots of seeds are sent to the mills. This leads to the problem that in case of an incident in the chain, while tracing back the lots of wheat seeds in a certain product all the farms, which put grain into the bin in a certain period of time are recognized as "origin" although their lot may not have been affected for real. A potential troubleshooting method could be to estimate the filling and emptying processes speed, to cut slices of the grain bin content covering a smaller number of origin lots (farms). Anyways, the speed is frequently irregular and due to technical problems during filling material may get mixed in the bin so the appraisal precision is low. The best practice of food safety requires a larger number of smaller grain bins and that they must be completely emptied before being filled again. The same problem is present at the mills level with flour.

5.3. Bulk Material

A number of agricultural products enter the food chain as bulk material (see also Section 5.2) and the identification of lots is usually made at the stage following the harvest (i.e. collectors, food processors, cooperatives). Labelling the lots at the time of harvesting is complicated and expensive. There have been methods discussed and researched where RFID chips are used directly in the bulk material to identify lots. While this may simplify the process of lot identification in bulk materials, there are still problems: Guaranteeing even statistical distribution of the markers in the material requires them to have similar physical properties as the material itself while on the other hand allowing them to be separated out for later processing stages (e. g. before transformation of wheat to flour) requires them to have different physical properties. Also due to current pricing of RFID technology, it is generally used mostly only in high value added chains. However, a benefit of RFID is, that it allows for lot attributes (grower, weight, variety, location, quality…) to be recorded directly on chip in the post-harvest stage.

5.4. Processing

From the information technology point of view, enablement of plausibility checks like e. g. calculating the mass balance is a major challenge in managing the food chain. Lots of processes change the nature of the material and the related units of measure (e. g. processing from fruit to juice or again from juice to jelly). Due to respiratory losses, without any further processing only during storage, weight loss is frequent for fish, meat and fresh products in general. If heating processes are involved like cooking or frying, the situation becomes even more complex as the product processed while loosing weight at the same time may take up water or oil. Where mass balance calculation is mandatory, as for certain quality insurance systems, transformation rate ranges have to be set for each transformation stage to prevent abuses or incorrect data.
In this cases, it is required for traceability systems to be able to store process attributes like temperature, time or pressure that will be dynamically linked to the output lots.

5.5. Risk of Deterioration

It is a commonly known characteristic of food products that they deteriorate after a certain period of time. Although other products also undergo an aging process, this problem is of special importance in the food sector, as deterioration generally happens much faster. Especially in cold chain management, where proper and uninterrupted cooling of food products during storage and transport has to be proven, this aspect plays an important role. In that case, it makes sense to capture further parameters – specifically temperature measurements – alongside of the common tracking and tracing data items described below in section 5.7.

But also non-cooled products can deteriorate. Apart from the spatial dimension – the location where a product has been – the temporal dimension is thus an important parameter to capture.

5.6. Immaterial Properties

From the point of view of the consumer, a number of properties of food may be important that can not be grasped by physical properties or are not at all or not easily measurable. This includes for example expected food processing according to certain methods due to ethical or religious convictions (e. g. kosher, halal), ethical and social aspects like guarantees concerning proper treatment of trade partners and employees (fair trade, fair wage) or statements about organic growing and processing.

Traceability depth, lot and process attributes to be stored are affected by these immaterial aspects of the final product (Figure 14).

