Contract No. IST 2005-034891

Hydra

Networked Embedded System middleware for Heterogeneous physical devices in a distributed architecture

D2.1c Scenarios for usage of Hydra in Agriculture

Integrated Project
SO 2.5.3 Embedded systems

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1. Introduction

The Hydra project develops middleware for networked embedded systems that allows developers to create ambient intelligence applications. System developers are thus provided with tools for easily and securely integrating heterogeneous physical devices into interoperable distributed systems.

The middleware will include support for distributed as well as centralised architectures, cognition and context awareness, security and trust and will be deployable on both new and existing networks of distributed wireless and wired devices that typically are resource constrained in terms of computing power, energy and memory. Hydra middleware will be based on a Service Oriented Architecture (SOA), to which the underlying communication layer is transparent.

Creating scenarios of end-user behaviour and interaction with platform functionality is an extremely useful instrument for identifying key technological, security, socio-economic and business drivers for future end-user requirements. The scenarios will provide the framework for subsequent iterative requirement engineering phase.

From the scenarios and storylines, a systematic formalisation of all relevant user requirements and subsystem functional, security and societal requirements will be derived. Functional user requirements specifications will involve the most important aspects of user expectations in the chosen application domains.

This document describes the work performed with the aim of establishing a set of plausible usage scenarios on 2015 involving the typical use of Hydra in the Agriculture domain.

2. Executive summary

Creating scenarios of end-user behaviour and interaction with platform functionality is an extremely useful instrument for identifying key technological, security, socio-economic and business drivers for future end-user requirements. The scenarios will provide the framework for subsequent iterative requirement engineering phase.

A series of one-day user workshops for each user domain have been organised to bring together appropriate expertise and experience. The activities carried out include identification of uncertainties, grouping and segmenting and flip/flopping (grouping in main directions). At the end of each workshop, scenes, acts and scripts for the scenarios have been defined. The results of these activities have been documented in a set of scenarios for each domain.

2.1 Scenario Thinking – The IDON method

Scenarios are snapshots of possible/alternative futures that help us plumb that uncertainty. Scenarios provide coherent, comprehensive, internally consistent descriptions of plausible futures built on the imagined interaction of key trends. The purpose of Scenario Thinking is to challenge the preconceived notions people have of the future, or their maps, and to afford people the flexibility to change those maps. The IDON method consists of two parts: *Scenario Development* and *Scenario Deployment*.

The scenarios are developed in the *Scenario Development* part using experts and based on knowledge and systematic analysis. The aim is to develop four mind-challenging scenarios for each user domain by mixing inevitable trends with creative fiction.

In the *Scenario Deployment* part, technical experts and project decision makers interpret the scenarios and extract a framework for the functional and trust and security requirement specifications.

The core of the IDON technique is to examine a set of wider environmental factors ambiguities and uncertainties in order to resolve, which role they are likely to play in the unfolding of scenarios. The initial phase of the IDON method involves three steps: Gathering environmental factors grouping them according to their degree of uncertainty and deciding their relative position.

The next phase in IDON deals only with the factors with high uncertainty and direct impact on future trends. The uncertain factors are reformulated as "either / or" questions (flip/flop) and grouped according to connections and associations. Finally they are combined into four distinct possible futures extrapolated from the thinking done by the group.

The outcome of this Scenario Thinking process is 12 equally plausible scenarios for the future use of Hydra middleware in 2015 in three different user domains: Building Automation, healthcare and agriculture.

2.2 The Agriculture scenarios

Four scenarios have been developed to illustrate distinctively different aspects of future user behaviour in the agriculture domain. The scenarios have been made in response to the question:

How do we develop and deploy intelligent, ubiquitous and secure networked products and services in agriculture and the food industry in 2015?

We have created the four scenarios from two clusters: "Farming Methods" (traditional or high-tech) and "Consumerism" (conscious or indifferent comsumers). The possible combinations are the following:

1. Hi-tech farming + The indifferent consumer *(The Piggy Bank)*
2. Hi-tech farming + The conscious consumer *(From Farm to Fork)*
3. Traditional farming + The conscious consumer *(Ye Ole Barn!)*

4. Traditional farming + The indifferent consumer *(There is no hurry!)*

The scenes are typical agricultural situations around 2015. The market is influenced by consumers with high buying power, and an increasing share of the disposable income is allocated to foodstuff and other agricultural items. The information flow to consumers is extremely high and is cluttered with all sorts of commercial and informational messages causing frequent problems of information overflow leading governments to take an active role in defining what kind of information is relevant and must be made available to the public. The purpose is also to make sure that consumers have as much information as possible about potential risks and what is being done to minimise them.

Agricultural production continues to raise general public and governmental concern about the environment and the use of natural resources. In particular the fear of eco-toxicity and the depletion of scarce resources such as water, leads to increasing focus on sustainable agricultural production, recycling of agricultural waste as well as limits on agricultural production to protect the environment in particularly vulnerable areas. This leads to a further globalisation of agricultural production and the need for increased transportation.

The developer user is being presented with a series of requirements defined by regulators, farmers, food processors, distributors and/or consumers. The sheer amount of actors with different perspectives and different objectives makes it very difficult for the developers of infrastructure components and applications to provide real cost/benefit to more than one end-user at the time.

Further, the clock speed of some of the system is very long compared to "standard ICT systems". Farmers are not likely to scrap well functioning equipment just because a new version is being put on the market. The developer user is thus faced with the task of creating new or improved embedded systems and applications, which has to be based on the capabilities of existing devices.

3. The Agriculture domain

3.1 Background of the Agriculture domain

The advent of the PC in the late '70s led to a proliferation of systems with promises of simplified accounting, paperless offices, automated process control and even systems that could think. Much of this promise has not been delivered. Developments in the UK for example typify these ICT expectations - where in 1984 there were sixty three companies claiming to provide specialist agricultural software to farmers and growers. Even IBM decided to move into the apparently huge market of 100,000 British farmers. Most of those companies soon realised that there were no fast bucks to be made and numbers fell back quite quickly to four or five specialist operators. However, the UK was different than the rest of Europe in that much of our development was through commercial software houses whereas most other countries relied more heavily on the education and research sector to provide software and systems. Farmers in mainland Europe seem thus to be more willing to try new systems and embrace new technologies like decision support tools[1].

In the past 10 years, the use of innovative ICT technologies has seen a rapid increase throughout mainstream Europe in almost every area of agricultural production and distribution.

Farm Management Information Systems allows for elaborate farm planning, easy tracking of performance, e.g. dairy cow programs providing analysis of individual animal performance data. One of the biggest drivers to use of farming Management Information Systems has been the increasing emphasis on recording for statutory purposes, quality assurance and traceability.

The use of the Internet to deliver information is still in its infancy in farming, but there is now clear evidence that most benefits come from frequently updated, rapidly changing information on prices, market reports and the weather. Farmers do not want unsolicited material pushed at them but emerging decision support tools can be used to more intelligent present this type of information.

Using Geographic Information Systems to identify the position of any farm machine to a resolution of a few metres anywhere on the planet has intriguing potential but vision has in some respect moved ahead of reality. There is undoubtedly scope to adjust inputs either to take account of existing levels of say phosphate or potash or to modify nitrogen or spray regimes to reflect the yield potential. The problem is that many of the yield variations within a field are far from repeatable year on year because there are complex interactions between a host of variables like soil type, aspect, temperature, disease pressure, variety and sowing date. This means that the original predictions of being able to control automatically, the application of inputs using yield map data and clever agronomic software are some way off at present.

Using computer systems to assimilate information and provide advice is perhaps the most exciting opportunity for the future use of ICT. The computer models can incorporate knowledge and expertise from many different specialists and can sift and apply a huge range of relevant information to arrive at suggested courses of action. Typical applications to date have included pest management in grain stores, arable crop disease control and grass seed mixture formulation.

The fundamental issue with ICT adoption in agriculture – as in most other industries as well – is the lack of real and perceived benefit to the user, i.e. the effort required to use a piece of hardware and/or software must be less than the benefit derived from its adoption. So we need to get better and devising systems which deliver real value to those whom we expect to use them – value they can understand in their terms.

This chapter provide a brief introduction to some of the regulatory demands on the agricultural sector followed by a short overview of the adoption of selected ICT solutions into an industry, which ranges from small, part time business to large agri-businesses. The purpose of this is to give a framework for understanding the scenario process, its discussion and its outcome.

[1] E. Gelb, A. Offer: ICT in Agriculture: Perspectives of Technological Innovation. ADAS Woodthorne, 2006

3.1.1 European Union policies on safe food

The concern of the European Union is to make sure that the food we eat is of the same high standard for all its citizens, whether the food is home-grown or comes from another country, inside or outside the EU[2].

EU food policies have undergone a major overhaul in the last couple of years as a response to headline-hitting food safety scares in the 1990s about such things as 'mad cow' disease, dioxin-contaminated feed and adulterated olive oil. The purpose was not just to make sure that EU food safety laws are up to date but also that consumers have as much information as possible about potential risks and what is being done to minimise them. The EU does its utmost, through a comprehensive food safety strategy, to keep risks to a minimum with the help of modern food and hygiene standards drawn up to reflect the most advanced scientific knowledge. Food safety starts on the farm. The rules apply from farm to fork, whether our food is produced in the EU or is imported from elsewhere in the world.

There are four important elements to the EU's food safety strategy:

- rules on the safety of food and animal feed;
- independent and publicly available scientific advice;
- action to enforce the rules and control the processes;
- recognition of the consumer's right to make choices based on complete information about where food has come from and what it contains.

