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Hydra

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

D10.8 Business models in agriculture

Integrated Project
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1. Introduction

1.1 Background

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 Hydra middleware is based on a Service Oriented Architecture (SOA), to which the underlying communication layer is transparent. The middleware includes 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.

The middleware is being validated in three application domains: building automation, healthcare and agriculture.

1.2 Purpose and context of this deliverable

The present deliverable is a result of the Hydra WP10 (Task 10.2) activity focussed on the development of realistic business models for developer users and service providers representing the agriculture value chain. The document follows the delivery of other two related Deliverables, D10.6 Business Modeling in Building Automation and D10.7 Business Models in Healthcare, which follow the same approach in the respective domains.

The Hydra working group firmly believes it is important to apply new research for defining and measuring how to create value in dynamic constellations with the usage of the Hydra middleware. This work has led (and is leading) to innovative business structures involving content providers, service providers, device manufacturers, together with system integrators in a collaborative effort. The goal of the work is thus to provide the most promising business models, which can be used for customers and users of the Hydra middleware, and to instantiate them in realistic, sustainable business cases in the pertinent domain.

The content of the deliverable is also presented to the Hydra consortium partners (not participating in Task 10.2), in order to make the business modelling work transparent among all partners and to propose a common understanding and strategy for the Hydra deployment.

1.3 Methodology

The methodology followed is based on an enlarged participation to the business ideas brainstorming and it has been identified with the WP partners in order to ensure a wider scope and result for the Hydra technology in respect to the project partnership. As a consequence, the Hydra project has conducted three one-day high-level workshops in each domain with a group of experts in the respective field. The last event that was organized in Rome, Italy, on 28 January 2010, focussed on the agriculture and food processing sector. Invited to this workshop were experts from a wide range of stakeholders, especially from Italy, but also from Denmark and Germany. The participants represented diverse viewpoints and roles in the agriculture business domain, such as solution providers, system and component integrators, academic researchers and agro-economists.

The agenda is attached at the end of the document (Annex I: Workshop agenda), while the list of confirmed participants appear immediately after.

The workshop was initiated with a lecture on “Interoperability and security issues in networked applications for agriculture” reported from Thomas Njesum Madsen, representing the Danish company TNM A/S which is among the leading national enterprises working in the ICT technology applied to the livestock sector.

The key note lecture was followed from an overview on Networking systems and devices – visions and possibilities in the Internet of Things and Services scenario. The presentation described how the Hydra middleware could facilitate advanced, networked services in a heterogeneous environment.

Two ICT-related agriculture examples taken from real scenarios were presented for kick-starting the discussions that followed. The scenarios covered 1) food traceability in the post-harvest fishing industry applied in the Uganda-Nile area; 2) wireless sensor networks used for precise agriculture in the rural semi-arid areas of developing countries.

After the previous presentations, the rest of the day was devoted to the expert discussion on three topics.

Firstly, the experts identified potential applicative scenarios for the introduction of the ICT and especially Hydra technology in the farmers' activity. During this discussion the limitations and opportunities of networked applications and services were discussed and attempts were made to prioritise the identified use cases in order to understand where the Hydra technology could be best beneficial and effective.

The discussion then moved to identification of the business framework and the involved actors and stakeholders. Special attention was given to the selection of market niches where ICT use is most visible and to the identification of potential early adopters who could be particularly interested in the development of business models for Hydra enabled applications.

Finally, the experts attempted to estimate the potential added value for each stakeholder and their revenue source and cooperation strategies. The agriculture area is complex and relatively low penetrated from modern information or communication systems, so the introduction of an innovative technology in the sector strongly depends on peculiar circumstances and preferences. Thus, despite the limited time of the workshop, different hypothesis on potential benefit to the value constellation were drawn, and the Hydra business modelling tool will be able to perform various simulations under different conditions allowing us to assess the potential revenue streams in future services or applications.

The meeting minutes of the discussion can be found in the Annex III: Workshop minutes. The discussion yielded a fundamental input to the business cases presented in this deliverable.

1.4 Outline of this deliverable

The document is organised as follows.

The second chapter contains the Executive summary, giving a useful description of the whole analysis in a few pages.

Hydra vision, products and expected outcomes are described in chapter three while chapter four reports a brief contextual analysis of the market drivers and the regulatory framework applicable to the agriculture sector. The study is focussed both on a European and international view, trying to summarise the major trends and relevant issues.

Chapter five is focussed on the business models and cases. In particular three use cases emerged during the workshop appeared as guiding examples for understanding Hydra's potentiality in this domain.

Finally, Chapter six summarises the deliverable conclusions.

2. Executive summary

2.1 The products

The Hydra products are not intended to be deployed directly by consumers or private end customers. Rather, the Hydra project offers a toolbox that supports developers to build smart building automation applications more easily. By using the Hydra development tools in the development of new devices and applications, producers can provide value-added intelligent solutions for their customers, where the complexity is hidden behind user-friendly interfaces. The goal for the producers is to be able to build cost-efficient Ambient Intelligence (AmI) systems with high performance, high reliability, reduced time to market and a faster deployment and even integrate the assets of the installed base. The Hydra project develops the middleware itself (in the form of software libraries) and also accompanying development tools like a Software Development Kit (SDK), a Device Development Kit (DDK) and an IDE (Integrated Development Environment). The middleware itself consists of three layers - the network, service and semantic layer. Each layer holds elements according to their functionality and purpose. The device and application elements are described in detail in D3.9 Updated System Architecture Report. The SDK and DDK are two different views on the middleware. The SDK will allow developers to develop innovative software applications with embedded ambient intelligence - using the middleware, while the DDK will allow device developers to enable their devices to participate in a Hydra network. The IDE will provide solution developers with a high-level interface for developing networked embedded AmI applications. The IDE is integrated with common IDE's such as Eclipse and Visual Studio.

A typical building automation platform consists of several devices and embedded systems that are all interconnected by the Hydra middleware and can thus interact among each other. Developers can now utilize the Hydra network to build up ambient and intelligent home automation applications, e.g. by writing intelligent web services for automation of devices based on the context engine, that is able to process external or internal information coming from the distinctive devices of the Hydra network. All devices interoperate on the basis of web services. The Hydra network is thus completely platform agnostic and scalable.

In our view, the future of Hydra in the agriculture domain is in the interoperability assured from the middleware in order to apply effectively the remote sensing control of the farm appliances and monitoring devices. In the context of a future typical crop or livestock management application, the network shall be connected with the Hydra middleware that integrates the bi-directional gateways, the information flow and the sensor networks. The wireless or wired infrastructure is able to provide an instant overview of the farm situation and the central intelligence is able to retrieve and analyse data and elaborate complex algorithms offering support decision tools.

2.2 Agriculture and ICT technology: an early stage sector

Ambient Intelligence (AMI) is spreading also in traditionally less "technological" sectors such as agriculture. AMI allows end users to gather and analyse any measurable physical or environmental parameter remotely. The recent shift in technology applied to the agriculture domain is also following this trend which is leading towards a broader use of LAN (network) installations inside the farm. The actual technology consists in the usage of LAN switches for animal housing control processing inside the farms in order to monitor climate (temperature, humidity, ventilation, CO2 concentration), electronic feeding systems, water flow management and animal status (weight, temperature, localisation), all accompanied by a centralised management software (resident on a dedicated server). The collected data are extensively used for calculating statistics and obtaining predictions. For example, sows have a certain drinking behaviour which may change if the sow is ill and by monitoring its drinking behaviour it is then possible to detect special diseases 24 hours earlier than before (i.e. without monitoring).

The system architecture in a modern farm is often constituted by 50 up to 100 local controllers on the LAN, 5 to 10 PCs and 1 mainframe. It has been forecasted that in a few years a relevant percentage of the farms in Europe will turn to this technology, also because they have been absorbed by competitors (usually bigger farms). All the farmers who need information for their production can access a Central Database with statistics on the production. This process has started recently, but it is foreseen to have a big impact on the sector in the near future. An added-value represented by this service consists in the guarantee of real-time information. The technology is going forward in the direction of putting sensors directly into the LAN to be able to communicate with the controller, with no need of intermediaries. In livestock especially the technology also includes small sensors put on the animals, able to transmit a 3D monitoring measurement to the central controller as well as new electronic ID for animals, based on UHF – RFID and able to read over a distance of 2/3 meters. Computer vision technology is being evaluated for the pigs' growth monitoring, while for instance not yet for animals' temperature.

A major issue is to integrate equipment from different hardware vendors, so the actual limit consists in the lack of a Central System in the farm able to gather all the data from different systems and sensors. ISO (International Organization for Standardisation) only covers 50% of the used data. The standard from ISO with reference TC23 / SC19 considers the electronic devices' compatibility in the agriculture domain, but it appears as a relatively old reference. The most recent widely used communication protocols in this domain are the Agricultural Data Interchange Syntax (ADIS) for broadcast communication and Simple Object Access Protocol (SOAP) for web-services based architectures. An unresolved issue with the actual communication interfaces is related to the security aspect.

2.2.1 Market conditions

During recent years the rapid growth in world population, overall global income and meat consumption (beef 14%, pork 11% and chicken 45%) are the major drivers behind increased demand for raw materials. This poses a great challenge on the agriculture sector for covering the world food demand. On a first level there's the need to increase the area cultivated, thus putting further pressure on the remaining land, including marginal ground and forests, or, on a parallel level, to increase the productivity of the land currently cultivated. Secondly, to improve the distribution of agricultural products and to ensure they are in the right place at the right time. Finally to increase the environmental sustainability and optimise the consumption habits. These challenges can be met by modern technologies, which therefore play a considerable role in sustainable agriculture.

From a policy point of view the priority of the Common Agricultural Policy (CAP) of the European Union should be to ensure that agricultural products are healthy and safe, promote the respect of the environment, protect medium or small sized farms and help farmers to adapt their production to consumer expectations. Some major issues are:

- Sustainability
- Food quality
- Animal welfare
- Food safety
- Control mechanism

Producers of devices and components are increasingly facing the need for networking their own and complementary products. The interoperability aspect emerged not only as an input from the key note speech but also from the experience reported by the experts present at the workshop. The enormous amount of heterogeneous devices with embedded systems are already in place, but the diversity of the producers and manufactures, without a proper standardisation framework in place, causes many difficulties in relation to the selection of the right technology and devices to be installed in the farm. Often different clock speed of technology deployment is an issue, and there is a large need for hardware and tools that easily can add, implement and exploit the intelligence embedded in the devices.

As regards Europe, the most active countries in the development of new strategies and methodologies in the agriculture and food chain sector are: UK, Germany, France, Denmark and the Netherlands.

2.3 Stakeholders

In the context of the agriculture business case the following relevant stakeholders have been identified:

Farmer - The farmers are the final user of a Hydra enable product. They obtain substantial benefits due to the improved system integration and better control of their livestock or crop. Hardware is no more dependent on the farm management system, so farmers can decide what and where to buy. We envision also the possibility to use the security features ensured from the Hydra farm management service for providing certified data to the National agriculture authorities for financial assistance (or a de-taxation scheme).