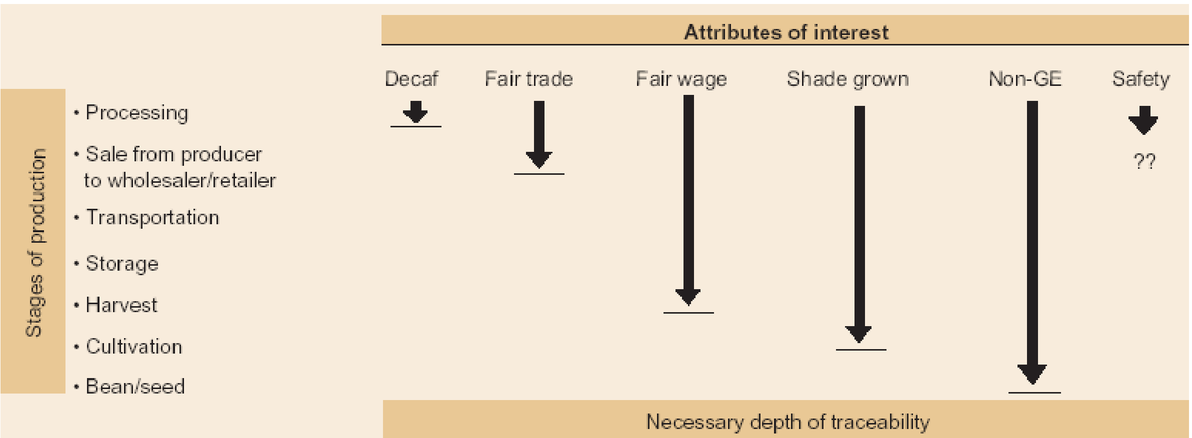

Figure 14: Necessary depth of traceability depending on attributes of interest.

This is one of the reasons, why IT systems currently are tailored for a specific food chain and predefined frameworks are difficult to establish. From the consumers' point of view, the "processed tomato" food chain doesn't really exist. Consumers demand for the additional information about immaterial properties that a specific final product is expected to have to be traced. This situation has developed over the past few years. At the very beginning tracking and tracing IT systems were adopted for food safety purposes only and they were asked to manage just the products recall. Now, they can play a crucial role to support the marketing of quality products.

5.7. Conclusions

The special properties of food and processing methods mentioned have implications on the setup of a tracking and tracing backbone. While a number of problems can be avoided by following certain handling and processing best practices as e. g. depicted in section 5.2, certain mixing and division steps of lots during processing are unavoidable in the food sector. In a distributed system without centralized storage, it may be best to deal with this aspect in setup of identifier handling. A hierarchical scheme supporting formation of sub-lot numbers based on the original lot number for divisions may work in certain cases but leads to clumsy and large identifiers upon mixing of lots. Rather dynamic tracing is possible, when identifiers serve also as network addresses that can be resolved to retrieve further information through e. g. web services. In such a system, a chain or even more complex networks can be navigated by simply resolving a lot identifier, querying the identifiers of the comprising lots and – resolving these again – following the resulting links to the next service providing further information on composition of lots. Systems following that kind of approach are used e. g. in the pharmacy sector. However, to implement tracking functionality, this method requires nevertheless a mechanism for querying the most recent position of a certain object in the chain from outside of the chain. Further analysis of different processing scenarios is required to evaluate the suitability of this scheme for the food sector.

A basic information set to enable tracking and tracing can easily be agreed upon. The data items necessary have been identified by the working group of system providers as being:

- Who: The company that shipped a certain good
- When: shipping date and time information
- What: A product code identifying the product
- Lot number: A number identifying a certain lot of a product. The necessity to provide a lot number also serves as an incentive for good management practice, as this will lead to shorter lists of lot numbers in case of a tracing request.

The discussion in sections 5.1 to 5.6 and also 4 above however indicates that for enabling transparency in the food sector, we are not yet done with that. Further attributes either to the product itself or other information stored elsewhere may be necessary to allow for additional controls using plausibility checks (mass balance), checks for other parameters (proof of uninterrupted cold chain) or safety proofs (pesticide applications, additives) and for chains to be separated based on scope (e. g. organic/non-organic, fair trade/standard trade system). Therefore, it is required to be able to attach a flexible "backpack" of additional information to the information set depicted above.

To keep the information set small and suited on the one hand to be transferred across slow links, and on the other hand to be captured for lots of smaller items in mass production without blowing up stakeholders databases, it may be necessary to capture some of the data in central directories. This lends itself especially to the "who" data item given above. The EPCglobal standards framework provides a standard for such a service called the ONS (Object Name Service) that may serve as a repository of additional stakeholder data.