The result was a new piece of 'umbrella' legislation known as the General Food Law. This law not only set out the principles applying to food safety. It also introduced the concept of 'traceability'. In other words, food and feed businesses – whether they are producers, processors or importers – must make sure that all foodstuffs, animal feed and feed ingredients can be traced right through the food chain, from farm to fork. Each business must be able to identify its supplier and which businesses it supplied. This is known as the 'onestep- backward, one-step-forward' approach.

It is a further principle underlying EU policy that animals should not be subjected to avoidable pain or suffering. Research shows that farm animals are healthier, and produce better food, if they are well treated and able to behave naturally. Physical stress (e.g. from being kept, transported or slaughtered in poor conditions) can adversely affect not only the health of the animal but also the quality of meat. Increasing numbers of European consumers are concerned about the welfare of the animals that provide them with their meat, eggs and dairy products. This is reflected in clear rules on the conditions in which hens, pigs and calves may be reared and in which farm animals can be transported and killed.

3.1.2 Farm Management Information Systems

Many examples of Management Information Systems applications are available on the market: Animal and herd registration, milk recording, quota management, milk analysis, fertility analysis, bull selection, grass measurement and budgeting, nutrient management, maps, tracking of inputs and outputs, numerous accounting applications, farm enterprise analysis, etc., etc.

Software relating to all these topics and many other farming systems is widely available. The big question is then: Why don't more farmers adopt ICT on the farm? To alleviate this dilemma, much more coordination is required between equipment manufacturers, agribusiness and the professionals serving the farmer to achieve an integrated and harmonious approach.

The farmer is under siege from so much interesting and generally useful information that it is difficult for him to utilise it in a way that will benefit him in practical terms. It will have to become more targeted, more personal. What really interests him most is his own data: *my* herd data, *my* calf registration, *my* soil sample, *my* payments! This is where the producers and holders of farmer

[2] European Commission, From Farm to Fork - Safe food for Europe's consumers, European Commission, July 2004

information in electronic format can accelerate the process of farmer involvement in terms of building relationships to benefit both the farmer and the outside actors[3].

A large incentive at farm level could come from the e-government agencies accepting electronic data input for the various schemes and regulations they operate, benefiting both farmers and public bodies in terms of speed of data submission, accuracy and speed of payments. Since data collection and data input is a demanding and intimidating task for the farmer, the capability of co-operatives and other agribusiness organisations to download the farmer's own data on to his machine for automatic input to a particular program for analysis should help drive the uptake of ICT at farm level. But there is a serious problem facing users of advanced ICT networked systems. Exposure to the internet runs the high risk of abuse and of invasion of privacy from an incredible range of menaces and threats. Solutions to this increasingly important dimension must be factored into the services being offered to farm users.

3.1.3 Traceability

Traceability along the food supply chain is basically the combination of two processes: intra-enterprise traceability and inter-enterprise traceability[4]. If enterprises working in the same sector adopt different ways to describe the input, the production processes, and the output, it will not be possible to communicate information either to providers or to consumers.

Consequently, it is necessary to focus on the adoption of common data references at enterprise level (the farm), to describe e.g. crop protection chemicals, implements, interventions, analysis (soil, milk, etc.) in a consistent way. As traceability at intra-enterprise level is becoming established, traceability at inter-enterprise level may be seen as totally linked to logistics that makes it necessary to have a precise identification of all products. As far as information about these products is concerned, three options are most often considered:

- The first type is information of a proprietary nature. It remains at the enterprise level, and will be published only when a problem occurs. This is the basis of most available traceability systems today.
- The second type of information is freely transmitted along the chain e.g. to guarantee the food quality. In this case, the role of the Internet for low-cost information exchanges is increasing.
- The third type of information is managed by neutral third parties, which develop proprietary multilingual and multi-actor information exchange platforms, where producers and distributors can publish the history of the products that they produce and distribute. The success of such platforms remains questionable today and will depend on the attitude of the main distribution networks.

A first choice has to be made between PC based solutions and / or Internet solutions. PC based solutions are almost exclusively marketed by well-established agricultural ICT companies whereas Internet based solutions are offered both by "newcomers" and well established ICT companies.

Care should be taken when implementing solutions of traceability at the farm level. Farmers own expectations should taking into account in order to avoid that the traceability is weak or even wrong. It has also to be kept in mind, that most farmers are not very used to ICT technologies and sometimes act reluctantly with implementation if new systems.

Efficient solutions need to be based on a free choice of technical implementation combined with information feed back: e.g. the evaluation by farmers of their own technical performances compared with those of other farmers.

[3] Stephen B. Harsh: Management Information Systems, Department of Agricultural Economics, Michigan State University, 2005
[4] Guy Waksman: The situation of ICT in the French agriculture, Proceedings of the EFITA 2003 Conference, 5-9, July 2003, Debrecen, Hungary.

3.1.4 Dairy farming

Dairy farming systems probably are the most complex of the agricultural production systems. In most other systems, involving plants and beef cattle, inputs and outputs occur a few times per year and they relate to one or two products. In contrast, the dairy system is one in which inputs and outputs are continuous: e.g. milk, births, deaths, sales or purchases of animals, feed and labour costs. The outputs of the dairy system are varied, milk, meat and surplus animals. They are the outputs of individual cows, the cost of which makes them individual production units that vary in performance. Maximizing revenue requires continuous decision making at both individual cows and herd levels, which can only be properly carried out on the basis of data evaluation, if one excludes situations in which freedom of choice is limited. This system internalized a wide range of sophisticated hardware and software, which required a large investment. The presence of such investments indicates that response to information flow is greater in the dairy farming system than in other components of the agricultural sector. This is true however only for certain categories of dairy systems and of hardware or software.

3.1.5 Precision Farming and Mapping

Precision Agriculture or site-specific crop management can be defined as the management of spatial and temporal variability at a sub-field level to improve economic returns and reduce environmental impact with the main activities being data collection and processing and variable rate applications of inputs. The tools available consist of a wide range of techniques and technologies from information and communication technology as well as sensor and application technologies, farm management and economics.

The most common Precision Agriculture applications consist of software to generate maps (e.g. yield, soil); to filtering collected data; to generate variable rate applications maps (e.g. for fertilizer, lime, chemicals); to overlay different maps; and to provide advanced geostatistical features. The machinery companies that provide yield meters also offer software to generate yield maps and fertilizer companies provide software to generate variable rate applications maps. Some of the packages are very complicated for farmers to use and are fairly expensive, while others are considerably simpler and cheaper with fewer options.

A study shows[5] that the practitioners of Precision Agriculture tend to belong to a younger generation and they cultivate larger areas than the average farmer. The average age of the Danish respondents was 43 years old and 46 for the American respondents (Fountas, et al, 2004). In Denmark, the average age of farmers in 2000 was 52 years old (Danish Agricultural Council, 2000) and in the USA in 2002 was 55.3 (USDA, 2002). Another particular aspect is that farmers are very reluctant in entrusting the data storage and data protection to entities outside the farm. 81 % of the Danish and 78% of the US Corn Belt farmers indicated that they would prefer to store the data themselves, while 88% of the American respondents would prefer not to store the data in a shared Internet-based database (Fountas et al., 2004).

3.2 Organization of workshops

The planning of the workshop took place at a meeting on 10 August 2006 at C-LAB in Paderborn, Germany. At the meeting, the major features of the workshop were decided, the roles were distributed and the participants in the workshop identified. It was decided to conduct the workshops under the label of "agriculture", and to invite at lease one expert from each of the following areas, in order to have a wide spread in expertise and experience:

[5] Spyros Fountas, Søren Marcus Pedersen, Simon Blackmore: ICT in Precision Agriculture – diffusion of technology, ICT in Agriculture: Perspectives of Technological Innovation. ADAS Woodthorne, 2006

Pervasive agricultural expert	Agricultural academics
Pesticide Manufacturer	Food technology expert
Cooperatives	Agricultural manufacturers

The scenarios were developed through a one-day workshop held at INNOVA in Rome, Italy on 17 November 2006.

Moderator of the workshop was Jesper Thestrup (IN-JET). Supporting roles were assigned to Christine Ludwig (C-LAB), Trine F. Sørensen (IN-JET), Tommaso Foglia (INNOVA) and Francesco Niglia (INNOVA).

The users participating in the workshop came from various parts of Europe and were selected because of their personal expertise and their reputation. The participants were:

1. Dr. vet. Jens Yde Blom – Biosens, Denmark (Lifestock/agricultural manufacturing consultant)
2. Prof. Marco Bravi – University of Rome, Italy (Food technology expert)
3. Prof. Pasquale Ferranti – University of Napoli, Italy (Agro-food academics)
4. Dr. Tiziana Granato - University of Napoli, Italy (Agro-food academics)
5. Mr. Ole Kristensen, Danish Agro Business Park, Denmark (Livestock agro-manufacturer)
6. Dr. Gianfrance Mamone – University of Avellino, Italy (Agro-food academics)
7. Dr. Riccardo Mesiano – Agriconsulting s.r.l., Italy (Agriculture consulting)
8. Mr. Steckel – Claas (Agricultural machinery manufacturer). *Cancelled*
9. Ms. Catalina Valencia Peroni – Labor s.r.l., Italy (Chemistry applied to the agro-food sector)
10. Dr. Michele Wegner – Architect, Italy (Sustainable development expert)

Participants from pesticide manufacturers and cooperatives were not available.

3.3 Selection of application area and time horizon

Both livestock and non-livestock agricultural production was discussed, which included feed for livestock. The time horizon was set for year 2015, which participants felt was suitable when discussing future trends and developments in the agricultural domain. This also means that by the end of the Hydra project in 2010, there is plenty of time to deploy the platform and develop the business cases to roll out in time for the scenarios in 2015.

3.4 Trigger question

The "Trigger question" for identification and grouping of environmental factors is:

> How do we develop and deploy intelligent, ubiquitous and secure networked products and services in agriculture and the food industry in 2015?