Device manufacturer - The barriers for market entrance are much lower for new device producers, enabling larger distribution of single products and not just as fully-featured integrated installations, which tends to be sold to greater farms.

National Authority - They could set up a scheme where they collect seamlessly, remotely and without delay the enormous amount of data available from the farms located in different parts of Europe.

System integrator - The business case is based on a re-engineered farm management service on the hypothesis of putting it in use for the farms already managed from the company or from the enlargement of the customer basis. The business case shall identify the value creation around this actor and to the different stakeholders providing a basis for discussion and evaluation.

Hydra service provider - The support of the Hydra system integrator in the interoperability aspect of the farm management platform, developing new software modules for interfacing devices and components with the server infrastructure and facilities, is strategically important, although the analysis is particularly focussed on the benefit obtainable from the "external" entities.

2.4 Business models and cases

The typical wariness of the agriculture environment towards technology is constantly fading due to the strong know-how and improvements reached in the sector and the intervention of a simplified and more user-friendly equipment. More and more stakeholders are devoting greater attention towards technology and market solutions applied to the agriculture and food processing domain. The application of Information and Communication Technology (ICT) in agriculture is increasingly important and support for the enhancement of agricultural and rural development is emerging through improved information and communication processes: all stakeholders of the agriculture sector need information and knowledge about all phases of the agriculture industry (from crop cultivation to food marketing) to manage them efficiently.

The major challenges are not just technical, but also increased regulatory pressure, which turns into a need for documentation and goes in parallel also to a request of increased economical efficiency. Common issues faced in this domain are the sustainability, food quality, animal welfare, food safety and control mechanism, as noted also in the previous paragraphs. As a general trend in this sector, there is a strong emphasis on networked solutions, e.g. for animal housing and control processing inside the farms, in order to monitor: climate (temperature, humidity, ventilation, CO2 concentration), electronic feeding systems, water flow management, animal status (weight, temperature, localisation), all accompanied by a centralised management software (resident on a dedicated server). Apart from farming management, the collected data are extensively used for calculating statistics and obtaining predictions.

The overall picture sees producers of devices and components increasingly facing the need for networking their own and complementary products. The enormous amount of heterogeneous devices with embedded systems are already in place, but the diversity of the producers and manufactures, without a proper standardisation framework on place, put many difficulties to the selection of the right technology and devices to be installed in the farm. Often, different clock speed of technology deployment is an issue, and there is a large need for hardware and tools that easily can add, implement and exploit the intelligence embedded in the devices.

According to the experts, being able to support the ubiquitous nature of widespread sensing applications should be one of the core features for the future Internet of Things and Services, exactly in line with the main outcome of the Hydra project. Hydra proposes and poses itself as a breakthrough technology, a potential enabler for making good business in the future agriculture scenarios, by ensuring an optimal usage of the ICT infrastructure.

Understanding the business framework in the agriculture ecosystem is therefore an essential prerequisite for the successful deployment and exploitation of new solutions and applications, in (not only) this domain.

3. Hydra products

The Hydra middleware has a significant potential for being used to design cost-effective and easy to deploy applications for ICT-supported environments. Through its unique combination of Service oriented Architecture (SoA) and Model Driven Architecture, the Hydra middleware will enable cost-effective development of intelligent, networked applications and services.

The Hydra product consists of the middleware itself (in the form of software libraries) and accompanying development tools: Software Development Kit (SDK), Device Development Kit (DDK) and Integrated Development Environment (IDE).

The Hydra middleware is based on a Service-oriented Architecture, to which the underlying communication layer is transparent, and which include support for security and trust, distributed as well as centralised architectures, reflective properties and model-driven development of applications.

The Hydra middleware is not intended to be sold/deployed directly to service providers. Rather, it is a tool for *developers* in different domain applications. By using the Hydra development tools in the development of new products and applications, producers of devices and components can provide higher value-added intelligent solutions for their customers, where the complexity is hidden behind user-friendly interfaces. The goal for the producers is to be able to build cost-efficient Ambient Intelligence (AmI) systems with high performance, high reliability, reduced time to market and faster deployment and still build on the assets of the installed base.

This chapter will briefly discuss the Hydra products to allow the reader to understand the various example scenarios and the business models that will be developed in subsequent chapters and the business rationale related to the creation of value through new services, transactions and interrelations among the stakeholders.

3.1 Middleware

The Hydra middleware is aimed at providing interoperability of networked embedded systems, supporting distributed as well as centralised intelligent architectures.

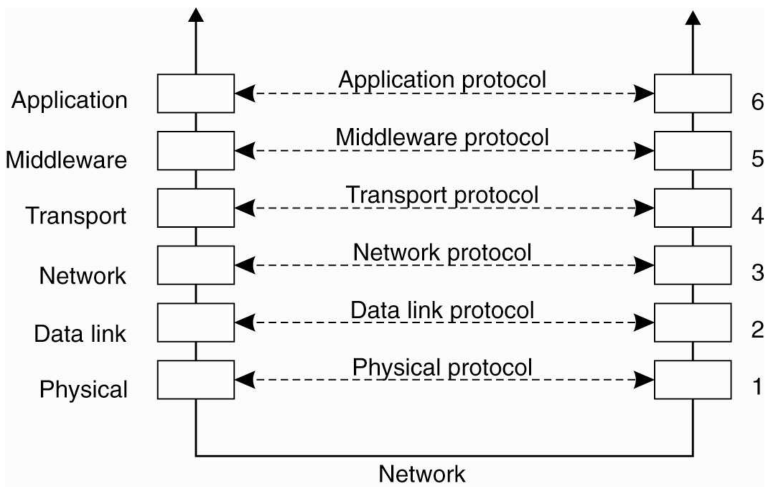


Figure 1: Hydra middleware layers

The concept of middleware in distributed systems is often taken to mean "the software layer that lies between the operating system and the applications on each site of the system" (Krakowiak, 2003). Another characteristic in terms of the ISO OSI stack (Day and Zimmerman, 1983) is that middleware provides protocols that run on top of the transport layer and that provides services to the application layer (Tanenbaum and Van Steen, 2007, p. 123) as shown in Figure 1. Thus, application services such as graphical user interface support or domain-specific application functionality and transport-level services such as sockets are most often thought not to be part of middleware.

The desired functionality is implemented through various layers and components in the Hydra middleware as visualised in the following architecture:

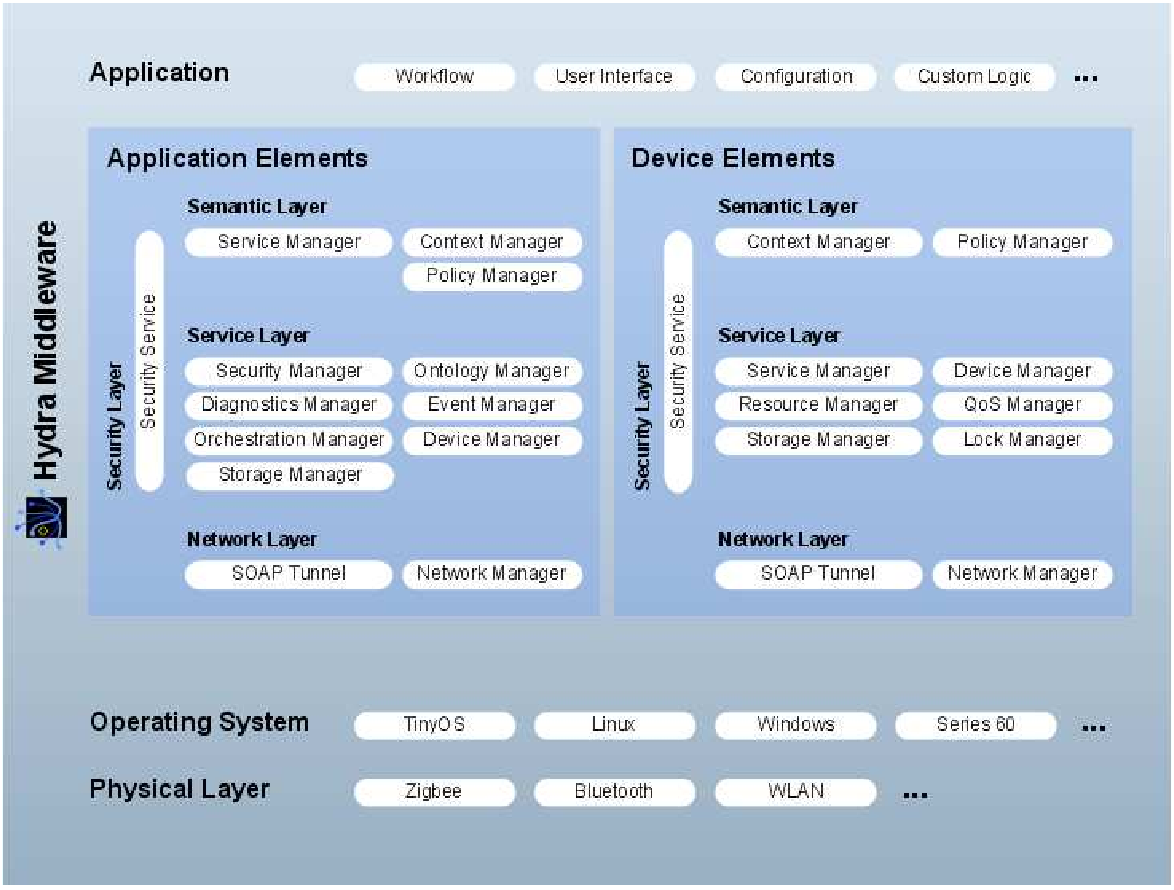


Figure 2: Software architecture layers

The Hydra middleware elements are enclosed by the physical, operating system and the application layer shown at the bottom and at the top of the diagram respectively.

The physical layer realises several network connections like ZigBee, Bluetooth or WLAN. The operating system layer provides functionality to access the physical layer and manages many other hardware and software resources and provides methods to access these resources. The application layer contains user applications. These layers are not part of the Hydra middleware.

The middleware itself consists of three layers - network, service and semantic layer. Each layer holds elements according to their functionality and purpose. Note that some device elements have similar counterparts among the application elements, and are thus similarly named. Both device and application elements have a Security Manager. To express that this manager is an orthogonal service, it is depicted in a vertical format and covers all three middleware layers. The device and application elements are described in detail in D3.9 Updated System Architecture Report.

By incorporating semantic web services at the device level, the Hydra middleware opens up for interoperability of networked embedded systems and provides provision for creating AmI services and systems through a model-driven, semantic approach. Every device, sensor, actuator enabled with Hydra middleware will be able to be considered as a unique service. Support for dynamic reconfiguration of devices will allow for self-configuration of applications. The middleware thus has provision for monitoring systems, discovering failures, reasoning about failures, and reacting to failures within the Hydra middleware environment.

The Hydra Middleware is strongly focused on wireless objects and aims to hide the complexity of the underlying infrastructure while providing open interfaces to third parties for application development and ease of use for end-users. The communication layer is thus not part of the middleware.