6. Existing Tracking and Tracing Systems

As the system specification to be developed is meant to integrate existing systems into a larger network backbone, it is necessary to take a look at the products currently available on the market of information technology supported tracking and tracing systems. It is of special importance to gain an overview of the networking facilities that are already implemented in products as methods and standards used there may serve to find a smallest common denominator that provides a low entry barrier to adoption of a new backbone network. The analysis also showed that there are a number of systems out there that provide an especially well designed solution to certain aspects of the problem and which thus may serve as an inspiration for the backbone solution specification.

Appendix B gives an overview of the systems evaluated. A framework of analysis with regard to the following aspects has been setup:

- Provider and product names, general description and information on contacts, information sources etc.
- Scope of application, application area, supply chain monitoring start and end point, integrated levels of supply chain, stakeholders
- Interfaces, networking, information technology standards in use, organization of data storage (centralized/decentralized)
- Quality standards to which the product adheres and for which the product can provide support in management of the chain
- Necessary investments

Oriented on that framework, information for all listed solution providers using material commonly available in publications, leaflets and on the websites of the respective companies has been collected. To deepen the understanding of certain aspects, together with the invitation to a system providers working group meeting, the questionnaire that can be found in appendix C has been sent out. Although only a return of four of the questionnaires was achieved, a number of interesting results with regard to the requirements of the backbone solution could be derived.

Most of the system providers analyzed are specialized in the agrifood sector. Others offer systems to track and trace all kinds of items and provide a certain system or program for food. A number of enterprises focus on other sectors where similar demands exist, e. g. Kezzler and rfXcel that are concentrating on the pharmaceutical industry, or Savi Technology that offers solutions for aerospace, defense, civil agencies and natural resources.

Most companies are situated in Europe or in the USA, but there are also several system providers located in Thailand, Malaysia, South Africa, and Tanzania.

For a number of enterprises, the operational status at the time of the analysis was unclear. The German enterprise Transparent Goods was closed in 2008. The French organization Setrabio became insolvent. The current status of support for their product Tracerbio is unknown from the information sources we had access to. Furthermore, it was not possible to collect adequate information about a traceability system for shrimp and seafood called ThaiTraceShrimp. It is provided by the Department of Fisheries in the Ministry of Agriculture and Cooperatives in Thailand. Neither the corresponding website nor other contact information was available.

6.1. Application Areas

Several systems cover multiple food products. Systems with two possible fields of application have been assigned to the more important sector. Systems with multiple fields of application have been ranked among "food in general". Thus, the high number of available systems in this category can be explained (see figure 2). Nearly all systems cover the whole food supply chain from the farm to the point of sale. It becomes more and more common that consumers themselves can trace back their purchases with the help of product codes via the internet. HarvestMark by YottaMark, Foodtag by Lyngsoe Systems and several other traceability systems offer this possibility.
The field of food in general is covered by solutions such as ChainPoint or Q-Tracing by ChainFood from The Netherlands, String by Historic Futures from UK, Foodtag by Lyngsoe Systems from Denmark and many more.
Concerning meat the Irish company identiGEN's solution DNA TraceBack can be mentioned which uses genetic identification to trace the source of meat products through the entire supply chain. The German HI-Tier Database focuses on cattle and includes first of all farmers, but also veterinarians and slaughterhouses. Matiq from Norway offers another solution to trace meat and meat products.
Fruit and vegetables can be traced with the Dutch system IQMO fruit & agro, web4trace by the German provider Winckel, and QualiTrack from South Africa.
Special solutions to trace fish and seafood are OpsSmart and ProductionSmart (FXA-group, Thailand) and a tracking system provided by Trace Register, USA.
The American rfXcel and the Norwegian Kezzler create solutions for the pharmaceutical industry.
ARGE Kaisergetreide from Austria represents a quality program for grain. The program Tracerbio by the former organization Setrabio dealt with organic grain mainly in France.
Standards and accompanying applications are offered by the EPCglobal network. It provides basic technologies for tracking and tracing like RFID and barcoding identification standards and services and directories to query data and was designed to support all kinds of products. It has however to be noted, that not all processing events occurring in the food chain, especially events, in which a product does undergo transformations, are supported by EPCIS. The US company Savi Technology created highly developed traceability solutions for aerospace, defence, civil agencies and natural resources.