3.5 Identification of environmental factors

Factors were identified from among all the possible environments that would influence agriculture and food products and applications in 2015:

- Technology trends
- Market trends
- Economic futures
- Social values and life-styles
- Ethical and value questions
- Products, production and logistic systems
- Ecological and environmental issues
- Global political influences

In the following, we present the results of the brainstorming discussion, summarise the items of both certainty and uncertainty identified by the experts as well as the subsequent analysis and clustering performed by the consortium.

The workshop participants defined a total of 54 factors in all areas:

Technology trends (T)
Unawareness of hi-tech solutions
Small farms have technological limits
Interoperability
Automated farming management systems
Human experience modelled in IT systems
Intelligent systems
Information verification rules
Information systems
Smart devices
Tissue sampling
Biometric modelling
Information collection
Identification of relevant information
Information overflow
Data extraction
Scalability

Market trends (M)
Diverse food products
Local food products
History of foodstuffs
Continuous information to consumers
Authentication of products
Food labelling

Economic futures (€)
Sustainability
Increased buying power

Social values and life-styles (L)
Distrust in foreign food products
Consumer trust
Adaptability to intelligent systems
Traceability
Increased awareness
IT attitude

Ethical and value questions (V)
Global-minded public
Genetic modification
Food risks and hazards

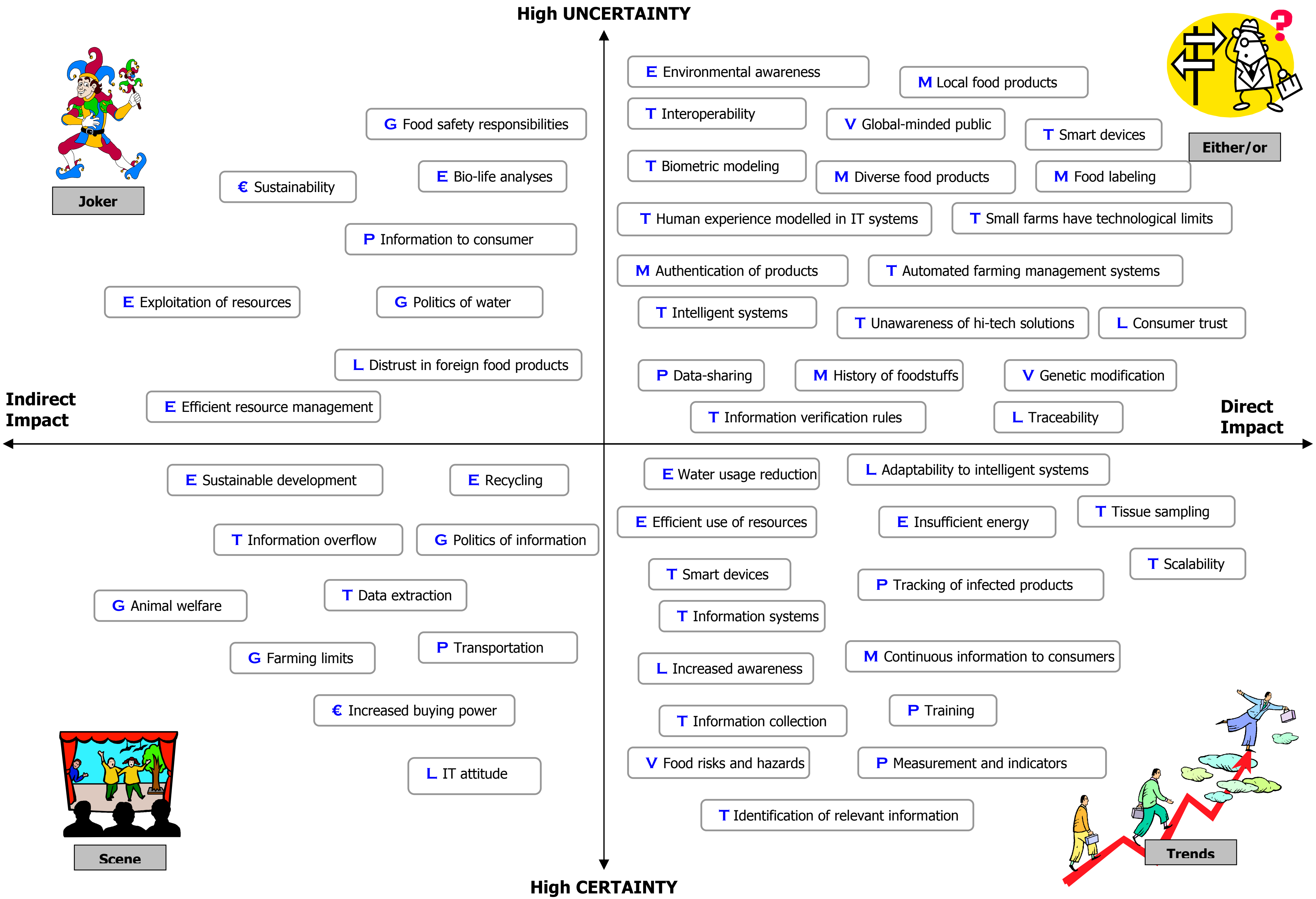
Products, production and logistic systems (P)
Information to consumer
Data-sharing
Training
Tracking of infected products
Measurements and indicators
Transportation

Ecological and environmental issues (E)
Exploitation of resources
Bio-life analyses
Environmental awareness
Efficient resource management
Efficient use of resources
Water usage reduction
Insufficient energy
Sustainable development
Recycling

Global political influences (G)
Food safety responsibilities
Politics of water
Politics of information
Animal welfare
Farming limits

A further explanation of each factor is found in Appendix A.

The environmental factors were then group according to the certainty and impact criteria, which yielded the following matrix:


High UNCERTAINTY
High CERTAINTY
Indirect Impact
Direct Impact
Joker
Either/or
Scene
Trends
G Food safety responsibilities
€ Sustainability
E Bio-life analyses
P Information to consumer
E Exploitation of resources
G Politics of water
L Distrust in foreign food products
E Efficient resource management
E Environmental awareness
M Local food products
T Interoperability
V Global-minded public
T Smart devices
T Biometric modeling
M Diverse food products
M Food labeling
T Human experience modelled in IT systems
T Small farms have technological limits
M Authentication of products
T Automated farming management systems
T Intelligent systems
T Unawareness of hi-tech solutions
L Consumer trust
P Data-sharing
M History of foodstuffs
V Genetic modification
T Information verification rules
L Traceability
E Sustainable development
E Recycling
T Information overflow
G Politics of information
G Animal welfare
T Data extraction
G Farming limits
P Transportation
€ Increased buying power
L IT attitude
E Water usage reduction
L Adaptability to intelligent systems
E Efficient use of resources
E Insufficient energy
T Tissue sampling
T Smart devices
T Scalability
P Tracking of infected products
T Information systems
M Continuous information to consumers
L Increased awareness
P Training
T Information collection
V Food risks and hazards
P Measurement and indicators
T Identification of relevant information

3.6 Flip-flopping the pivotal uncertainties

Looking at the factors in the "Either / Or" quadrant marked we now turn to grouping them in clusters. Each of the clusters will form different scripts in our scenarios.

We now think of each of the uncertainties as a question, for which there are two possible outcomes: The "flip" (+) and the "flop" (-) outcome. When the factor in question has either "flipped" or "flopped", the uncertainty is resolved.

The following table presents all the uncertainties in the Either/Or quadrant and the related flip-flow questions.

Interoperability Standardisation of devices allow them to interoperate	+	Standardisation is widespread and devices are fully interoperable
	-	Devices cannot interoperate due to lack of standardisation and protocols
Local food products What is consumers' attitude towards local food products?	+	Consumers demand predominantly local or regional food products
	-	Consumers are not concerned with the geographical origin of food products
Environmental awareness Do environmental concern among the public have any influence on agricultural production?	+	Global and local environmental issues related to agricultural production are subject to heightened public awareness and concern
	-	Environmental issues and agriculture's affect on the global and local environment do not cause interest or concern with the public
Genetic modification Is genetic modification a controversial issue?	+	Genetic modifications are acceptable to consumers as a mean to improve foodstuff's quality
	-	Consumers are scared of genetic modifications in foodstuffs and seriously questions its purpose
Human experience modelled in IT systems Can human experience be modelled in IT embedded systems?	+	Embedded systems are so advanced that they can model the human experience
	-	Embedded systems have not developed sufficiently to be able to learn from human experience
Diverse food products What kind of food products will be available to consumers?	+	The suppliers can meet consumers' demand for a wide range of different food products
	-	Consumers are used to a very small selection of different food products
Information verification rules With all the information available will there be a system in place that can distinguish between fake/wrong and real/true information?	+	Systems can dynamically index information and verify its relevancy and authenticity
	-	With so much information available there is no way to distinguish between false and true information
Authentication of products Can we avoid unsafe food product through a system of authentication?	+	Authentication of agricultural products is used as a measurement to avoid unsafe food products
	-	There is no real system in place to authenticate food products before they enter the market
Global minded public Do consumers place issues concerning agricultural production in a global context?	+	Consumers' perceptions and attitudes towards agricultural production are firmly grounded within a global context
	-	Consumers are only concerned with how agricultural production affects the local environment
Unawareness of hi-tech solutions Are farmers up-to-date on hi-tech solutions for their agriculture production?	+	Farmers are actively engaged in finding and employing hi-tech solutions to improve production
	-	Hi-tech solutions for agricultural production do not have high priority with farmers