In order to solve the rapidly growing challenges of privacy, identity theft and trust, the Hydra middleware addresses security goals such as confidentiality, authenticity, and non-repudiation by a particularly trustworthy design and implementation of personalised agents.

3.2 Development tools

To facilitate the software implementation, a series of development tools have been designed: a Software Development Kit (SDK), a Device Development Kit (DDK) and an Integrated Development Environment (IDE).

The SDK and DDK are two different views on the middleware. The SDK will allow developers to develop innovative software applications with embedded ambient intelligence computing using the middleware, while the DDK will allow device developers to enable their devices to participate in a Hydra network. The SDK consists of the managers and associated tools (compilers, archives, debuggers, documentation, etc.), which are used to develop an application, together with the associated programming interface. In contrast, the DDK consists of the managers needed to Hydra-enable a specific device. Both the SDK and the DDK offer Hydra functionality but at a low programming level.

The IDE will provide solution developers with a high-level interface for developing networked embedded AmI applications. The IDE is integrated with software development platforms such as Eclipse and Visual Studio.

3.3 Scenarios

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. Scenarios have been used extensively in Hydra to visualise functionalities, opportunities and constraints. The scenarios are constructed from a varied background of knowledge and guesswork about the relevant environment and the trends and discontinuities likely to happen in the future and affecting the users operations and way of work.

More specifically a set of "Vision Scenarios" were described during the first part of the Hydra project in the deliverable D2.1 "Scenarios for usage of HYDRA in 3 different domains". Among the agriculture depicted scenarios, the traceability one named "From farm to fork" has been considered as a key point from where to understand how effective the ICT assistance could be in the relative domain, but it is important to highlight some of the outcomes that constituted the basis on which the vision scenarios deliverable was constructed.

3.4 Envisioned agriculture application

In the following paragraph we consider both the initial vision scenarios, obtained trough a workshop held in Rome the 17th of November 2006, and the real use cases found as good examples of the use of ICT tools and methodologies applied to the agriculture domain, which represent a possible instantiation of the Hydra envisioned future agriculture.

3.4.1 The origin - vision scenarios

The agriculture and food processing use cases start from an brainstorming exercise where some experts were asked: "How do we develop and deploy intelligent, ubiquitous and secure networked products and services in agriculture and the food industry in 2015?". The trigger question was useful to understand aspects like market trends and threats, what are the needs of the farmers and how spread is the use of IT / ICT in the agriculture field.

The material collected at the meeting allowed to build up four scenarios elaborated after an intense reconstruction of the potential factors that could drive the future food production chain. Given the results shown in D2.1, in the next paragraphs we provide a short description of each of them, and then try to go backwards in respect to the exercise done during the initial Hydra workshop focussed on agriculture.

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.

The two major factors that were crossed to obtain the exemplificative scenarios are the technology exploitation in farming activity and the level of interest of the consumer towards quality food, as represented in the next Figure.

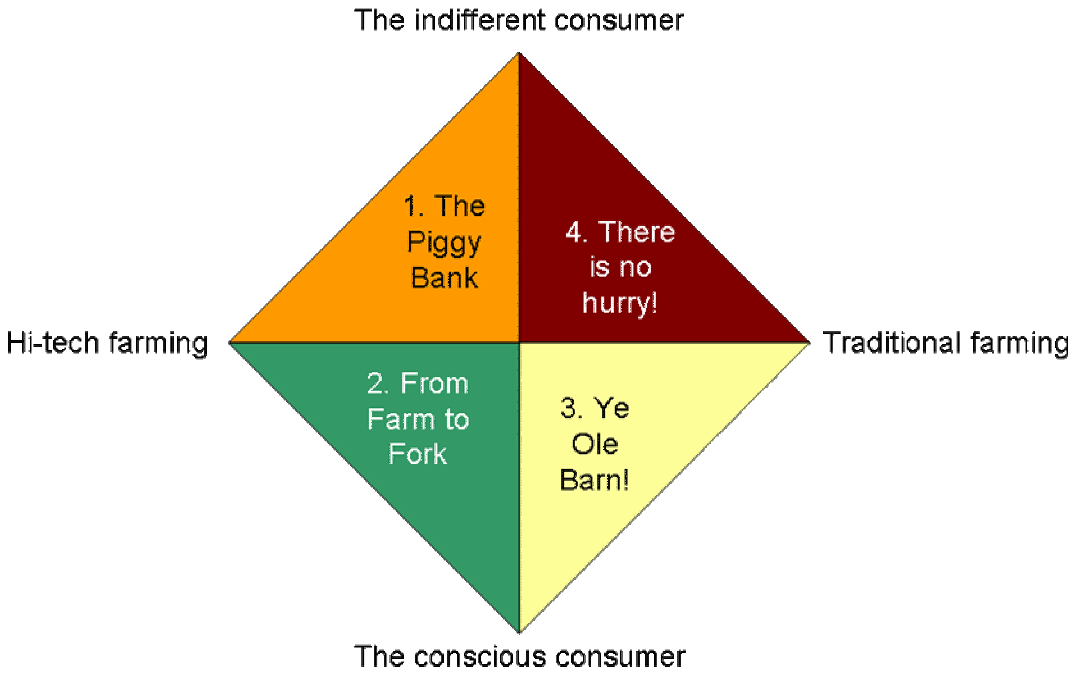
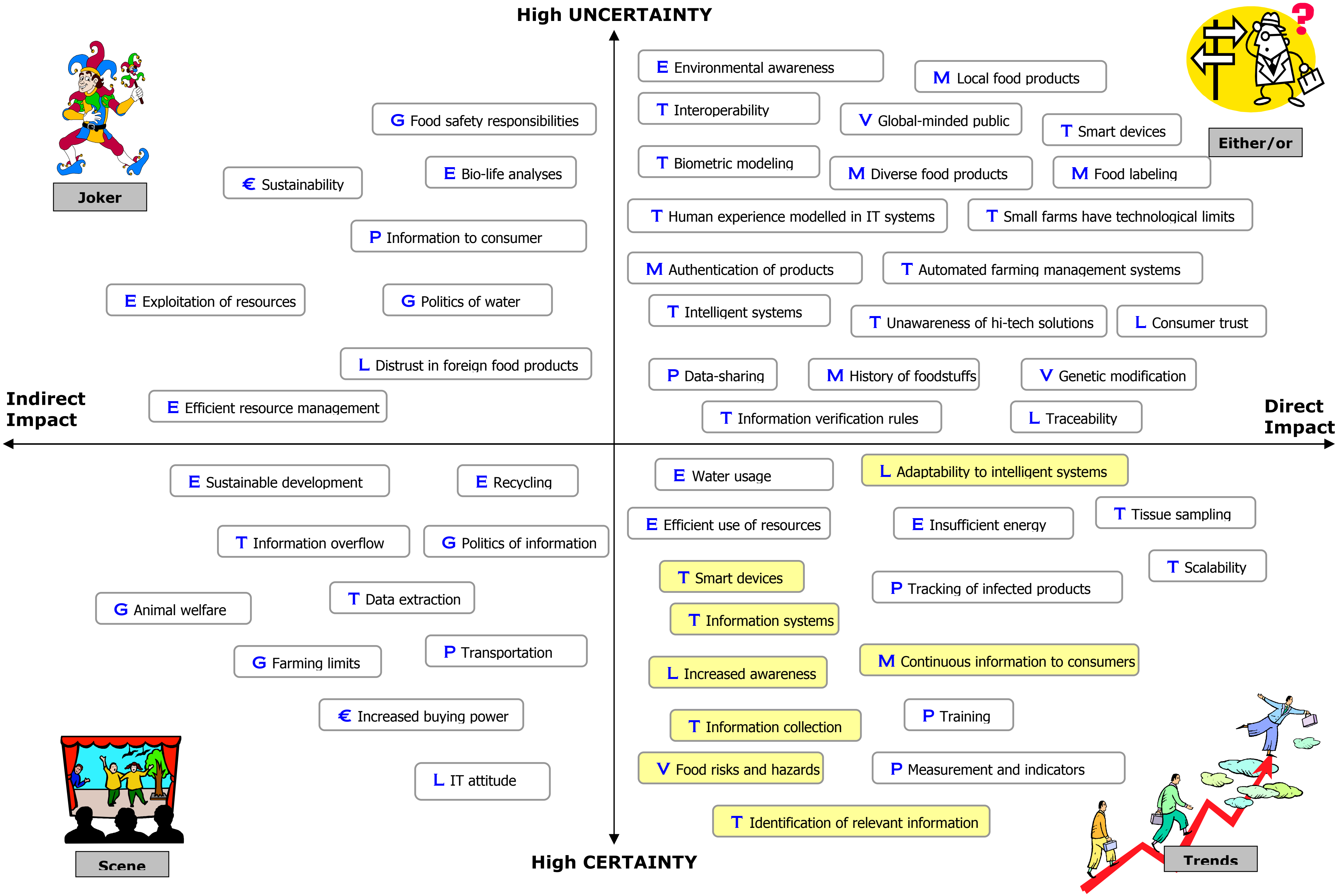


Figure 3: Relevant factors for building up the vision scenarios

The four scenarios answer to specific questions and fulfil special features which are relevant to the modern agriculture. We could observe that a major issue and need arising from societal demand is the increased safety for human beings, which in turn means better conditions for the livestock, as an example. During the same brainstorming a series of aspects emerged as drivers potentially influencing the organisational models in the agriculture and food processing domains.

The Table in the next page reports the important factors for the investigating the evolutionary paths for agriculture. We have highlighted the factors on the chart's Direct Impact and High Certainty quarter those concepts that the second workshop (i.e. the business modelling workshop) also highlighted as fundamental for the useful exploitation of the ICT into the most ancient and still traditional human activity.

The automatic recognition and storage of information (*awareness*) done with means of systems capable of automatic data collection (*smart devices*) and that are easily plugged into different context (*adaptability*) can provide a full set of information where both intermediate stakeholders (also and especially farmers) and final consumers are able to respectively guarantee the quality and verify the risks related to the food elaboration.



High UNCERTAINTY
High CERTAINTY
Indirect Impact
Direct Impact
Joker
Either/or
Scene
Trends
G Food safety responsibilities
E Bio-life analyses
€ Sustainability
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
L Adaptability to intelligent systems
E Efficient use of resources
E Insufficient energy
T Tissue sampling
T Scalability
T Smart devices
P Tracking of infected products
T Information systems
M Continuous information to consumers
L Increased awareness
T Information collection
P Training
V Food risks and hazards
P Measurement and indicators
T Identification of relevant information

It is interesting to observe that the same concepts underlined above emerge as important inputs in the actual use cases taken from real application implementing ICT in the food products and soil monitoring sectors, as reported in the next paragraph.

3.4.2 Uses case taken from implemented agri-ICT applications

After introducing the vision scenarios, an attempt has been made to identify implemented agriculture or food processing applications taken from real scenarios. The two examples activities reported below, presented during the workshop, seem in line and consistent with the Hydra objectives as the middleware usage in these frameworks could be effective and beneficial.