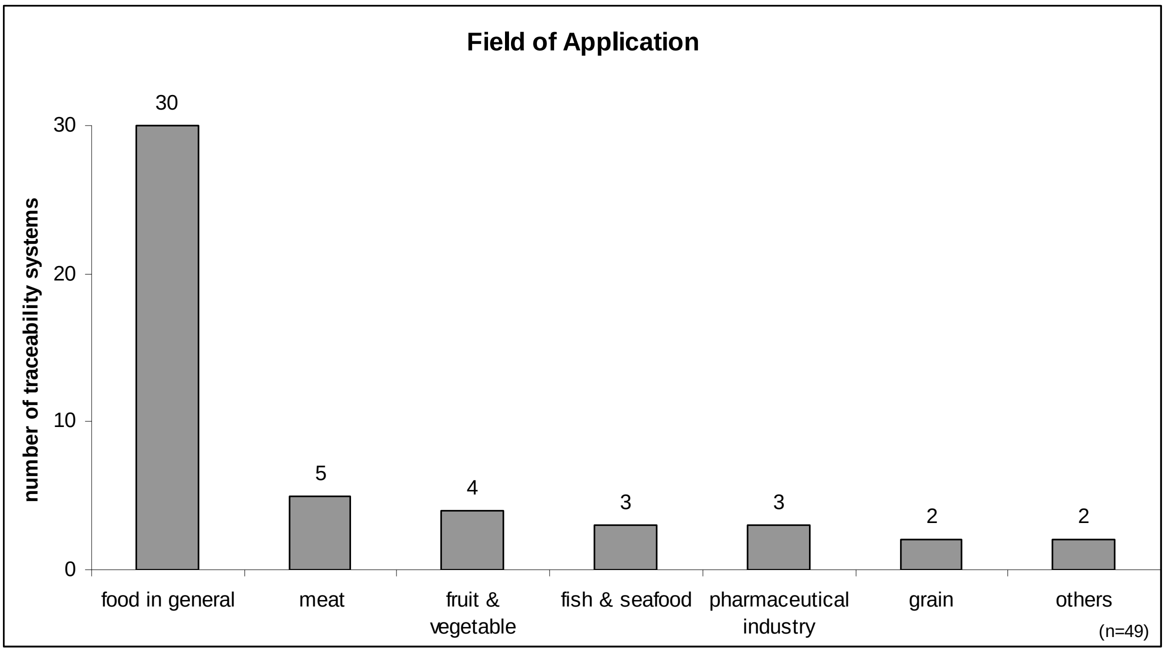

Figure 15: Scope of application of evaluated tracking and tracing solutions.

6.2. IT Standards

Every system provides some kind of data export or import functionality. XML is mentioned as being applied as a data format by seven out of 39 investigated providers (18%). The rest of the providers either do not work with XML or no detailed information could be found.

EPC/GS1 is the most common IT standard among the reviewed providers. It is used by 20 of the 39 selected providers (52%). It is however important to note that EPCglobal standards are layered (see Ref 5) and the identification technology layers can be implemented independently from service layers like EPCIS or ONS. There was no information available as to what degree the providers support these different layers. Considering the fact, that EPCIS is also based on XML, also the use of XML as such may be much higher than in only the 18% of systems mentioned above. Nineteen providers (48%) either do not support EPC/GS1 or give no statement about it.