Small farms have technological limits Are ICT solutions available and suitable for all types of farms?	+	It is possible to customise ICT solutions to the needs of each specific farm regardless of size
	-	ICT solutions for agriculture is developed for large farms only
Automated farming management systems Are farmers using automated farming management systems?	+	Farmers will increasing adopt automated farming management systems
	-	Farmers tends to revert to traditional farming techniques
Data-sharing How will farmers react to increased data-sharing?	+	Farmers see clear advantages of sharing their farming data with others in the pursue of optimising production and end-products
	-	Farmers feel very protective of their farming data and are not convinced of the advantages of sharing data with others
History of foodstuffs Will access to the history of foodstuff become a priority for consumers?	+	Consumers will increasing choose to buy those foodstuffs where they have full access to its history
	-	Consumers are not concerned about knowing the history of the foodstuffs they buy
Consumer trust What is consumers' attitude towards the issue of food quality?	+	Improved quality control of food production enabled by new ICT solutions increases the consumers trust in food products
	-	Consumers are sceptical of foodstuffs' quality because there are no clear and easy way for them to get information on the quality control in place
Traceability Will traceability of foodstuffs be prioritised?	+	Systems for tracing foodstuffs from farm to fork will be widespread
	-	It is technically not possible, nor a priority, that foodstuffs can be traced
Smart devices What will characterise the future availability of smart devices?	+	Widespread availability of smart devices
	-	There are only few smart devices available
Biometric modelling Will it be possible to use biometric modelling of physiological data to predict outbreak of diseases in animals?	+	Early prediction if diseases in animals is possible using a wide range of available biometric models
	-	Few biometric models limits the usability of predicative systems for even common diseases
Food labelling Will there be a demand of food labelling?	+	Consumers demand clear and understandable labelling of all foodstuffs
	-	Consumers do not see the need or purpose of food labelling
Intelligent systems Will intelligent systems in agricultural production be available and used?	+	Intelligent systems are extensively in use in automated agricultural production
	-	Intelligence and availability of intelligent systems for automating agricultural production is low

3.7 Clustering the uncertainties

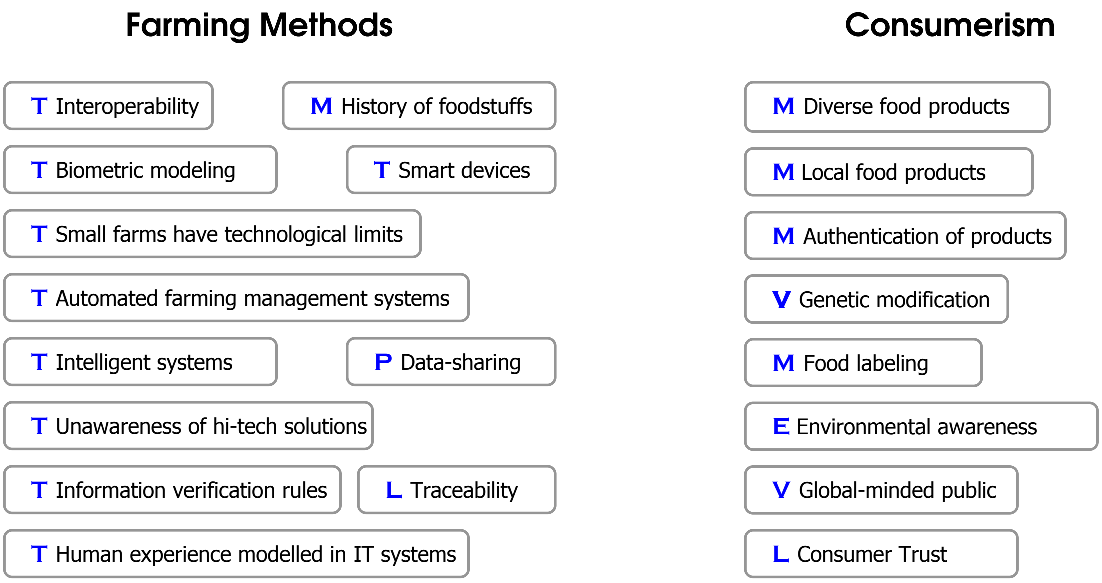
We will now group the pivotal uncertainties in two groups by searching for connections and associations between the various uncertainties.

When inspecting all 20 uncertainties it becomes obvious that they can be separated into two distinct groups. The first group of uncertainties is related to the methods used in agricultural production and as such describes what methods and technologies are used in the production. The agricultural production technologies can thus be either dominated by modern ICT applications and technologies or by traditional and few, or none, modern ICT applications. This is dependent on the agricultural producer's (farmer's) attitude as well as existing technological limits and innovations.

The clustering of these uncertainties has been named **"Farming Methods"** as shown in the figure below. Within the cluster, uncertainties tend to counter align in flip-flop questions so that if one flips, the other will flop (e.g. ICT-prone or traditional-prone farming methods).

The second group of uncertainties is related to the products themselves and the market situation, which obviously includes the consumers. This group is connected to issues of product history and quality as well as consumer expectations and demands, and as such also correlate to market push and market pull factors. These uncertainties relate to both local and global markets.

The uncertainties in this cluster also tend to align in flip-flop questions, i.e. they will all flip or all flop simultaneously, like a domino effect. This cluster has been named **"Consumerism"**.



3.8 Naming the sub plots

Having identified all the flip-flop questions and grouped the uncertainties in two clusters, we are now ready to perform the last step before scenario write-up, i.e. naming the different subplots that will define the scripts.

In the clusters we now deploy the flip-flop questions from above. We analyse and group the responses thus resolving the entire cluster as a large-scale flip or a large-scale flop. We do this for each cluster at the time.

In the **Farming Methods** cluster we arrive at the following large-scale flips and flops:

Big Flip Cluster "Farming Methods"	**Big Flop Cluster "Farming Methods"**
• Standardisation is widespread and devices are fully interoperable • Embedded systems are so advanced that they can model the human experience • Systems can dynamically index information and verify its relevancy and authenticity • Authentication of agricultural products is used as a measurement to avoid unsafe food products • Farmers are actively engaged in finding and employing hi-tech solutions to improve production • It is possible to customise ICT solutions to the needs of each specific farm regardless of size • Farmers will increasing adopt automated farming management systems • Farmers see clear advantages of sharing their farming data with others in the pursue of optimising production and end-products • Systems for tracing foodstuffs from farm to fork will be widespread • Widespread availability of smart devices • Early prediction if diseases in animals is possible using a wide range of available biometric models • Intelligent systems are extensively in use in automated agricultural production *which leads to the name:* **HI-TECH FARMING**	• Devices cannot interoperate due to lack of standardisation and protocols • Embedded systems have not developed sufficiently to be able to learn from human experience • With so much information available there is no way to distinguish between false and true information • There is no real system in place to authenticate food products before they enter the market • Hi-tech solutions for agricultural production do not have high priority with farmers • ICT solutions for agriculture is developed for large farms only • Farmers tends to revert to traditional farming techniques • Farmers feel very protective of their farming data and are not convinced of the advantages of sharing data with others • It is technically not possible, nor a priority, that foodstuffs can be traced • There are only few smart devices available • Few biometric models limits the usability of predicative systems for even common diseases • Intelligence and availability of intelligent systems for automating agricultural production is low *which leads to the name:* **TRADITIONAL FARMING**

The "big-flip" of the **Farming Method** cluster describes agricultural production processes that are dominated by innovative hi-tech applications and solutions and where producers are active in applying ICTs to optimise and improve production procedures. Combined with many of the environmental factors with high certainty, it points towards a *hi-tech farming* scenario.

The "big-flop" situation is similarly dominated by scenarios where the issue hi-tech applications and solutions for agriculture influence how the production process is structured, but in this case it is the absence of hi-tech applications and solutions that dominate the production process. The scenario here is best characterised as an example of *traditional farming*.

In a similar way we can group the **Consumerism** cluster:

Big Flip Cluster "Consumerism"	**Big Flop Cluster "Consumerism"**
• Consumers demand predominantly local or regional food products • Global and local environmental issues related to agricultural production are subject to heightened public awareness and concern • Genetic modifications are acceptable to consumers as a mean to improve foodstuff's quality • The suppliers can meet consumers' demand for a wide range of different food products • Consumers' perceptions and attitudes towards agricultural production are firmly grounded within a global context • Consumers will increasingly buy foodstuffs where they have full access to its history • Improved quality control of food production enabled by new ICT solutions increases the consumers trust in food products • Consumers demand efficient labelling of all foodstuffs *which leads to the name:* **THE CONSCIOUS CONSUMER**	• Consumers are not concerned with the geographical origin of food products • Environmental issues and agriculture's affect on the global and local environment do not cause interest or concern with the public • Consumers are scared of genetic modifications in foodstuffs and seriously questions its purpose • Consumers are used to a very small selection of different food products • Consumers are only concerned with how agricultural production affects the local environment • Consumers are not concerned about knowing the history of the foodstuffs they buy • Consumers are sceptical of foodstuffs' quality because there are no clear and easy way for them to get information on the quality control in place • Consumer do not see the need or purpose of food labelling *which leads to the name:* **THE INDIFFERENT CONSUMER**

The "big-flip" of the **Consumerism** cluster describes a situation where the production of agricultural products is well-regulated with a good input – output balance and adapted to consumers' wants and needs. Innovative ICT developments enable producers to produce high quality products that meet the high demands of the market. Producers see clear advantages of using ICT to improve cooperation with other producers, as well as a mean to optimise the quality of their products. This cluster leads towards scenarios where the consumers are *conscious and trusting* of agricultural products.

In the "big-flop" situation, ICT are neither well-received by producers nor are they sufficiently developed to meet the needs of an improved product control system. Agricultural production is not balanced in regards to input – output nor are producers engaged in finding ways to improve quality or consumer trust. Consumers' needs are generally ignored or not fulfilled. where consumers are indifferent to almost anything but prices, and this situation is dominated by *indifferent* consumers.