SCENARIO 1 - ICT applied to the food products Supply Chain management: "A healthy fish in our meal"

ICT innovation and competition have led to improvements in the supply chain management for food products. Supply chain improvements mainly aim to reduce inventories, waste, and costs, and thus increase efficiency within the firm and the market channel. In the following we report an example scenario from the post-harvest fishing industry, namely the Ugandan Nile perch exporter Marine Products Ltd, which is using methods originally designed by NASA to keep food safe in outer space.

Like other branches of the food sector, the post-harvest fishing industry depends on providing products that are both safe and which meet consumers' increasing demands for quality. Fish exporters have a particularly difficult job because fish are extremely susceptible to contamination. They are exposed to everything from pathogens and allergens to heavy metals, parasites and toxins, so the potential health hazards for fish consumers are legion. Moreover, fish are highly perishable. Especially in hot climates, significant quality losses can occur very soon after the fish are caught.

What is needed, then, is a control mechanism that takes in both these factors right through the entire fish processing supply chain, from the moment a fish is caught to the dispatch of the final product.

The chain starts with the local fishers, who are increasingly using ICTs in their daily activities. Localisation technologies and mobile devices, for example, now allow fishing crews to communicate with staff on shore, to notify them of any preparations that need to be made or to alert them to any difficulties. Many larger fishing vessels are equipped with computers and software that allow their crews to weigh their catch immediately and store it at the right temperature. Also, in the near future, sophisticated GPS and sonar devices will provide an affordable means of accurately tracking and determining the size of fish stocks.

Once ashore, the fish are subjected to quality control inspections with the help of software that measures the catch against predefined standards, assessing everything from the freshness and shelf-life of the fish, to their texture and post-mortem skin colour. The results are entered into a database. Fish that pass the test are transported to the processing plant, where they are weighed by electronic scales and graded with the help of another software package. The next step involves plant workers filleting or de-scaling the fish, while computer programs calculate the speed at which this is carried out and continually regulate work environment temperatures. When the fish have been de-skinned and trimmed, they are graded once more as workers input their new weight and quality parameters into a database. They are then quickly moved to a chilling/freezing area, where a computer monitors the temperature and total amount of time the fish are required to stay inside. The fish are subsequently packed in boxes or cartons and moved to a separate cold storage area, which is also computer-controlled, before being dispatched to the airport or port.

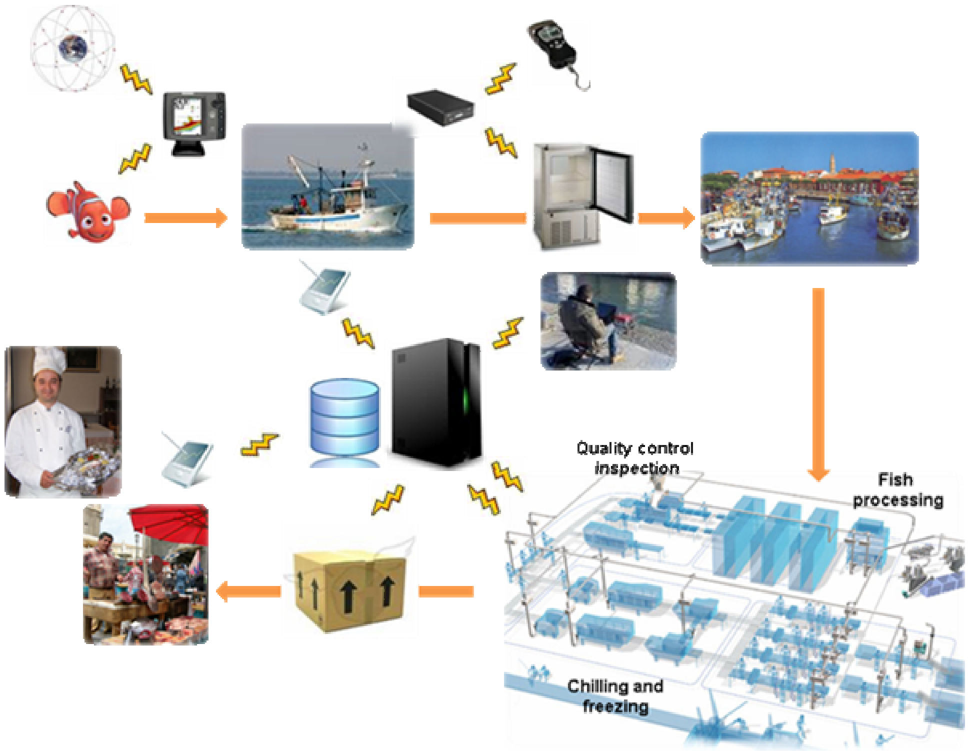


Figure 4: Traceability in the food value chain

The tracing ability so far stops here because the regulatory framework foresees that the control are transparent to the final user, but we could imagine that when the chef brings the meal we just ordered, he would be potentially able to let us know when and where the fish was caught, how it was fished, who transformed it into a fillet and the eventually the fish-shop where the restaurateur bought it (maybe not how much he paid for it!).

This final step would represent the link between the origin and the history of the food and the final consumer, ideally closing the loop "from farm (in this case the sea) to fork".

SCENARIO 2 - Wireless Sensor Networks for Precision Agriculture: "Sensing capabilities in open space through ICT"

Thanks to developments in the field of wireless sensor networks as well as miniaturization of the sensor boards, precision agriculture started emerging. Precision agriculture concentrates on providing the means for observing, assessing and controlling agricultural practices. Precise agriculture covers a wide range of agricultural concerns from daily herd management through horticulture to field crop production. It concerns as well pre- and post-production aspects of agricultural enterprises.

A facet of precision agriculture concentrates on site-specific crop management ("precision farming"). This encompasses different aspects, such as monitoring soil, crop and climate in a field; generalizing the results to a complete parcel; providing a decision support system (DSS) for delivering insight into possible treatments, field-wide or for specific parts of a field; and the means for taking differential action, for example, varying in real-time an operation such as fertilizer, lime and pesticide application, tillage, or sowing rate. In the following we report two concrete examples.

The COMMON Sense project (Community-Oriented Management and Monitoring of Natural Resources through sensor network) is about designing and developing an integrated solution for precise agriculture in the rural semi-arid areas of developing countries. It aims to provide poor farmers with a decision-support tool based on an improved knowledge of the conditions prevailing in the field, and on well-established models of crop prediction. For this, it proposes to use a wireless network of ground-sensors that will record periodically the state (salinity, humidity, etc.) of the soil, the temperature, the volume of precipitations etc. In a second phase, subterranean sensors will also be used to monitor the level and quality of ground-water.

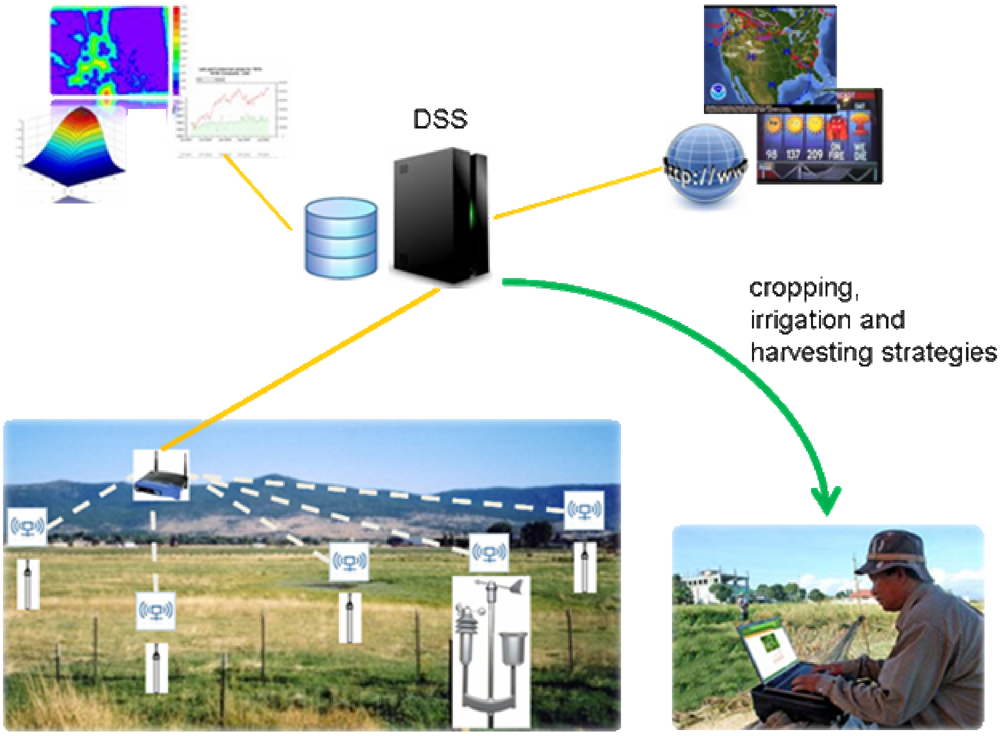


Figure 5: Soil monitoring: is it possible efficiently and economically?

More precisely, the applications envisaged are of 3 types:

- Calibration and verification of existing prediction models: A precise assessment of soil moisture can represent a significant asset for existing crop-prediction models, which were developed at a time where such information was not available and had to be assessed indirectly (based on precipitation). A more precise calibration to particular conditions could be made, as well as a validation.
- Assessment of water-conservation techniques: Comparative readings of soil-moisture can be used to assess the efficiency of different water conservation measures, such as building bunds and planting trees to trap water in the shallow layers of the soil, or using mulching and gypsum to reduce evaporation. In that case, soil moisture readings are used directly. Sensors are placed in comparable fields, where different water conservation measures are used.
- Deficit irrigation management: Deficit irrigation management requires optimizing the timing and degree of plant stress within restrictions of available water. Of particular use to the farmers is the knowledge of benchmark points for crop/trees water requirements (those points are specific to a particular crop). Using the recent trend of soil moisture values recorded by sensors and the knowledge of these points, the farmer can predict the behaviour of his crop and use simple water management techniques.

Sensors record data on a periodical basis, and send them in a multi-hop fashion to a centralized processing unit, which uses simple statistical computations and correlates them with meteorological and ground-water data to assess the optimal cropping, irrigation and harvesting strategy. The centralized processing unit can be linked to external meteorological servers to help in its decision process. This can be done, depending on the environment, through a wired or wireless connection, or a satellite link. Geographical distribution and density of sensors will depend on the particular field's topology, but in general a single ground-water sensor can span a few square kilometres, whereas soil-sensors can cover a few hundred meters each.

The pilot application deployed in Pavagada – a poor and rural region in India - consists of wireless sensors which are deployed in geographical clusters corresponding to the assignment to one base station, which is connected to a centralized server via an 802.11 (Wi-Fi) link. The sensors are also organized in groups, each group corresponding to a particular application, be it crop modelling, water conservation measures assessment or deficit irrigation management. From then on, the data are sent periodically to a centralized database. Sensors from different groups can collaborate for data relaying.