Several companies also mention use of other IT standards than XML and EPC/GS1. AltaVia from Italy, for example, uses ASCII text files for exchange. SQL is applied for manipulating data and running queries (Pernec from Malaysia, AltaVia from Italy). The German enterprise Axway works with EDI, however it is unclear, if they support any standardized incantation like EDIFACT or if they used the term just to mention the fact that they can interchange data with other systems. TDS and TDT are applied by EPCglobal. Fab4minds from Austria and Kezzler from Norway both mention the use of the Java 2 Enterprise Edition platform as a standard applied, which refers more to a programming language than to an interface.

6.3. Data Management

With regard to data management and storage either a central approach with a single database at the core of the system or a decentralized approach with distributed interconnected databases is possible. Sixteen of the regarded tracking and tracing systems (41%) apply the central data management approach, only four systems (10%) use a decentralized system. However, a large number of enterprises (49%) do not specify their mode of data handling in publications commonly available.

6.4. Quality Standards and Programs

Only fifteen providers explicitly give information about the quality standards and programs their traceability systems are compatible with on their websites. Most of them support multiple standards, for example, HACCP and ISO in combination. HACCP, the EU General Food Law Regulation 178/2002, ISO 9000 and 22.000, BRC, GlobalGAP, and IFS are the most frequently used standards for quality management in the systems evaluated.

6.5. Necessary Investments

Most systems do not require expensive investments. A couple of systems are internet based applications or databases and therefore an internet connection is necessary. Others require the purchase of specific software. The user can either buy this software or rent it for a monthly fee that depends on the amount of transactions. Furthermore, a sign up or license fee to join the systems is quite common. For a few systems special hardware is inevitable. For the use of fab4minds' Bio Stock Manager a special chip card reader is needed. YottaMark's HarvestMark requires an extra label printer. Kezzler does not only sell its own software system but also compatible marking and coding systems. The Tanzanian Traceability-T supplies the necessary software, hardware, and capturing devices for participants. Several companies such as RedLine Solutions offer training courses, like seminars and webinars, to instruct employees in handling the systems.

6.6. Questionnaire Evaluation

The questionnaires provided a more detailed view on certain aspects of systems in place and showed where systems differed and where there were similarities. Although only four questionnaires were returned (from the companies Agron SA, AltaVia Srl, Kezzler AS and TraceAssured), they provided insight into a number of aspects important for the further work of this work package. All systems allowed for web based access. Using HTTP to access data from the outside is an option in all of the systems, so on the protocol level, this may be the common ground to settle on. Encrypting network traffic using SSL and/or TLS is possible, some of the systems even support more sophisticated business-to-business authentication using client certificates alongside the more common server certificates known from SSL-secured websites. Formalized service descriptions like WSDL seem to be used only to a minor degree.

Concerning the IT environment, even with information from only four providers, a broad diversity can be observed. As for operating systems and web server software used, Linux with Apache and Microsoft Windows in combination with Microsoft's Internet Information Server (IIS) were mentioned. Each of the companies that returned their questionnaire implemented their solution in a different programming language (PHP, Java, VB.Net, Perl). Persistent data storage is done using the database systems MySQL, Microsoft SQL Server or PostgreSQL. It is to be expected that this diversity is still even much larger when regarding the whole sector of tracking and tracing system providers. This observed diversity poses certain restrictions on the methods and standards that may be used in a backbone solution. Specifically, only easily portable and system independent technologies should be applied.

For the purpose of identification, the providers supported a variety of schemes and methods. RFID and bar coding were mentioned for tagging, both in standardized (EAN/EPC) and in non-standardized variants.

A striking fact was that none of the providers uses a standardized data dictionary (e. g. for product names) and each of them is laying out their database records to their own semantic view of the sector. The reason may be that the initiatives in the food sector in this area are still relatively young. The lack of a common vocabulary that can be used may turn out as a challenge to integration of different systems in a backbone solution.