3.9 Multiple images of how agricultural systems are being developed in 2015

We are now able to define the structure of the scenarios for the Agriculture domain.

3.9.1 Developing the scene

In this process, we start with the scene, which is common for all scenarios. The elements for defining the scenes are found in the lower left "Scene" quadrant of the original grid of environmental factors. These factors are deemed to be rather certain by the experts and thus serve at the reference point for all four scenarios. The "Scene" factors are mostly related to external influences on agricultural production in the future, such as regulations and market demands.

The market is influenced by consumers with high buying power, and an increasing share of the disposable income is allocated to foodstuff and other agricultural items. The information flow to consumers is extremely high and is cluttered with all sorts of commercial and informational messages causing frequent problems of information overflow leading governments to take an active role in defining what kind of information is relevant and must be made available to the public. The purpose is also to make sure that consumers have as much information as possible about potential risks and what is being done to minimise them. Epidemics like mad cow disease or foot and mouth disease have increasingly strengthen public interest in the conditions of livestock husbandry.

Agricultural production continues to raise general public and governmental concern about the environment and the use of natural resources. In particular the fear of eco-toxicity and the depletion of scarce resources such as water, leads to increasing focus on sustainable agricultural production, recycling of agricultural waste as well as limits on agricultural production to protect the environment in particularly vulnerable areas. This leads to a further globalisation of agricultural production and the need for increased transportation.

Member states are also increasingly focusing on animal welfare, both in regards to livestock farms and the intensified transportation of livestock. A large number of European consumers are concerned about the welfare of the animals and support government regulation in this area to avoid physical stress on animals from being kept, transported, or slaughtered in poor conditions.

Agricultural producers, small and large, are responding to these challenges by applying new and innovative ICT based solutions in their production in order to optimise and improve their agricultural production and products, improve their competitiveness and earnings, as well as for complying with governmental and voluntary standards and regulations.

3.9.2 Building the sets

The environmental factors in the lower right "Trend" quadrant constitute the changing sets that are built on the scene for each scenario. The experts have identified several trends. They do not necessarily form a cohesive, single targeted trend for the future. Rather, the trends point in different directions for different sorts of applications and different target groups. The trends are incorporated in the four scenarios defined later (identified in [square brackets]).

One trend [1] points in the direction of an agricultural industry where innovative and intelligent ICTs have become an integral part of the production process. Various devices are available and easily adaptable to specific needs and purposes. Farmers are constantly up-to-date on new technological developments that can optimise their production and the quality of products on the market.

Another trend [2] is particularly related to livestock production and the end-products that enter the market. The market demands a high level of transparency in relation to foodstuffs' history and among the public there exists a no-risk attitude towards foodstuffs. This means that tracking, authenticity and labelling of products, made possible by recent ICTs developments, are basic requirements for agricultural products to be accepted by well-informed consumers. The goals defined in the paper, "From Farm to Fork", published by the European Commission have thus been fully realised.

A third [3] concerns the way in which traditional agriculture affects the environment. Sustainability is an increasing concern to consumers around Europe. On the one hand there is a need to contain the use of pesticides and fertilisers and to reconsider the usage of scarce resources such as water and fossil fuels and on the other hand to provide food at reasonable prices. Future agricultural production faces real problems, if no solution is found soon.

Finally, one trend [4] indicates that there is focus on certain issues and problems that affect agricultural production but that it has not been possible to find solutions that are acceptable or adopted by farmers. Similarly, consumers can get access to some information about foodstuff products on the market but only few take advantage of this or actually use it to put pressure on agricultural producers to improve and optimise production processes and products.

3.9.3 Defining the script

<u>What is happening?</u>

The scene shows a typical user situation around 2015. The developer user is being presented with a series of requirements defined by regulators, farmers, food processors, distributors and/or consumers. The sheer amount of actors with different perspectives and different objectives makes it very difficult for the developers of infrastructure components and applications to provide real cost/benefit to more than one end-user at the time.

Further, the clock speed of some of the system is very long compared to "standard ICT systems". Farmers are not likely to scrap well functioning equipment just because a new version is being put on the market. The developer user is thus faced with the task of creating new or improved embedded systems and applications, which has to be based on the capabilities of existing devices.

How is it happening?

The main thrust for the developer users script are the commercial benefits to be derived from the under laying business case. The developer user thus relies on cost/benefit analysis of the various professional actors involved and business modelling is an essential part of all requirement specification work to make sure that the planned solution delivers sufficient economic benefit to the professional users, which later can be passed on to the consumer as price advantages.

The developer user will tend to focus on integration of existing systems and devices using standardised middleware, which can be embedded in systems and devices. By using the Hydra middleware, the developer users are capable of developing secure, integrated solutions with high degree of functionality and precisely targeted the end-user group in question.

Why is it happening?

The developer users are faced with a multitude of actors with different backgrounds, skills, objectives and means. He is faced with the task of developing products and services that are properly focused in the primary target group and yet at the same time understanding the intricate co-existing of the other actor groups and their impact on the design and functioning of his product and service.

One target group is the technically competent end-users, who have strong desire to work with the system and build new functionality and applications. The aims and needs of the target groups thus have different priority and the script differs correspondingly.

Another target group is consumers that increasingly take interest in the operation and safe functioning of agricultural production systems. They want safe, healthy and well tasting foodstuff at reasonable prices.

In all cases, the end-users have strong and clearly defined economic requirements that force the developer user to use technology only to accomplish a specific set of market requirements; technology for technology's own sake is not an option.

Writing the scenarios

The four scenarios have been written on the basis of the scenario thinking process with the group of international experts in agricultural technologies and embedded systems for farm automation and sensor equipment. The scenarios have been illustrated with pictures and drawings to stimulate the reader's imagination.

3.10 Writing up the scenarios

We are now going to define four scenario structures generated from the two clusters "Farming methods" and "Consumerism" each of which has two states or sub-plots. The possible combinations are as follows:

5. Hi-tech farming + The indifferent consumer
6. Hi-tech farming + The conscious consumer
7. Traditional farming + The conscious consumer
8. Traditional farming + The indifferent consumer

From these four combinations we can write-up four scenarios in the following way:

1. The Piggy Bank

The consumers have no special requests and mostly demand low cost food, which is conveniently distributed. They demand safe food, but focused on the needs of their family, not so much in general and they have only marginal interest in animal welfare. Innovative and intelligent ICT solutions have become an integral part of the production process. Farmers are constantly up-to-date on new technological developments used to industrialise the production, optimising output and lowering the cost of products to the consumers. Governmental regulations are seen as unavoidable costs.

2. From Farm to Fork

New technology is used to satisfy demands, primarily from consumers. The focus on high quality regional food requires new, sustainable farming methods to provide a full spectrum of food to be produced in all regions, and to avoid unnecessary transportation. The market demands a high level of transparency in relation to foodstuffs' history and there is no-risk attitude towards food. Tracking, authenticity and labelling of products are basic requirements for agricultural products to be accepted by well-informed consumers. Farmers are genuinely interested in new technology, which is used to create high quality products with regional diversity and using sustainable production methods. The costs are generally offset with higher prices, which most consumers can and are willing to pay.

3. Ye Ole Barn!

Consumers are increasingly turning their back to industrialised food and demand locally produced products, with individual characteristics and personality. The wide selection of industrialised, generic food products is replaced with a narrower selection of man-made, locally produced food. Consumers accept seasonality in availability for certain products and the cost associated with less industrialised production. Sustainability is a real concern to consumers and farmers try to contain the use of pesticides and fertilisers and to reconsider the usage of scarce resources such as water and fossil fuels.

4. There is no hurry!

Consumers are generally indifferent to large varieties of food products and are not concerned with the history of food, nor its quality. Consumers can get access to information about foodstuff on the market, but only few take advantage of this. Only safety and low prices are of some importance. Similarly, it has not been possible to find ICT solutions that are acceptable or adopted by farmers, who are slow to take-up new technology solutions because of costs involved, lack of clear, understood benefits and in fear of not being in control of their farming process.

4. Agriculture scenarios

The Piggy Bank

4.1 The Piggy Bank

The consumers have no special requests and mostly demand low cost food, which is conveniently distributed. They demand safe food, but focused on the needs of their family, not so much in general and they have only marginal interest in animal welfare.

Innovative and intelligent ICT solutions have become an integral part of the production process. Farmers are constantly up-to-date on new technological developments used to industrialise the production, optimising output and lowering the cost of products to the consumers. Governmental regulations are seen as unavoidable costs..

Jeffrey and Sandra operate a family owned industrial pig farm in central Yorkshire. Jeffrey is now 41 years old. His grandfather was a traditional farmer raising milking cows, pigs, hens and horses. When Jeffrey's father inherited the farm in 1970, he decided to focus the production on pigs, because prices were attractive and it was more economical to concentrate on a single production.

Over the years, pig farming has turned into a €100 billion a year livestock industry. Consolidation over the last fifteen years has resulted in fewer but even larger swine operations and it is not uncommon today to see industrial pig farms with 20.000 pigs or more. Jeffrey and Sandra has 10.000 prime Yorkshire pigs.

There have been many environmental problems with these large industrial operations. Animal waste is a major pollutant, e.g. North Carolina has ten million hogs producing twice as much feces and urine as the populations of the cities of Los Angeles, New York and Chicago combined. The waste used to be sprayed untreated, as manure, on fields, but in areas with high density of industrial farms, the amount of animal manure is much more than the land can absorb. This created serious contamination of e.g. nitrogen, hydrogen sulphide, cyanide, phosphorous in the groundwater as well as frequent rifts with neighbours, who find the stench to be unbearable. Regulations have now been put in place to limit or, in some areas, completely banning the spreading of animal waste on fields. Also from last year, farmers have been forced to install liquid manure treatment plants to reduce the sulphate content and degrade the organics pollutants. Jeffrey has already installed such a system at a great expense, and he is now looking for other means to reduce his operation costs.