4. Contextual analysis

In the past years, the use of innovative ICT technologies has seen a rapid increase throughout mainstream Europe in almost every area of agricultural production and distribution. The ICT agriculture and food processing application areas are almost unlimited and specific implementations will be determined by actual customer requirements at the time of deployment.

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.

Farm Management Information Systems allow for elaboration of farm planning and easy tracking of performance, e.g. dairy cow or pig programs providing analysis of individual animal performance data. One of the biggest drivers to use farming management information systems has been the increasing emphasis on recording for statutory purposes, quality assurance and traceability. An interesting finding emphasises that the greatest increase in the IT usage in UK in the agriculture sector was due to a new VAT exemption scheme requested from the UK regulatory system, and the support given from the computers for completing the calculations was high.

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 intelligently present this type of information.

Moreover using Geographic Information Systems to identify the position of any product, farm or machine to a resolution of a few metres anywhere it is located is already a reality in the largest agriculture areas and in some special cultivations. There is an increasing interest to monitor existing levels of phosphate or potash and 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.

On the "demand" side, a 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.

4.1 Agriculture market description

4.1.1 General European overview

International food industry and food supply chains always faced an ever increasing pressure to deliver sufficient, safe, healthy and attractive food in a highly competitive environment. At the European level a turning point for the agriculture sector happened right after the Second World War, as there was a basic need to recover the European capacity to produce food and to increase the food production elsewhere (especially in the United States) for the export to Europe. The goal was, therefore, to supply abundant food at the lowest possible cost to consumers. EU farmers accordingly adopted new technologies to enhance production and, at the same time, fiscal policies to externalise the environmental costs of food production were promoted.

At a later stage, steps were taken to optimise the continental production. Farmers moved towards full electrification and mechanisation, wider use of chemicals to control weeds and pests, applications of information and computer sciences to improve management and marketing efficiency, use of knowledge of genetics to select appropriate varieties and modify desired characteristics and, finally, new external devices and sensor systems such as lasers for precise levelling of fields and global positioning system (GPS) technologies with satellite tracking and onboard computer monitoring to assist with more precise application of chemicals.

In the mid-1970s to the late 1980s the growth rate for global demand for agricultural commodities stabilised on an annual grow of 1.5% while from the mid-1990s to the present the market demand increased to 1.9% per year (USDA, Goldman Sachs Commodities Research, 2008). In recent years, although production is an excellent goal, the challenge that lies ahead in the forthcoming period is to make the transition from production agriculture to agricultural sustainability. Moreover, claims made with respect to health effects, sustainability and ethical aspects of the production chain need to be transparent to society.

The rapid growth in world population (13%), overall global income (36%) and meat consumption (beef 14%, pork 11% and chicken 45%) in the last decades are major drivers behind increased demand for raw materials.

Region	**1964–66**	**1997–99**	**Projection for 2015**
World	2 358	2 803	2 940
Developing countries	2 054	2 681	2 850
Sub-Saharan Africa (excluding South Africa)	2 058	2 195	2 360
Industrialised countries	2 947	3 380	3 440

Table 1: Global and regional per capita food consumption (kcal)

There are essentially four options available to meet this challenge:

1. increase the area cultivated, thus putting further pressure on the remaining land, including marginal ground and forests;
2. increase the productivity of the land currently cultivated, which is a more sustainable option;
3. improve distribution of agricultural products to ensure they are in the right place at the right time;
4. increase the environmental sustainability and optimise the consumption habits.

These challenges can be met by modern technologies, which therefore play a considerable role in sustainable agriculture.

Technologies and methods to ensure sustainability	Technologies and methods to ensure food security	Other technologies not directly linked to agri-food
Sustainable land use, production and distribution	Improved production efficiency	Bio-fuel production; logistics
Non-tillage practices	Food stocks' storage	R&D
ICT-based agriculture	Grain improvement	Logistics
Indicators for monitoring	Marker-assisted selection	R&D

Technology to counteract climate change	Genetically modified plants; bio-diversity	

Table 2: Agricultural technologies by category

A sustainable agricultural approach is to introduce technologies aiming to reduce input and increase output without depleting resources, such as soil-derived nutrients and water. Among them, biotechnologies and ICT have assumed an increasingly important role in boosting productivity while reducing manpower and production costs. As a result, over the last 50 years the cost of food has been decreasing steadily by between 10 and 50% compared with the average family's income. In order to achieve this, food production and distribution processes have been constantly evolving, from optimisation of use of arable land to new methods to turn areas not accessible at present, due to adverse environmental conditions, into arable land.

4.1.2 Information and communication technologies (ICT) in agriculture

ICT is one of the major technologies driving changes in both consumer demand and supply chain organisation. ICT allows the transformation of the food economy from an economy based on the production of physical goods to an economy based on the production and application of knowledge. Value added is created by making smarter use of natural and other resources. This imposes a strong pressure on true innovation in short cycles, which in turn requires a continuous interaction between analytical science (creating new insight), applied research and development (creating new products and processes) and industrial applications.

Information technology plays an important role in increasing transparency, but also in supporting production. New ICT applications are implemented in order to meet changes in consumer demand, sustainability requirements, international competition, logistics and product sourcing.

The ICT support in the domain is two-folded, as it is applicable "within" and "outside" the farm. In the first option the technology is installed or applied into the inner world of the farm or the livestock breeding. It means deploying a technical and organisational infrastructure for the management, control, help and advisory functions and activities throughout the farm business, aiming at information accessibility and elaboration at all places in the organisation through connectivity and interoperability.

After the original product has been realised inside the farm, the technological developments (ICT, processing and transport) make it possible to transform and commercialise it reaching suppliers and customers all over the world. Companies in the food industry are acting more and more on a global scale. This is reflected by company size, increasing cross border flows of livestock and food products, and international cooperation and partnerships. Food supply chain networks develop into open networks sharing information and offering many opportunities for generating added value. Food supply chain networks slowly become a part of the knowledge economy.

The spread of computer technology brought an increased number of agricultural practices that may be remotely controlled and monitored by computer-assisted methods. Although this provides cheap products to consumers, it raises questions regarding the quality, integrity and safety of the food.

The next Figure reports the increase in IT and ICT usage in the United States market between 1997 and 2007. Despite Europe has a basically diverse agricultural model where small and medium farms are much more diffused, the chart is a representative datum for understanding the worldwide level of diffusion of such technology within the agriculture sector.

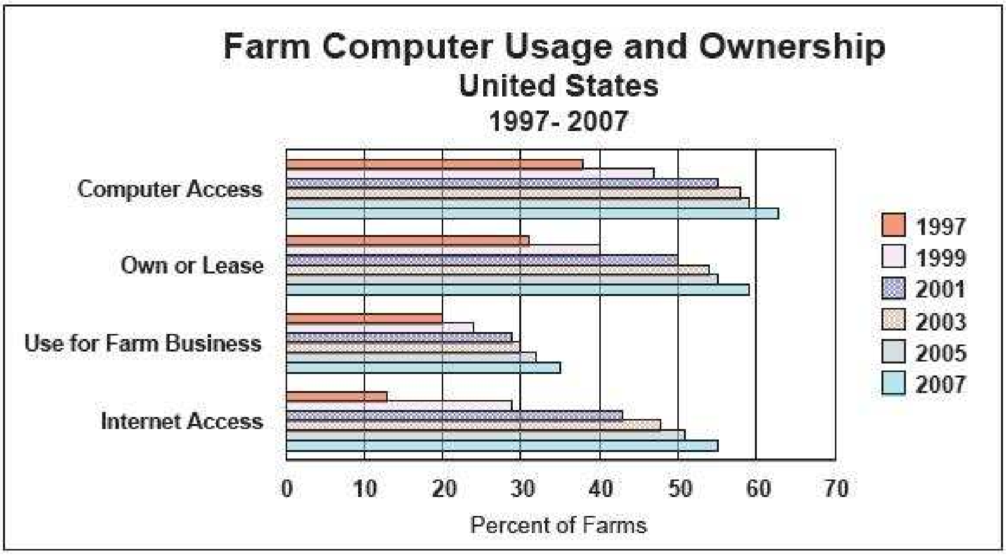


Figure 6: Information and comuunication technology penetration in US farms

Precision farming, also called 'site-specific farming', is the newest method in the most developed countries, in which advanced information technology tools are employed to ensure better land management, use of resources and quality control. With the aid of a global positioning system (GPS) and a geographical information system (GIS), nowadays it is possible to map precisely the area of farmed land and to monitor physical soil characteristics such as topography, salinity, etc. All the data can be stored and analysed at any time. Major advantages of such technology include improved crop yields, more efficient (lower) application of chemicals and, therefore, a reduction in the pollution caused by releases of chemicals into the environment. The decrease in chemical input applies both to use of fertilisers, due to 'variable-rate' fertilisation (applying discrete quantities exactly when they are needed), and to variable spraying of pesticides and herbicides, based on precise topographical maps which make restricted use possible. Precision farming is still at an experimental phase in some countries (e.g. USA), but could spread quickly once its advantages over conventional farming are established and commonly accepted. Agricultural technologies offer farmers new and better crops where also the ability to monitor certain input traits is fundamental, such as disease resistance (to virus, bacteria, fungi, etc.), pest (insect) resistance, herbicide tolerance and resilience to abiotic stresses (tolerance to cold, heat and drought) and so allow the farmers to increase harvest yield and minimise losses.

The production, processing and distribution of agricultural products and food are generally accepted as routine parts of everyday life, and the (increasing) interest of the agriculture world towards ICT moves step by step. Food and agriculture are means to an end that is not only technical, economic or political in nature but also inherently ethical, namely to feed the world's population while respecting future generations' needs and expectations in terms of food security, safety and sustainability. Moreover there are a few bottlenecks in the knowledge economy:

- new technology is initially used by early adopters, while ease if use is not always the major feature in innovation
- companies collect many data most of which are not used at all
- companies are not ready to process all data available

Managers, employees and the models they work with are not fully prepared for the knowledge economy as yet. ICT and the knowledge economy are about two issues: technologies and people. The most important challenge the food economy faces is getting the people ready for the new era.

4.2 Policy framework

The common agricultural policy (CAP) has been a key policy pillar of the European Union since its origins. It was originally conceived to expand production and provide secure food supplies to Europeans, following the food crisis after the Second World War. The CAP was therefore a key objective of the Treaty of Rome in 1957. The most important step allowed by the CAP in Europe was establishment of free trade in agricultural products between European Member States, in response to the need to allow a controlled market with a system of annual guaranteed prices and a compensation system to maintain fixed prices regardless of market fluctuations.

The CAP also established:

(1) a mechanism of high tariffs to prevent imports of products from non-EU countries at prices cheaper than those agreed in the EU

(2) subsidies for EU agricultural exports at a reduced price to help them to penetrate non-European markets.

This system, typical of the 1960s and 1970s, led to overproduction of food supplies. In the 1990s it was criticised for lack of food security, for the environmental impact of intensive farming and for its effects on rural employment and global justice. The EU has responded to the price surge on agricultural markets by adjusting market management: intervention stocks have been sold and export subsidies reduced — for example, to zero for dairy products. In addition, the EU Council of Ministers of Agriculture and Fisheries agreed to suspend, for the last year, the obligation for farmers to set aside 10% of their arable land, along with the import duties on cereals. Furthermore, the general move towards more market oriented agriculture, with less market support but also less restrictive supply control mechanisms, is allowing farmers to respond quicker to price signals.