6.7. Conclusions

As diverse as the food sector structure is the market of existing tracking and tracing solutions. Web technologies seem to have found their way into systems, but methods used differ. Nevertheless, there are a number of commonalities among systems. Dealing with HTTP-requests and applying textual data formats like XML or similar alternatives for data exchange obviously pose no problem at all to any of the providers who returned questionnaires. On the one hand, GS1 standards are broadly used in the sector, on the other hand however the degree of support varies and providers are reluctant to accept the standard as the one and only solution for several reasons including pricing policy as well as over-engineered service interfaces and incompleteness with regard to the issues and problems of the food sector.

The central database paradigm is widespread in comparison to a distributed storage approach. The centralized approach has a number of advantages in implementation of a tracking and tracing system like e. g. facilitating integrity checks. However, database system interfaces may not map as easily into a networked infrastructure as systems, that by design support a distributed approach.

7. Other Organizational and Technical Issues

7.1. Identification

No tracking and tracing can be setup without unique identification of the objects to be tracked, the so called TRUs. Identification systems, especially when identifiers are to be distributed among a potentially unlimited number of stakeholders and valid globally, require a certain organizational framework to be in place. In the past, in closed systems under the control of a single entity, identifier handling was mostly left to the databases used to implement the system. Sequences setup provided serial numbers and control that there are no duplications was done by uniqueness constraints and checks done by program logic. Such a built-in, mathematically formalized mechanism can not easily be put to work in a distributed manner. However, there are methods and mechanisms in place to allow for management of globally unique identifier assignment. Commonly used

ones involve a hierarchical setup, where from a number of stakeholders each one takes responsibility for a certain value space. Examples for this approach are best known from the internet, e. g. the organization of IP addresses into subnets, within which free assignment is possible or the hierarchical structure of the DNS with top level domains being managed by country-wide organizations and host name assignments that can be done by stakeholders having registered a certain domain name.
One common method used in web services – also for tracking and tracing systems like e. g. EPCIS (Ref 6, page 23) – is the use of URIs not only for addressing the service but also for identifying the objects to be tracked or the stakeholders being involved. There are two subclasses of URIs, the URN and URL. Both of them have different advantages and disadvantages, e. g. the URN being persistent, but non-resolvable while the URL is non-persistent but resolvable. The EPCIS standard allows the use of both of them and mentions mechanisms by which electronic product codes can be represented as URIs. Using resolvable URIs has the advantage, that web data requests are thus directly encoded into the identifier and services like the one mentioned in section 5.7 can be built. By using two-dimensional barcodes, it is even possible to directly encode URLs and thus load data on the tagged object via the internet onto mobile equipment without further user input.
It currently seems that there is a huge potential in these kinds of technologies and there are a number of promising implementations. However, further work is required to find out how these methods may be used in a system-independent tracking and tracing backbone solution.

7.2. Semantic Harmonization

As mentioned in section 6.6, there is currently no standardized or even system-independent data dictionary in use by any of the systems evaluated in depth. However, for efficient data exchange it is necessary to be as clear as possible among the stakeholders involved about the meaning of terms and data items used without going through the hassle of bilateral agreements (which is unfeasible in a global network). This may involve even more than a data dictionary. Formalized semantics in the sense of having the subjects of discourse and their relations defined also in machine readable form are required to facilitate machine-based interpretation of data packets. This work can start out as simple as defining and describing the core tracking and tracing data items identified in section 5.7 and then gradually be extended into the “backpack” of information. Such an undertaking also has the potential of enhancing transparency by providing navigational aids and novel views onto existing data sets and thus increasing the level of understanding of and knowledge on relations and patterns in information.