Jeffrey has other problems to consider. The air in the stables, saturated with gases from manure and chemicals, can be lethal to the pigs and the environmental temperature for each pig is instrumental for the pigs' wellbeing and ability to face off diseases. Jeffery has installed expensive ventilation systems running 24/7, which adds considerably to his already high energy bill. However if they break down for any length of time, pigs start dying. The ventilation system is the tool to provide the pigs with good air quality and the appropriate effective environment temperature. Ventilator speeds are determined from formulas involving in- and outdoor climatic parameters and the size of the stable and its ventilation equipment. The ventilation formulas are automatically adapting to the actual number of pigs and their density (automatically provided by the location sensors) in the stable.

The wellbeing of the pigs is potentially affected not only by average ambient temperatures, by also by drafts from air inlets, door ways and in winter, unused summer fans leaking. Increasing the speed of air entering may cause drafts and leaving a door open in summer will "short-circuit" the system and actually increase effective temperature by reducing airspeed. Therefore the stable control system is fully integrated with other subsystems controlling doors and windows. A sensor network measures air speed and turbulence, humidity, ammonia and carbon monoxide concentration and dust in various areas of the stable whereas light sensors observe influx of lights. Based on these inputs, the system calculates various in-door climate parameters, which are then fed back to the ventilator control system or other subsystems. The control system is further connected to on-line micro-weather forecasts, from where short term prognosis are used to determine control parameters in parts of the system loops with longer time constants, i.e. feed heaters and floor heating in farming pens.

In order to optimise the space, Jeffrey has previously had up to forty hogs occupying one pen, but it created problems since they could trample each other to death. A new law requires pregnant sows to move freely in a large pen. This is a challenge for Jeffrey, because it adds to the production costs and he is not always sure of when the sows are pregnant. In order to comply with the regulations, he has temporarily moved sows, which he thought to be in the heat period, to larger pens. Now he has ordered a sow-monitoring system from the company Hogthrob. The system provides a sensor network infrastructure, which will be integrated with his stable control system using Hydra middleware and thus effectively upgrade his overall Farm Management Information System.

His sows will be equipped with a SOC (system-on-chip) sensor incorporating RFID tag, movement detector (accelerometer), temperature sensor and a ZigBee radio communication device. The sensors are hosted on a single networked chip in order to minimize energy consumption and production cost and providing room for robust packaging.

Jeffrey's Management Information System has wireless contact with the sensors and tracks the sows roaming freely in their pen. The RFID transmit the sow's identification to the stable control system, which identifies the precise pen, to which the sow is assigned.

The sensor system will facilitate other monitoring activities that are important for his production costs. The temperature sensor will precisely detect the sows heat period. Missing the day where a sow can become pregnant has a major impact on his pig production economy. The movement sensor can detect possible illness, such as a broken leg. Further it is possible to detect the start of farrowing. This information is then sent to the stable control system, which detects the pen, where to which the farming sow is assigned, and automatically turns on the heating system for newborns when farrowing starts.

In late September, the system has been installed and tested. The installation took only 5 weeks due to the widespread use of standardise interfaces and thanks to the Hydra middleware platform, which allowed the system integrator to perform much of the subsystem integration without evening having to involve the original manufacturer. Jeffrey sits down at the computer and logs into the new extended Farm Management Information Systems and feels very pleased with its capabilities. He also knows that in the next 6 months he will have to operate the system in learning mode, in order to optimise all the different decision support functions, such as the automatic ventilation control system and the automatic farming heating system. as well as local traditions and preferences. Thus it requires Jeffrey's close monitoring and attention until it is fully run in, but then he expect it to provide substantial savings on his operational costs, and allow him to maintain his competitive edge in the increasingly price sensitive market for pig meat.

4.2 From Farm to Fork

New technology is used to satisfy demands, primarily from consumers. The focus on high quality regional food requires new, sustainable farming methods to provide a full spectrum of food to be produced in all regions, and to avoid unnecessary transportation. The market demands a high level of transparency in relation to foodstuffs' history and there is no-risk attitude towards food. Tracking, authenticity and labelling of products are basic requirements for agricultural products to be accepted by well-informed consumers.

Farmers are genuinely interested in new technology, which is used to create high quality products with regional diversity and using sustainable production methods. The costs are generally offset with higher prices, which most consumers can and are willing to pay.

The crowd is intensely looking at the PDA in the woman's hand. There is a tremendous sense of excitement in the room. Will this work? Will the technology deliver what the developers have promised? Will the politicians be able to show what strong political will can achieve?

The woman holds a small PDA-like computer in her hand. She reaches forward, takes a package from the shelf and holds the PDA to it. She stares at the screen, as the little hourglass happily turns. Her entire body shows relief when the screen starts to fill up with information. It works!

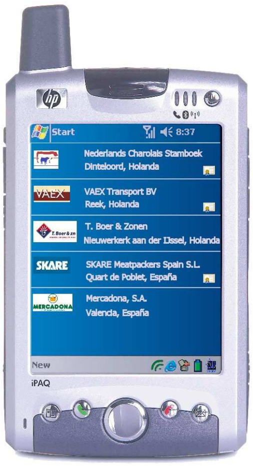
The woman is the Spanish Ministra de Agricultura, Pesca y Alimentación Christina Ramos. She has just inaugurated Spain's and Europe's first fully automated, integrated and networked system for tracking foodstuff "from farm to fork". For the first time ever, consumers will now be able to see the entire history of the food that they buy.

This major breakthrough in consumer and industrial cooperation has only been possible thanks to a very close cooperation between government regulators, industry and consumer associations, farmers and technology developers. And they are all there today in the Mercadona Supermercado in Valencia to see the first public presentation of the new system which is called Hydra: "Humanes, animales y distribuidores in cooperación para regulaciones en agricultura". With Christina Ramos is Gregorio Ruiz Antolin, the minister for Sanidad y Consumo, the CEO of Mercadona Juan Roig, directors and presidents of Spanish agricultural associations and major industrial manufacturers associations, vendors and developers of the numerous parts of the system that has to work together as well as a great number of people from across Europe. The guests of honours are the EU commissioner for agriculture and the EU commissioner for Information Society and Media, who have been instrumental in making this new system possible.

The minister now looks at the PDA screen and cameras are zooming in. What is so exciting? On the screen is displayed a list of the entire value chain that the product has gone through in its lifecycle. The minister took a product randomly off the shelf, which is in fact a package of four steaks. With the build-in reader in the PDA, the minister reads the entire history of these four steaks from the RFID embedded in the price tag. The screen displays the steps that the meat has passed from the farm, via the slaughter house, the meat packager, the wholesaler and until it reaches the retailer. Christina Ramos can not only see that the meat left the farm in DInteloord in The Netherlands on 17 February, and ended up in the slaugtherhouse in Valencia on 20 February, but she can also see the electronic certificates of all the authorized actors in the value chain.

The Minister enthusiastically explains all the details of the screen to the press corps and highlights the importance of presenting this kind of information to the consumers. She also stresses the major breakthrough in attitudes that has been necessary in order to extract the vast amount of private data and make it into useful information for consumers and farmers alike. This is the first time farmers are being given the opportunity to advertise in a commercial context in connection with consumer safety.

The minister turns around and urges a tall man standing in the back to come forward. He presents the man to the press as Pedro Ramarosa, the chief architect of the project and asks him to show how the system can give detailed information of the farm.



Pedro clicks on the farm and explains that the consumer is on-line with the farm information web site. The site links to the historical information database, where all the historical data pertinent to this particular piece of meat are stored. All along the food value chain, data area automatically collected from the various actors. The privacy of data is preserved, because none of the data ever leaves the repositories of the data owners, unless specifically provided for by law, until the consumer specifically asks for it in the store.

Pedro explains: At farms across Europe, all relevant information is automatically collected by thousands of local sensors and systems in the production, indexed and intelligently registered in the farmers own databases. Pedro clicks on the info link and immediately gets a full description of the animal and its health history. This is possible because the authentication is provided for by the Mercadona, who certifies that the requested is in fact a shopper in its supermarket. The value to the farmer is that the farm site also allows the farmer to advertise his products directly to Mercadona's customers. Especially suppliers of brand products have been overly enthusiastic about this new way to communicate directly with their end-customers at a very low cost.

The system also displays the transporters involved in the logistics chain. Pedro clicks on the transporters link and is transferred to the site of the transport company. The map on the screen shows the actual route that the animal was transported on its final leg to the slaughterhouse in Valencia including information on total travelling distance and time, maximum and minimum ambient and body temperature and other relevant information, which allows the consumer to assess the well-being of the animal during transport. This data is requested by law to be available to consumers and since the authorities also have access to the data, it provides an integrated control and monitoring systems for animal health and well-being during transportation.

Pedro explains further, that GPS data are automatically collected from the transporters fleet management systems and transferred to the cargo identification database. The Hydra tracking systems can perform automatic searches in these databases and extract information on animal handling, maximum and minimum temperatures during transportation and combine it with the actual route.

The system extents further into the Valencia slaughterhouse and the meatpacking company. All systems are equipped with elaborate trust models that protect the identity and privacy of the consumer while at the same time providing full authorisation for customers of Mercadona and third party certification of the supplier of the data. As an example of this embedded security framework, Pedro calls up the electronic certificate for the slaughterhouse which was in effect at the time the cow was slaughtered. This is a security for the consumer and the slaughterhouse against repudiation and falsified, unsafe products.