In 2007, the EU adopted specific short-term measures to reduce prices of agricultural products, including increasing the volume of arable land by abolishing mandatory set-aside, increasing milk production quotas for 2008, reducing buffer stocks and export refunds and suspending import duties on most cereals. On 29 July 2008, the European Commission proposed establishing a special 'facility for rapid response to soaring food prices in developing countries'.

Agriculture is the main provider of food and has a great impact on nutrition and health and on economic growth. There have been many arguments about the distribution of both food and farmland between the rich and poor, in developed and developing countries alike. Most of the world's poor are small tenant farmers.

In order to increase their standard of living, the governments of many developing countries adopted (in the 1970s) policies for 'industrialising' agriculture. The fact that today there are more than 800 million people worldwide whose food supply is uncertain, even though sufficient food is being produced, points to a worrying distribution problem and is a sign of inadequate structures in agriculture and in world trade in agricultural goods. Global food production has apparently more than kept pace with population growth in recent decades and a diminishing proportion of the world's population are undernourished. There is, however, a worrying distribution problem in many countries. As the population has been increasing steadily during the last century in every continent, agriculture has been facing increasing challenges to meet goals such as provision of resources and, most importantly, of food.

As the world population along with its need for food grows, new technologies are necessary for creating and encouraging new methods of agricultural production and trade with a view to developing equitable food distribution capacity and a food-secure world. The current amount of land under cultivation cannot expand much further without detrimental environmental effects. Therefore, food production technology must create methods to improve the productivity of the land currently under cultivation and prevent harvest losses. An integrated scheme for effective use of land is crucial.

The importance of local culture and knowledge

It is important to recognise that agriculture is practised at a number of levels. Industrial agriculture, whether practised in developed or developing countries, cannot be confined to the requirements set out in this opinion, but provides currency and security to countries that can be used for the benefit of the people. It might be necessary to ensure that agriculture addresses the needs of local and/or regional markets first. This consideration makes it clear that development of the agricultural sector calls for an integrative action plan that covers, among other things, local and regional transport systems, health and education infrastructure and systems of accountability of political institutions and companies as much as rules for regional, international and global trade.

The ways in which food is prepared, served and consumed differ from one culture to another. Traditional and local knowledge constitutes an extensive realm of accumulated practical knowledge and knowledge generating capacity that is needed if sustainability and development goals are to be achieved. Many effective innovations are generated locally, based on the knowledge and expertise of indigenous and local communities rather than on formal scientific research.

Traditional farmers embody ways of life beneficial to conservation of biodiversity and to sustainable rural development. Local and traditional knowledge has been successfully built into several areas of agriculture, for example in the domestication of wild trees, in plant breeding and in soil and water management.

4.2.1 European Union regulations

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.

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:

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

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 'one-step backward, one-step forward' approach.

Farm to fork traceability

The European Union (from January 1, 2006), the United States, Australia, Japan and other Western regions have over the last few years introduced tough new traceability requirements covering farm products entering their ports. 'Traceability' describes the process of identifying what has happened to a product all along its supply chain, from the producer through the exporter, packager, distributor, retailer, etc., to the consumer.

Such comprehensive information exchange is necessary if traceability is to fulfil its goal of ensuring food safety while letting consumers know precisely what they are eating and assuaging their concerns surrounding such issues as intensive farming techniques, the use of chemical fertilizers and pesticides, and transgenic produce. These strict requirements on tracking farm products can sometimes be quite onerous for farmers. Retailers must increasingly be able to deliver information relating to labour conditions and environmental standards along their supply chains, and the farmers have a choice of doing nothing, and thereby being excluded from markets, or they can attempt to adapt. The web applications, GIS, GPS and RFID technologies are experimenting in developing-world farmers in order to continue to sell their products. With these technologies, control officers, supermarkets and ultimately consumers are now able to track the safety of food products 'from farm to fork'.

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 or transported 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 slaughtered.

European Convention for the protection of animals kept for farming purposes (ETS n. 87)

In March 1976, the member states of the council of Europe, considering that it is desirable to adopt common provisions for the protection of animals kept for farming purposes, particularly in modern intensive stock-farming systems, issues a convention to define basic principles should be observed about animal life conditions in a breeding context. In particular these articles define that:

(1) Animals shall be housed and provided with food, water and care in a manner which (having regard to their species and to their degree of development, adaptation and domestication) is appropriate to their physiological and ethological needs in accordance with established experience and scientific knowledge

(2) The freedom of movement appropriate to an animal, having regard to its species and in accordance with established experience and scientific knowledge, shall not be restricted in such a manner as to cause it unnecessary suffering or injury

(3) Where an animal is continuously or regularly tethered or confined, it shall be given the space appropriate to its physiological and ethological needs in accordance with established experience and scientific knowledge.

(4) The lighting, temperature, humidity, air circulation, ventilation, and other environmental conditions such as gas concentration or noise intensity in the place in which an animal is housed, shall - having regard to its species and to its degree of development, adaptation and domestication - conform to its physiological and ethological needs in accordance with established experience and scientific knowledge

(5) No animal shall be provided with food or liquid in a manner, nor shall such food or liquid contain any substance, which may cause unnecessary suffering or injury

(6) The condition and state of health of animals shall be thoroughly inspected at intervals sufficient to avoid unnecessary suffering and in the case of animals kept in modern intensive stock-farming systems at least once a day

(7) The technical equipment used in modern intensive stock-farming systems shall be thoroughly inspected at least once a day, and any defect discovered shall be remedied with the least

possible delay. When a defect cannot be remedied forthwith, all temporary measures necessary to safeguard the welfare of the animals shall be taken immediately.

Animal Transports

On 22 December 2004 the Council of the European Union adopted a Regulation on the protection of animals during transport, which helps to safeguard animal welfare by radically improving the enforcement of animal transport rules in the EU.

The Regulation amounts to a radical overhaul of existing EU rules on animal transport and identifies the chain of involvement in animal transport, defining "who is responsible for what" and thus making for more effective enforcement of the new rules. The Regulation has more efficient monitoring tools, such as checks on vehicles via a satellite navigation system as from 2007. It also has much stricter rules for journeys of more than 8 hours, including a substantial upgrading of vehicle standards.

4.2.2 Rights and responsibilities in agriculture

Agricultural ethics is about choices for people engaged in agriculture, either directly as farmers or indirectly as government regulators, extension agents, researchers, industrial workers, lawmakers, technology developers, consumers or protestors. This calls on decision makers and relevant stakeholders to promote and implement responsible use of agriculture, based on respect of a number of (ethically justified) fundamental rights. In this context, decisions on ethically sound design of new technologies in modern agriculture place responsibilities on those called to take them and monitor their implementation.

Of necessity, agriculture is intended for the benefit of human beings, society and, if sustainable, the environment.

These are not necessarily the same, since the benefits to living human beings could, in the short or long term, entail a cost to the environment. Human use of the environment over the 10 000 years we have been harnessing nature has been relatively benign. In the last 100 years, however, we have made rapid, and possibly irreversible, changes to the environment, including excessive use of fossil fuels in relation to their replacement, excessive use of water, production of greenhouse gases and a huge increase in the human population. In this context, the concepts of beneficence and non-maleficence acquire a relevance to support the production of safe, healthy and high-quality food in agriculture.

Individual and collective responsibilities for food security and sustainability should not be confused. As far as food security is concerned, responsibility also lies with individuals and their choices in food consumption. For example, following diets rich in meat products and purchasing non-seasonal food certainly have an impact on global warming, food scarcity and erosion of arable land.

Similar considerations apply to management of food waste and global hunger. Consumers' responsibility with regard to food security and the hunger divide is lower than their responsibility for food sustainability, since food security depends mainly on the design of national or supranational agricultural policies and trade rules. Responsibilities also lie with different players involved in the agro-food sector: food producers, food retailers, food distributors and policymakers in the agricultural sector at regional, national or supranational levels (the EU Member States and the EU as a whole).

Food producers have direct responsibilities for food safety and quality (technologies used for production and methods) and food sustainability (methods of production and raw materials imports). Food retailers have direct responsibilities for food security monopolies, food price increases, non-seasonal food, etc.), food safety (food quality and public health) and food sustainability (imports of food, large-scale farm production, etc.).

Food distributors have direct responsibility for sustainability (food miles and methods of transport).

Policymakers have responsibility for implementation of equitable and fair food systems (food security, safety and sustainability) at both national and supranational levels. They also have responsibility for monitoring that all involved in the food production, processing and distribution system act in ways consistent with the abovementioned rights.

4.2.3 Food safety and waste

Food safety covers the conditions and practices that preserve the quality of food to prevent contamination and food-borne illnesses. It entails protecting the food supply from microbial, chemical and physical hazards or contamination that can occur at all stages of food production and handling: growing, harvesting, processing, transporting, preparing, distributing and storing. Food safety is therefore a heterogeneous and multidisciplinary issue that concerns not only the food products as such but also the production methods. In this context, considerations relating to agricultural safety (use of chemicals) for the environment, wildlife and farm workers take on key importance.

The major problem for farmers who supply supermarkets is that they cannot raise their prices to pay for the investments needed to meet the quality and safety requirements set by the supermarkets. This appears to be true through out the world, whether in developed or developing countries. An emerging concern is, therefore, whether the EU CAP should focus on food safety and consumer protection and promote the quality and healthiness of food products. European food safety measures applied to importing countries should be proportionate. The EU, Member States and relevant bodies (European Food Safety Authority-EFSA in particular) are working to enforce the food safety standards and consider it necessary that:

- food safety standards have to be based on scientific data only;
- if food safety standards for food products from arable agriculture differ from international standards, they must be scientifically justified.

Food waste is a major issue in modern times from several points of view. First of all, from an ethical point of view, as better management and distribution of food resources could be beneficial to society's least privileged. Secondly, from an economic point of view, as food waste implies a considerable loss of money. And thirdly, from an environmental perspective, as decomposition of organic material is a major contributor to greenhouse gas (GHG) emissions which cause global warming.

Every process entails a certain margin of error, from production to distribution and consumption. There are several sources of waste all along the process, starting from harvest, where efficiency is never 100% and some of the harvest is lost because it is damaged or not ripe enough. Post-harvest losses then add up to 30% to 70% during storage (where part of the harvest will be lost because of inappropriate storage conditions, e.g. due to mould, rodents, etc.) and during transport from the production, storage or processing site to retail shops, where a certain amount of production is lost because of damage. Eventually food reaches supermarket shelves where, under current marketing practice, a proportion of it is unavoidably thrown away because either it has passed its sell-by date (a problem connected to overstocking of products) or it is overripe or spoiled. Last but not least, at the consumers' end, household food stocks are not optimally managed, resulting in remarkable quantities of food waste (though very difficult to quantify).