8. Overall Conclusions and Outlook

An important challenge in drafting the backbone solution specification will be working out how the scalability requirements of the solution resulting from the sector structure can be achieved. Methods and technologies used will have to accommodate on the one hand large amounts of smaller data packages and on the other hand a large number of small stakeholders.
Data from a chain may be used by different stakeholders in different scopes (e. g. organic production only, cold-chain-management only etc.). The demands upon providing the

possibility to allow for different views and for a number of varying analysis methods are high. This has the consequence that not only on the data layer, but also on the service layer, careful consideration has to be given to the reusability of data in different contexts. To achieve this, querying mechanisms have to be generic and flexible.

As has been shown in section 5, it does not suffice to provide tracking and tracing only to achieve transparency in the food sector. A number of other attributes are of increasing interest, not only to allow for quality control but to also be able to market quality products. While these additional attributes initially are not in the scope of the work of providing the tracking and tracing backbone, it is important that the data models used are designed to allow for extensibility without breaking backwards compatibility from the ground up.

Acceptance of an interoperability and networking solution for heterogenous systems also depends to a large degree upon the people having to implement an interface feeling comfortable with it. They will if it comes as close as possible to their own technical environment and fits the tools and methods they use well. On the other hand, to be able to accommodate all potential partners with their diverse information technology background and environment, a number of compromises will have to be made with regard to the methods used. It is a crucial factor for success to find a set of standards and methods that are up to the task but at the same time simple, clear and generic enough to be accepted by everybody. This choice is to a large degree influenced by broad support and good integration into toolsets used by the different companies. The entry barrier may be lowered further by taking care that, where reuse of a number of standards is possible, a set of orthogonal specifications without unnecessary duplication of functionalities is chosen.

Further work includes evaluation of existing and emerging technologies with regard to their usability for the tracking and tracing backbone solution in the face of the requirements laid down above. This work will be carried out as a feasibility study during the next few months. One of the issues will be to clarify the state-of-the art in vocabularies and similar preliminary work that could be used to start out harmonizing semantics between systems. To gain a clearer understanding of processes, a number of example tracking and tracing scenarios involving the special characteristics of the processes themselves and of the food products discussed in section 5 will have to be described and consequences, advantages and disadvantages of applying the technologies and methods evaluated in the feasibility study will have to be analyzed. From the experiences and knowledge gained, the backbone solution proposal specification that may result in a prototypical implementation later on can be put together.

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Campden BRI Magyarország Nonprofit Kft **(CCH)**	Hungary

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Appendix B: Examined System Providers

company/ institution name	product name	country of origin	application areas										
			grain	feed	fruit, vegetable	meat	fish, seafood	food industry	food trade	beverage	food in general	others	status unclear
AgInfoLink Global, Inc.	Beef Link	USA				x				x	x		
	Pony Express					x				x	x		
	Process Verification Program (PVP)					x							
AltaVia srl	Eti.NET	IT	x		x	x	x	x		x		cheese, olive oil, milk	
ARGE-Kaisergetreide	Kaisergetreide	AT	x										
ChainFood BV	ChainPoint	NL	x	x	x	x							
	Q-Tracing		x	x	x	x							
Connected Sources	Industry Compliance Portal (ICP)	F, USA		x							x		
EPCglobal Inc.	EPCglobal-Network	USA											x
fab4minds	Bio Stock Manager	AT	x	(x)	(x)	(x)		x	x			(milk)	
FoodLogiQ LLC	FoodLogiQ	USA	x		x	x					x		
FXAgroup	OpsSmart	TH			x		x					poultry/chicken	
	FarmSmart												
	ProductionSmart												
	TraceSmart												
Historic Futures Ltd.	String	UK									x		
IdentiGEN Ltd.	TraceBack	IE				x							
intact Consult	FlowWeb	AT	x		x				x	x		eggs	
IQMO	IQMO fruit & agro	NL			x						x		
	IQMO Food Industry												
Kezzler AS	Accipio	NO										pharmaceuticals	
	Intentor SSP												
Lyngsoe Systems	Brand protection system	DK								x	x		
	Foodtag										x	poultry	
Matiq AS	IBM InfoSphere Traceability Server,	NO				x						poultry	
	IBM Tivoli Directory												
Muddy Boots	QuickFire	UK									x		
Pernec Corporation Bhd.	HalalSquare	MY										halal products	
	i-Harvest						x					tea, rubber, oil palm,	
												coffee, flower, cotton	
proQuantis Ltd & Co.KG	QM-G	DE	x	x	x							potato, sugar	
QualiTrack Ltd.	QualiTrack	ZA			x								
RedLine Solutions Inc.	RedLine field, RedLine Packing,	USA									x		
	RedLine Cooler												
rfXcel Corporation	diverse	USA								x	x	pharmaceuticals	
Savi Technology Inc.	SmartChain, SaviTrak	USA										x	
Setrabio	Tracerbio	FR	x										x
StMLF	HI-Tier Datenbank	DE				x							
SupplyScape	Production Tracking, Product Tracking	USA								x	x	lifesciences	
SupplyScape	TraceLink Predictable Supply Suite	USA								x	x	lifesciences	
Department of Fisheries	ThaiTraceShrimp	TH					x						x
Traceability-T	diverse	TZ				x						honey, coffee	
Traceall	Traceall	UK					x			x	x		
TraceAssured	TraceAssured	UK									x		
TraceGains	CaseTrace PTI	USA									x		
Trace One	Trace One	FR						x	x				
Trace Register	Trace Register System	USA					x				x		
TraceTracker	GTNet	NO	x	x	x	x	x						
Tracewise	you.trace.it	BE									x		
Transparent Goods	COS	DE	x		x				x	x	x		x
Winckel	web4trace	DE			x								
YottaMark	HarvestMark	USA									x		