Thanks to Hydra, all steps in the life-cycle of the steaks are fully documented and accessible to relevant, authorised consumers on-line. Information is automatically collected from a multitude of different sensors and systems, and intelligently indexed and stored for later retrieval while at the same time honouring demands for trust, privacy, non-repudiation for all actors involved. Also manufacturers of sensors and devices can cooperate much more effectively now, because standardised middleware bridges the gap between previously stand-alone systems and provides the necessary security and trust for farmers, value chain actors and consumers.

4.3 Ye Ole Barn

Consumers are increasingly turning their back to industrialised food and demand locally produced products, with individual characteristics and personality. The wide selection of industrialised, generic food products is replaced with a narrower selection of man-made, locally produced food.

Consumers accept seasonality in availability for certain products and the cost associated with the less industrialised production.

Sustainability is a real concern to consumers and farmers try to contain the use of pesticides and fertilisers and to reconsider the usage of scarce resources such as water and fossil fuels.

Even if some people seem perfectly happy with foods they find in the supermarkets, a growing number of consumers are looking to locally produced food. For Sven and Lotta this trend was the determining factor when they decided to invest their money and future in building the most successful sustainable for local rural products in Southern Sweden.

As a trained computer scientist working for ABB in Vesteräs, he could not be further away from sustainable farming. But his life changed when he met Lotta. Lotta had studied hortology and was obsessed with everything being "sustainable". After they got married, their first son was born, Lotta gave up her studies and after a few years as housewife (a time when she perfected her ecologically grown flowers and vegetables) she resumed her studies at Swedish University of Agricultural Sciences in Uppsala. They continued to live in Västerås, so Sven had to do the shopping and started to get interested in foodstuff; especially in the increased industrialisation of it. This left them with lots of subjects to discuss in the winter evenings.

One day Sven found an article in a US magazine. Recent surveys had shown that seventy-three percent of Americans want to know whether food is grown or produced locally or regionally, seventy-five percent of consumers and consumers in seven Midwestern states give top priority to produce "grown locally by family farmers. Sven and Lotta were astonished about the number of people sharing their ideals, which was not obvious from life in the industrial town of Västerås. However, some further research revealed that the trend was also strong in Sweden and expert estimated that the same numbers could be reached in a few years in Sweden.

In an unrelated incident, they had come across a very old farm for sale in Spånga in the southernmost part of Sweden. The countryside there was very fertile and excellent for sustainable farming. It was so different from life in a northern city, and they had talked about retiring here. Over the next year, the two thought began to converge and one day Sven said: "Why don't we buy the farm and build our own ecological farm? After some deliberations, the decision was made and within one year, Sven, Lotta and Lotta's brother Karl (who had been running the family farm) opened up their local ecological farm in Spånga.

Sven is responsible for equipment and sales; Karl is responsible for the daily operations whereas Lotta is in charge of biological and ecological methods. They all agree that traditional farming methods must prevail. The farming methods must align with the demand of customers, so human safety, environmental concern, and animal welfare is unquestionable values. However, they are in no way technology foes. Sven used eCommerce methods from the day they started and today, about 70% of their sales come from internet trade. Customers can either pick up the produce at the farm shop or have it delivered through a local delivery service.

Sven is also responsible for finances. His early business models showed that with the high energy and water costs (and a look to the environmental load), resource consumption must be kept to an absolute minimum. He objective was to use advanced ICT systems and irrigation automation to enhance water use efficiency by 10% - 50%, and increase yield per land and water unit by 100% compared to industrial farming by using a volumetric approach, i.e. using a specific amount of water rather than a fixed time. Once the water budget of the crop has been calculated, it can be used for the programming of concrete irrigation scheduling.

After some market research, they decided for an advanced irrigation system based on Hydra middleware technology, which would allow them to easily integrate the various systems they needed for intelligent irrigation control. Future upgrades are also facilitated. The system has complex irrigation models with an expert system for advanced scheduling and decision support and dynamic search for up-to-date weather information. The system is responsible for the optimisation of water distribution on the entire farm, relating to topography, weather and pressure regimes.

Input to the irrigation control system is today coming from standard electrical conductivity sensors that allow mapping of soil characteristics, but Sven is planning to install a completely new and more accurate network based on subsurface soil moisture sensors in preset depths in the fields. The sensors are spread on the fields and ploughed into the ground. They communicate via RFID technology and a robotic radio transmitter to the irrigation system.

In a different part of the farm, the irrigation control system also interfaces to the irrigation system installed in the greenhouses, where they grow tomatoes, peppers and cucumbers. A new precision irrigation system based on estimation of crops water stress with acoustic emission (AE) technique has been installed in the greenhouse. The system acquires real-time acoustic signals and transpiration data from the tomato crop. The system also collects environment parameters of the greenhouse, such as temperature, air humidity, density of the sunlight and carbon dioxide density. The central irrigation control system uses and advanced optimisation algorithm to control the irrigation subsystem.

With his background in control software for large machinery, Sven has the skill to do most of the software development himself. He writes models and algorithms as well as embedded control software needed for interfacing the various parts of the system. One of the problems Sven has to deal with is the real-time aspects of the automatic feedback. Because the pressure in the main water supply line at times is seriously fluctuating, he must dynamically calibrate the water budget model. He does this by installing dynamic flow sensors in various places in the system and the model automatically calculates the total dynamic head, as a function of the varying water speeds. This very complex model required substantial skills and time, before it was working. But using only components with Hydra middleware, he was able to interface to the different manufacturer's sensors and components with relative ease, so he could devote his attention to developing the high performance software model.

His next big project is to utilise GPS-referenced information on chemical and physical soil properties and soil anomalies to complement the existing irrigation models. He will combine GPS positional information with yield data to produce yield maps. These yield maps will then be correlated with irrigation history in the irrigation model and used for controlling a new site-specific, centre-pivot irrigation system that will deliver individualised water budgets to crops in a given field. The problem is that many of the yield variations within a field are far from repeatable year on year because there are complex interactions between a number of variables, so his model has to compensate for these changes.

Increasingly, people in Sweden (and throughout Europe) are acting on their preferences for local eating, as evidenced by a doubling of number of farmers' markets in less than ten years, persistent growth in number of local farm producers like Sven, Lotta and Karl, and a growing number of independent restaurants and food stores relying on local foods for their competitive advantage. Sven and Lotta are extremely happy with this development. Thanks to extensive use of intelligent ICT technology, their farm is not only securing environmental sustainability. It is profitable and helping to ensure that fresh, healthy, locally grown food is available, affordable and accessible for all citizens in southern Sweden. And then it helps to preserve the rural communities, of which they are now prominent members.

4.4 There is no hurry!

Consumers are generally indifferent to large varieties of food products and are not concerned with the history of food, nor its quality. Consumers can get access to information about foodstuff on the market, but only few take advantage of this.

Only safety and low prices are of some importance.

Similarly, it has not been possible to find ICT solutions that are acceptable or adopted by farmers, who are slow to take-up new technology solutions because of costs involved, lack of clear, understood benefits and in fear of not being in control of their farming process.

Luxembourg agriculture is producing milk, meat, wine and cereals (bread wheat and animal feed) and is roughly as efficient as that in Germany. It is heavily dependent on subsidies for environmental protection, etc. Organic produce is favoured and the Ministry of Agriculture will not push for the use of biotechnological techniques in agriculture.

Vine growing has been practiced in Luxembourg since the arrival of the Romans. The Luxembourg vineyards cover the sunny hillsides along the Moselle from its arrival from Lorraine, at Schengen, to its departure to Germany at Wasserbillig. Vineyards cover an area of some 1400 hectares, or about 1% of total farmland, and the most cultivated grapes are Elbling, Riesling, Pinot blanc and Pinot gris.

This is the environment, where Georges Foucault has made his living as a wine producer; the fifth generation in the wine estate "Domaine Foucault" in Wormeldange. The family has always produced wines here for the high quality market segment, using vinification methods developed over centuries. Fifteen years ago they were appointed the prestigious distinction "Marque Nationale" (national brand). This distinction makes Georges very proud. Besides, it adds a little extra to his annual revenues through the higher prices he can obtain for his quality wines. His annual production sits around 150 casks annually with 30 per cent being exported to other Benelux countries, Germany and France.

The Luxembourg population in general is believed to have little interest in agriculture or even biotechnology. Although many people do have a close relationship with farming, or with farmers, they appear to have a sentimental view of the countryside but little actual understanding of farming.

Since most consumers see local wines as a part of their daily diet, they do not necessarily see the need for detailed information about the wine and where it comes from. Vin de Table is only traded on price and very few quality parameters. One exception, though, is the high end wine business, where Domaine Foucault is active. In this segment information about the wine, such as the grapes used, the wine's composition, the climatic conditions of the vintage, the vinification process, etc. are all very important for consumers, shops and restaurants. Georges' daughter Anne is responsible for marketing and she spends a great deal of time collecting the information and writing informative descriptions. This work is highly computerised and they maintain their own web site and distribute electronic newsletters to thousands of clients.

But outside marketing, ICT use in wine industry has mostly been about mechanising existing processes. Georges has invested in several PCs already. His accounting package allowed easier tracking of performance, less of a scramble at the year end to provide data for his accountant and, most important of all, his ability to claim back VAT easily and quickly. However, improved number crunching and tidy farm records are all very well but he find it less inspiring than growing his wine and determining the precise vinification method; he also finds the effort involved in consigning data to a computer system is greater than benefit he obtains.