Apart from ethical and economic issues, environmental concerns about food waste are attracting increasing attention, as biodegradation of food releases methane, a greenhouse gas (GHG) 20 times more damaging to the environment than carbon dioxide (CO2) as it adsorbs 23 times as much heat as CO2. Biodegradation in low-oxygen conditions ('anaerobic digestion') produces biogas, a natural gas which is made up of 60% methane and 40% CO2. If this process takes place in an open landfill, the biogas released makes an extremely negative contribution as a GHG emission, but if it occurs in a controlled manner (such as in a biogas power plant), this form of biogas conversion offers a renewable source of fuel. In this way, organic matter such as food waste could be used to generate energy in an environmentally friendly manner and as an alternative to using fossil fuels for the same purpose.

4.2.4 Sustainability of agricultural technologies

The need to maintain productive agriculture worldwide is emphasised by the fact that a large proportion of the world population lacks proper access to food and by the recurrent food crisis in 2007 and early 2008. However, the strong ecological impact of agriculture highlights the need to implement a different model of agriculture in the future: a sustainable and multi-functional agriculture where, apart from securing safe food for everybody, stewardship of the land, preservation of the resource base, the health of farm workers, preservation of the small biota that are rich in biodiversity, the value of rural communities and the value of the agricultural landscape acquire important status.

From an ethical perspective, sustainable agricultural technologies should help to maximise use of natural resources while protecting them from exhaustion and thereby allowing natural regeneration. In order to achieve this:

(1) there is a need to optimise processes involved in primary production, distribution and storage of food;

(2) use of arable land needs to be optimised and methods are needed to turn areas not accessible at present, due to adverse environmental conditions, into arable land;

(3) all other processes involved, ‘from farm to fork’, need to be optimised and simplified (to reduce harvest losses and waste and, where possible, to implement waste recycling systems).

Technology impact assessment and the European Group on Ethics (EGE)

In the field of new agricultural technologies, in addition to risk assessment, there is a need for impact assessment at national and European levels. Impact assessments examine the risks and benefits to human health and the environment of using a new technology and those of not using it, including the risks and benefits of retaining current technologies. They take account of the need to ensure sustainability, food and feed security and safety.

Such impact assessments should consider safety (agro-food and environmental) issues and also address the social implications, e.g. how agricultural technologies will affect social, economic and institutional structures, with particular concern for justice (equal access and participation in decision making) and fair distribution of goods. Furthermore, the research should also examine the risk of creating a technological divide which could widen the gap between the developed and developing countries.

The EGE (in science and new technologies) is aware of the great variety in primary production methods for agricultural products of plant origin and of the fact that several regions in the EU still use traditional methods of agricultural production. The group recognises the need to respect the diversity of EU primary production, but is equally aware of the need to make EU primary production of food, feed and fibre of plant origin competitive on the global market and, therefore, of the need for innovation in this sector.

The group supports the current efforts by the EU to promote innovation in agriculture but calls for specific efforts to support mainly technologies that are conducive to food security, safety and sustainability in order to ensure ecologically and socially sound agricultural production (techniques and methods), based on fair treatment both of the environment and of farmers.

The EGE also recognises that agriculture brings both benefits and harm, particularly to the environment, and that all technologies could involve risks with irreversible effects. The group therefore believes that, before a technology is considered for use in agriculture, its effects should be carefully studied and evaluated by means of an impact assessment that takes account of a comparative assessment of the current and new technologies. This assessment should be guided by an integrated approach to agriculture where both environmental and social implications are taken into account.

The group is aware that a number of products currently used in agriculture could pose a risk to human or animal health and to the environment, especially when used in high concentrations.

Technologies that reduce the need for dangerous chemicals whilst maintaining yield and quality should be promoted. In particular, protection of human and animal health by lower exposure to chemicals should be encouraged. As mentioned previously, the group urges that an impact assessment should be conducted for all new technologies used in agriculture in the light of the goals of this opinion, giving priority to food security, safety and sustainability.

The group is aware that soil erosion and water pollution are consequences of agriculture and therefore stresses the importance of the non-tillage techniques and improved water management plans developed over the last few decades in order to implement better preservation practices, in keeping with its recommendation on an integrated approach to agriculture. The group encourages use of all technologies and methods to increase soil productivity prevent soil erosion (deterioration of soil quality) and water pollution and promote recycling of waste material (e.g. cellulose biomass for production of ethanol). In this context, the group supports the use of:

(1) proven techniques (such as contour farming and non-tillage techniques), where appropriate for sustainable use of soil;

(2) bioengineering for the sustainability purposes indicated above (e.g. reduction of spray pollution, active ingredients in herbicides and CO2 emissions);

(3) modern genetics, where appropriate and safe in order to improve and select crop varieties appropriate to specific environmental conditions (e.g. in the case of MAS for plant tolerance to high salinity);

(4) ICT tools for optimisation of agricultural plant products (global positioning system and geographical information system or ICT tools to optimise irrigation and monitor physical characteristics of soil, such as topography, salinity, etc.);

(5) all technologies and methods that could be beneficial to better water management and prevention of water pollution. The EU should allocate funding for the implementation of optimal use of water resources.

The group supports precision farming in the EU and developing countries, where its advantages over conventional farming could be greater, and international initiatives such as UNESCO's International Hydrological Programme (IHP) for water research, water resources management, education and capacity-building, which aim to assess the sustainable development of vulnerable water resources and to serve as a platform for increasing awareness of global water issues.

The EGE group encourages the EU to increase the budget for research in agricultural sciences, green biotechnologies and all other sustainability-oriented agriculture research sectors within the seventh EU framework programme for research activities (FP7) in order to achieve the goals supported by the group in this opinion. At the same time, the group believes that Europe should ensure the highest standards of knowledge in these fields (including food safety, food technology, nutrition science, etc.), so that it can monitor introduction of these new products for public consumption. Research in these areas should be encouraged both at European and Member State levels for the benefit of European consumers and farmers.

Modern agricultural research should choose an integrated approach; accordingly, the overall aim of agrosystem research, including the interaction between different crops and the environment (plant sociology), landscape ecology, etc., should be to achieve an optimum net harvest of solar energy in forms beneficial to mankind and the environment.

Research funding and the brain drain in agro-food sciences

The seventh EU research framework programme (FP7) has a dedicated theme entitled 'Food, agriculture and fisheries, and biotechnology' covering three major activities:

(1) sustainable production and management of biological resources from land, forest and aquatic environments;

(2) "from farm to fork": food (including seafood), health and well-being;

(3) life sciences, biotechnology and biochemistry for sustainable non-food products and processes. It is important that Europe continues to have the highest standards of knowledge in these fields (including food safety and food technology) and, most importantly, that researchers in agro-food sciences are supported and motivated to stay and work in Europe. The brain drain towards non-EU countries seems to be a serious problem, as there is a risk of not fostering the next generation of researchers who will maintain high skills and knowledge in the EU.

The objective of the European officers, fulfilled also by engaging the most influential experts in the domain, is to assure a real impact of new technology in the agriculture sector, driving new forces and ideas towards the common benefit of having good and healthier products at our tables.

5. Business models and cases

5.1 Workshop on business ideas for the ICT use in agriculture

For contextualising the economical analysis into real business cases, an international workshop with invited experts and interested stakeholders was organised in Rome on 27/01/2010. The somehow provoking title was "Agriculture vs. ICT technology? Business ideas for integrating the Hydra middleware in the agriculture sector" recalling the typical wariness of the agriculture environment towards technology which indeed is lowering day by day due to strong know-how improvements obtained in the sector and the intervention of a simplified and more user-friendly equipment. The idea to mix together experts oriented on typical agriculture topics (the side more related to the "land", also with an academic background) and stakeholders with a greater orientation towards technology and market solutions (but applied to the agriculture or food processing domain) gave the possibility to prepare a common ground where triggering questions could stimulate the discussion and the comparison between different points of view.

The experts' interventions clearly showed that the application of Information and Communication Technology (ICT) in agriculture is increasingly important. An emerging support for the enhancement of agricultural and rural development through improved information and communication processes is needed and taking place: all stakeholders of the agriculture sector are exchanging information and knowledge about all phases of the agriculture industry (from crop cultivation to food marketing) to manage them efficiently.

The major challenges to be faced are not just technical, but also related to an increased regulatory pressure, which turns into a need for documentation creation, and goes in parallel also to a request of increased economical efficiency. Common issues faced in this domain are the sustainability, food quality, animal welfare, food safety and control mechanism, as pointed out in the previous paragraphs. As a general trend in this sector, there is a strong emphasis on networked solutions, e.g. for animal housing and control processing inside the farms, in order to monitor: climate (temperature, humidity, ventilation, CO2 concentration), electronic feeding systems, water flow management, animal status (weight, temperature, localisation), all accompanied by a centralised management software (resident on a dedicated server). Apart from farming management, the collected data are extensively used for calculating statistics and obtaining predictions. There is an increasing trend towards the widespread use of sensors, also including small sensors put on the animals and able to transmit a 3D monitoring measurement to the central controller, as well as new electronic ID for animals, based on UHF – RFID, able to read a distance of 2/3 meters. These are used in a plug&play style, so if placed into the network they are able to communicate with the remote controller, with no need of intermediaries.

Therefore, producers of devices and components are increasingly facing the need for networking their own and complementary products. The enormous amount of heterogeneous devices with embedded systems are already in place, but the diversity of the producers and manufactures, without a proper standardisation framework on place, put many difficulties to the selection of the right technology and devices to be installed in the farm. Often, different clock speed of technology deployment is an issue, and there is a large need for hardware and tools that easily can add, implement and exploit the intelligence embedded in the devices.

Being able to support the ubiquitous nature of widespread sensing applications reported above is one of the core features for the future Internet of Things and Services, and this represents the main outcome of the Hydra project. Understanding the business framework in the agriculture ecosystem is therefore an essential prerequisite for the successful deployment and exploitation of new solutions and applications in this domain. The Hydra workshop on agriculture devoted the second part of the meeting on identifying suitable business case (value constellations) and the respective most proper answers to the following aspects:

- potential innovative applications enabled from the Hydra middleware;
- business drivers and elements of a potential business model for the envisioned applications;

- potential stakeholders to target;
- cost and benefit, revenue streams for the selected use cases.

According to the experts, the potential enablers and drivers for making business in future agriculture scenarios are changing/evolving regulations and legal constraints at regional and national level, as well as the environmental efficiency (e.g. farms' economic optimisation, quality assurance and maintenance, eco-sustainability) which could be obtained by optimising the use of ICT, the innovation in farming techniques and improved technology together with improved methods.