Appendix C: Questionnaire to the system providers

Design and Architecture

- If your system is able to handle multiple stakeholders in a supply chain: Do you use a central database to capture all the information or do you use a decentralized approach with multiple databases for each partner?
- If you use a central database:
  Please describe shortly how the data from multiple partners gets into the system.
- If your system is currently mainly a single entity/internal traceability system: How does your system communicate down-chain and up-chain?

Communication

- Apart from chain participants, are there other stakeholders that may get access to your system? If yes, can you describe shortly, how that works?
- Do you have any internet reachable interfaces in your system?
- Which low level internet protocols (e. g. HTTP, SMTP, FTP…) do you use in these interfaces?
- Do you use any higher level protocols (e. g. web services based)? If yes, which ones?

Access control, authentication and data security

- Do you use any standardized Authentication protocols (e. g. SSL client certificates, Kerberos etc.)? If yes, which ones?
- Do you use any standardized directory services (e. g. LDAP, Active Directory etc.) for storing authentication information? If yes, which ones?
- Does your system support role/group based access? If yes, can you shortly enumerate and describe the different roles/user groups you have?
- Do you encrypt communication? If yes, do you use any standardized encryption technologies (e. g. SSL, PGP etc.)?

Syntax

- Which Syntaxes or Formats (e. g. XML, EDIFACT, CSV…) do you use in data exchange?

Identification

- How do you identify your tracing units physically (i. e. on the unit itself)? Do you use standardized identification technology? If yes, which ones?
- How do you identify your tracing units in the IT system? Do you use standardized identification systems? If yes, which ones?

Semantics

- Do you use any standardized data dictionaries, controlled vocabularies, thesauri or ontologies in your system?
- If yes, which ones?

Data content

- Can you shortly describe the most important data items which can be imported/exported through internet reachable interfaces?

Environment

- Please describe shortly the IT environment your system or system components commonly operate in (e. g. programming languages used, operating system requirements, data base requirements (if any) etc.).

Standards

- Apart from standards already mentioned in one of the questions above, are there other standards of which you think that they may be of relevance for tracking and tracing systems?
- Apart from standards already mentioned in one of the questions above, which other ones do you support in your IT system?
- If you would have to give a classification of standards used in IT-enabled tracking and tracing and quality assurance systems, how would you do that? Which classes would you consider?