One of the biggest drivers to encourage greater use of computers in farming in the past was the increasing emphasis on recording for statutory purposes, quality assurance and traceability. People have spent years trying to work out exactly what information farmers need, and there is now clear evidence that most benefits come from frequently updated, rapidly changing information on prices, market reports and of course, the weather! Farmers do not want reference material pushed at them down a wire and there is scope to use the emerging decision support tools to be a little more intelligent about how we present this type of information.

Since 1993, the vine growers are forced to apply the quotas imposed by the Commission in Brussels (140 hl/ha for Elbling and Rivaner and 120 hl/ha for all the other wine varieties). This was initially a bit of a nightmare for Georges, but he now has a software package that can calculate the expected yield for each of his fields. He runs several simulations under different weather conditions and uses the results to plan next year's production, so that he does not exceed the annual quotas. He also uses the system for statutory reporting.

A few years ago, the association "Vinsmoselle" commissioned a portal providing access to members and distributor's own sites and a comprehensive e-Commerce section for consumers, shops and restaurants to select and purchase wines directly from the producers. The lesson was that facilitating and enabling existing trading processes is more successful than re-engineering the way a whole industry does business. The increasing acceptance of the internet as a business tool by the vine grower community is driven by a pragmatic and reasoned approach by existing businesses while recognising the opportunity in new ICT technologies. However, vine growers are unlikely to move too quickly until they fully understand the implications and costs.

This raises the fundamental issue with ICT adoption in wine growing as expressed by Georges at a meeting took with Mr. Marc Moreland, Head of the Wine Production Unit of the Agricultural Technical Services Administration. Georges point of view is that the lack of perceived benefit to the user prohibits the wide spread use of ICT in the vine industry. His simple rule state that if the effort required to use a piece of software is less than the benefit derived, adoption will occur; if not, it will not occur.

Effort may be defined as time, effort and cost while benefit (at least for the average wine grower) tends to be monetary. He also point out that the developers' perception of value (environmental benefits or software intended to save manual labour for example) may not always be shared by the wine growers. Georges was looking for better systems which can deliver real value to those who are expected to use them and pay for them – value they can understand in their terms.

In the future, if consumer demands for traceability and history continues to rise, if the cost of energy for the vinification equipment continues to go up, and if there are increased regulatory and environmental demands imposed on the wine growers, Georges expresses confidence that the use of ICT, also in rural area, will eventually become more widespread.

One important application he sees for ICT is in wine fraud. With the prices of wine futures soaring, and the large international market for rare bottles growing, fraudulent scammers and crooks are sure to take advantage of people by selling impostors and fakes. Traditionally, to combat fraudulent wine from being sold, professional tasters have been called in to make a determination on a bottle by tasting and comparing the wine for validity against his or her palate. Georges recently read an article describing researchers in Japan, who have developed a robot capable of comparing and identifying the unique characteristics of wines. He also sees the use of RFID tags as potentially very useful for tracing original wine, much in the same way as the pharmaceutical companies are doing.

He welcomes the challenge, but iterates the need for well defined, measurable and clear value propositions to farmers, combined with a large amount of training. Then he is ready to move.

5. Appendix A: Environmental factors in Agriculture

The following list is provided as a guide to the meaning of the various environmental factors identified and discussed by the expert during the agriculture workshop.

In the first column is listed the questions being discussed during the workshop and noted by the consortium partners. In the second column is provided a brief explanation of the content of the relevant discussions. In the last column is listed the corresponding short factor description used in the scenario discussion in this document. The identified factors have been listed according to the classification provided by the experts: High uncertainty vs. high certainty and direct impact vs. indirect impact.

Topic, statement or question	Explanation and comments	Environmental factor
High uncertain – indirect impact		
People don't trust in foreign food products	Consumers don't trust in the quality of foreign food products	Distrust in foreign food products
Present "nice" information to the consumer ("nice story telling")	Consumers will be presented with "nice to know" information about the product and its history	Information to consumer
Farmers will continue to exploit resources, i.e. no sustainability	Farmers over-exploit resources rather than produce according to sustainable principles	Exploitation of resources
Institutions are responsible for food safety	Food safety issues are handled by third party who are responsible to ensuring that food is safe	Food safety responsibilities
Political decisions about better use of water resources	It will be a political decision and requirement to use water resource more efficient	Politics of water
Analyse how bio-life in the desert is growing/born	Analysis of biological life in desert environment will be conducted in connection with effort to use water resources more efficiently and save on water	Bio-life analyses
Sustainability is only a monetary concern	Only monetary benefits/disadvantages are considered in relation to sustainability issues	Sustainability
More efficient use of resources is achieved	Resources will be used more efficiently within agricultural production	Efficient resource management
High uncertain – direct impact		
Possibility of interoperability among devices (standardisation)	Devices will be able to interoperate due to standardisation	Interoperability
More local produce and products	Consumers prefer and request more local foodstuff products	Local food products
General concern and awareness of the (global) environmental issues	There will be a general concern and awareness of global environmental issues and how these relate to agricultural production	Environmental awareness
Genetically modified animals and food products are not accepted	Consumers do not accept that animals and foodstuffs are genetically modified	Genetic modification
Human experience modelled in the IT embedded systems	Human experiences and know-how will be modelled and included in IT embedded systems	Human experience modelled in IT systems
Need of diversity in food products	Consumers expect wide range of diverse food products	Diverse food products
How to avoid a mixture of fake and real information?	It will be necessary to have rules that ensure a separation of real/true and false/wrong information	Information verification rules
Products' authentication is widespread	There will be a system in place that can verify agricultural products' authenticity	Authentication of products
Globally-minded consumers and producers	Consumers and producers are globally minded in relation to the production of foodstuffs	Global-minded public
Most of farmers are not aware of hi-tech solutions	Farmers are not well-informed about technological solutions and possibilities in agriculture	Unawareness of hi-tech solutions
Small farms can't apply technologies	Small farms do not have the capacity, nor need, to apply modern technologies to their production	Small farms have technological limits
Farmers want to stay in charge – they don't want automation	Farmers want to stay in charge and control production rather than make some aspects automatic	Automated farming management systems
Data-sharing acceptable for farmers	Farmers accept that they have to share data	Data-sharing
Consumer wants to know foodstuff's history	Consumers want access to the history of foodstuffs	History of foodstuffs
Intelligent systems will be available	Intelligent ICT systems will be available in agricultural production	Intelligent systems

Topic, statement or question	Explanation and comments	Environmental factor
Growing importance of traceability of foodstuffs	It will be increasingly important to be able to trace foodstuffs from farm to fork	Traceability
Increasing number of smart devices for agriculture	There will be an increasing number of smart devices for agriculture	Smart devices
Biometric modelling of physiological data	Biometric modelling of physiological data will be available	Biometric modelling
Need of efficient food labelling	There will be a need of efficient labelling of foodstuffs	Food labelling
Generally the consumer trusts in product's quality	Generally consumers trust that the quality of foodstuffs is high	Consumer trust
High certainty – direct impact		
More efficient use of scarce resources is needed	Solutions for more efficient use of scarce resources, e.g. water, will be necessary	Efficient use of resources
We can cut down on water	It will be possible to reduce water usage in agricultural production	Water usage reduction
Less water due to insufficient energy to clean existing water resources	The energy resources needed to clean existing water resources will not be available which results in insufficient water resources for agricultural production	Insufficient energy
People will be able to adapt to intelligent systems	Farmers will adapt to the available intelligent systems	Adaptability to intelligent systems
Importance of the information systems	The importance of information systems will be high	Information systems
Tissue sampling of animals to ensure authenticity	Tissue sampling of animals will be used as a tool for authenticating the animal's history	Tissue sampling
Need of training for small farmers to reduce cultural gaps	Small farmers will need training in ICTs in order to reduce cultural gaps between small and large farms	Training
Scaling existing systems	Can existing laboratory systems scale to full market?	Scalability
Tracking of infected products	It will be possible to track the origin/history of infected products?	Tracking of infected products
Increased traceability leads to increased awareness which leads to increased caution	The increased traceability of foodstuffs creates more awareness of products' quality and therefore also more caution of risks associated with poor quality of foodstuffs	Increased awareness
Information systems must inform customers permanently	Customers will continuously and always be informed of foodstuffs quality/animals' health	Continuous information to consumers
Systems can collect information from different sources	ICT systems will be able to collect information from a variety of different sources	Information collection
Adaptive systems identify relevant information	Adaptive systems will be able to identify relevant information from data sources	Identification of relevant information
Continuous measurements and collection of indicators from animals	There will be continuous measurements and collection of indicators from animals	Measurements and indicators
People will not accept risks and health hazards in food	The public will not accept risk and health hazards related to foodstuffs	Food risks and hazards
High certainty – indirect impact		
Positive attitude to the use of computers	Farmers will be positive towards the use of computers in their production	IT attitude
Growing importance of sustainable development	Sustainable development within agriculture will be increasing important	Sustainable development
Need of recycling waste from agriculture	It will be necessary to recycle agricultural waste	Recycling
Information available to the public requires political decisions	It will be a political decision to define what kind of information related to foodstuffs there will be available to the public	Politics of information
Increased buying power leads to an increased critical consumer	The increased buying power of the consumer will also make consumers more critical of agricultural products	Increased buying power
Need of information overflow reduction	It will be necessary to reduce the existing information overflow	Information overflow
Only relevant information will be extracted	Only relevant information will be extracted from data sources	Data extraction
Intensive transport of animals (dead or/and alive) and foodstuffs	Transportation of animals (live and dead) and of foodstuffs will be intensified	Transportation
Animal welfare depends on country regulations and ethical matters	In some EU member states, e.g. UK, animal welfare is a main public concern and is regarded also as an ethical question. The public's attitude to animal welfare influence country specific regulations concerning this issue.	Animal welfare
Strict limits in farming to save on resources	Strict limits on farming will be put in place in order to save on resources	Farming limits