Business drivers

In summary the following important drivers for the development of ICT in agriculture must be considered:

- Regulations and legal constraints
    - o at level of policy makers, in terms of constitution of the Legal Framework
    - o at regional level, in terms of regulatory organizations responsible for control and verification
    - o changing regulations requires flexible technologies
- Farms' economic optimisation (e.g. animal growth monitoring, monitoring diseases, benefit from benchmark to other farms by getting more information about their production processes)
- Healthy food: food safety, food quality (animals not treated with medicine), traceability
- Quality assurance and maintenance (including taste?; place of origin certification)
- Eco-sustainability and environmental aspects (preference for local products, using less water, using less fertilizer, …)
- Predictive models (clustered, targeted groups)
- ISO Standards (i.e. 'Ontology of the Food' program, developed by the FAO)
- European / public aids to farmers

Constraints and risks

1. Security?
    - Data access shall be regarded as a fundamental requirement, as the information collected and processed in the food production and logistic chain are very sensible
2. Bandwidth / broadband?
    - Broadband could be an issue in the communication to the "external" world, in respect to the farm universe
3. Always-on / low power consumption?
    - The need to have a consistent and constant knowledge of the farms' building blocks appears as a problem for the sensors' power consumption
    - Complementary problem to the farm connectivity, as it is related to the inner farm management instead of the external communication
4. Business Intelligence?
    - Smart systems have been implemented, but they are covering single aspects of the farm management rules and are closed or proprietary applications

- Smart systems are related to both the inner management of the farm and its openness to external entities

5. Usability / easy of use?

- In a questionnaire (1999) prepared from the European Federation for Information Technology in Agriculture (EFITA) it emerged that the three most important factor determining a low penetration of IT into the agriculture sector were (i) the inability of farmers to use IT, (ii) the low perceived benefits - economic and others – and (iii) the difficulty to use or unfriendly interaction; cost was only at the fifth place.
- Also nowadays it appears that the usage of modern ICT systems in the farms is often managed from external experts or specialised consultancy, who know the software interfaces and the possible operations (this regards also the HMI) and algorithms

6. Cost?

- As said before the cost of the IT (ICT) technology doesn't seem to be the major problem faced from farmers. It is worth observing that while the sensing and communication devices could be found at low prices, most probably the need to call external expertise for ICT configuring, operating and maintenance can be perceived as a relevant expenditure
- As a consequence it is observed that only bigger farms can afford the initial investment cost for setting up the stables or crop fields infrastructure

One potential innovative application was identified during the event from TNM, while another business idea was shared among Whitehall and University of Bologna. In both cases the Hydra technology could intervene in the interoperability aspect for integrating the devices exploited in the scenarios, such as heterogeneous sensors seamlessly connected to the central intelligence, and create a homogeneous mean where the data can flow easily, allowing a smart (or unique) central equipment to get the single data converged and processed into the central elaboration system.

The experts' discussion session drafted a basic business model focussed on the collected experiences and proposals. The model, whose building layers resent also the tasks representative of a simplified agriculture value constellation, is represented in the following Figure and is applicable to both business cases. It presents a layering structure where each stakeholder / function is necessary for the layer above. The final user dimension is not indicated, but it would be of course at the top of the stack.

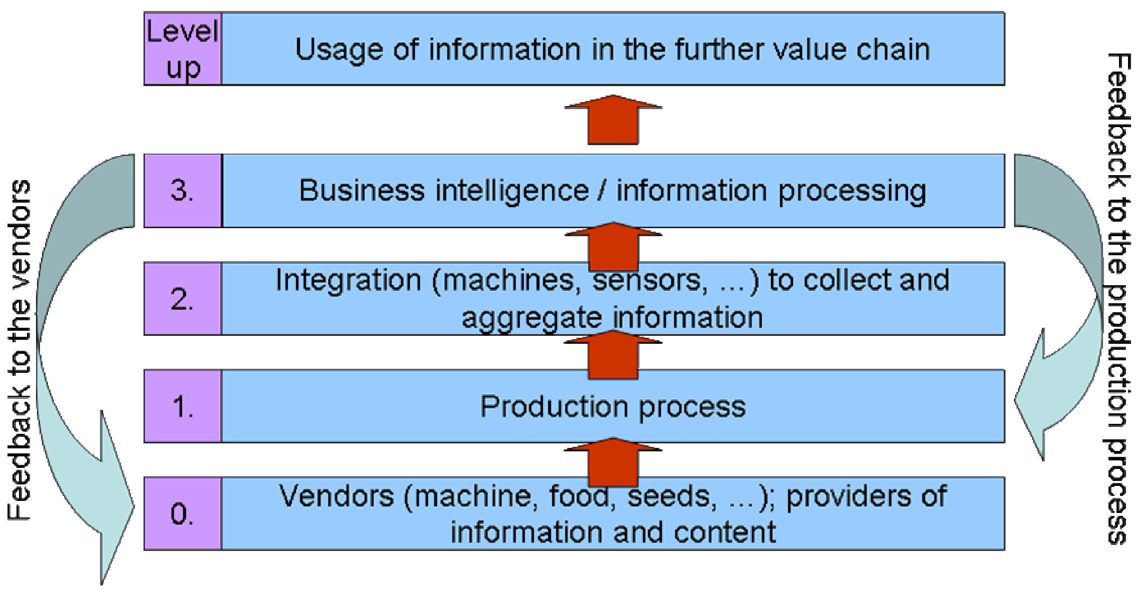


Figure 7: Basic model layering structure

The layers are characterised as follows:

Upper levels. *Usage of information in the further value chain* represents all the actors outside the "inner value chain" that are around our business concept. Here also end users are comprised, commercial representatives, or public bodies focussed on this domain.

3. *Business intelligence/ information processing* is referring to a knowledge based company able to elaborate the disaggregated and heterogeneous data coming from the soil (or the farm, the crops, the livestock) and extract useful data for the evaluation, management and certification of the agriculture production. Of course these data shall be given as a feedback to the production process but also to their suppliers which are the vendors and providers of basic products, information, devices used in the production process.

2. *Integration* (among machines, sensors, …) groups together any HW/SW system developer who implements an ICT infrastructure capable to collect and aggregate information, e.g. in a farm management system

1. *Production process* is the farmer himself or the food processing entity, who produce basic ingredients or elaborate them for preparing food stuff. Also packaging and delivery shall be listed among this group.

0. *Vendors* of machine, food, seeds, …, are the actors who provide material, components, information and content used to support the production process (i.e. land and animal monitoring machinery, weather databases, geographic information systems, satellite images providers).

The layering as it is organised represents also the basic actors present in a simplified agriculture value chain. Each stakeholder/function is necessary for the layer above, while the end user dimension is foreseen at the top of the stack.

By considering the former layering as the framework where our business model instantiation moves, in the potential use cases discussed at the workshop where Hydra could be extensively applied, a more detailed list of the key players involved in the business case could be identified as follows:

- Farmers and farms' employees
- Farmers' associations and local consultants
- Software producers for livestock / crops management
- Data modelling experts
- Database / content providers
- Device / machinery manufactures
- Governmental agencies and authorities (also product safety)

The exercise reported in the next paragraphs tries to identify a suitable configuration of the previous stakeholders, explaining the details of the two business cases and building an optimal instantiation of the value model. The value modelling study is applied through the e3Value tool, used for calculating the long term cash flow in order to verify the viability of the proposed use cases.

5.2 TNM A/S

5.2.1 General description

TNM A/S is a Danish company specialised in software development in software engineering, herd management and statistics on the agricultural sector. It has a high level of knowledge and experience in computer science based on mathematical methods/models and IT deployment and operations. Through close cooperation with other companies, trade associations and universities TNM A/S operates as a farmer's IT department and expert of IT security.

One of the departments at the TNM group is competent in delivering optimal IT solutions for existing farming machines and for new farm buildings; at present it administrates the IT infrastructure of approximately 2.000 farms in Denmark, installed by their experts in collaboration with farm automation suppliers. The enterprise has proprietary software and it is able to provide remote support to each farmer.

The next figure shows a typical architecture for the farm ICT infrastructure adopted from the company.

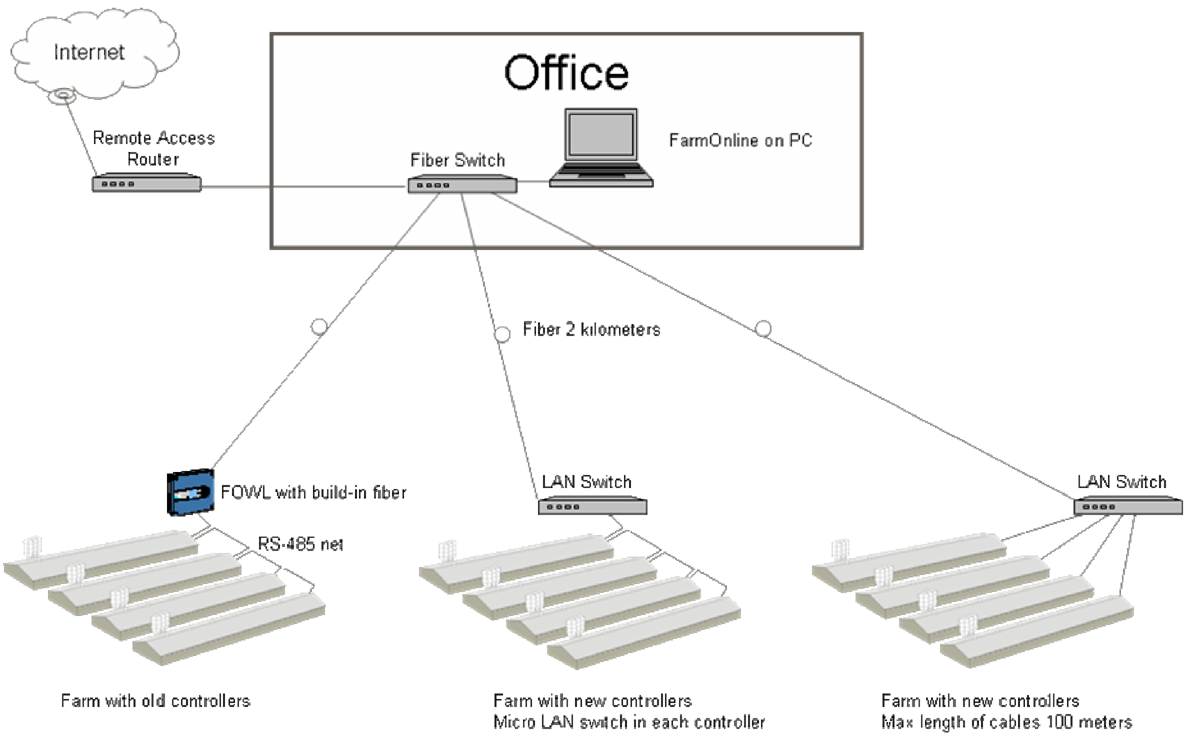


Figure 8: Farm IT management scheme

The solutions consider the highest level of IT security, as they must ensure the trustability and robustness of the system. The policy on who should have access to individual computer units on a farm is assured; this applies to employees, consultants and suppliers who typically need to have access to individual or several of the farm's computer units. Usually the farmer decides who has access to what on the farm, and for example, when an employee stops his tenure, the farmer can prevent him all access to the holding IT equipment. Their most successful application is called FarmGuard®, a software solution designed primarily for giving farmers the ability to manage and share IT at their farm in a simple manner with the highest degree of safety.

Figure 9 below shows an example of the user interface lay-out. The image contains a representation of the entire livestock farm, which is a pig breeding farm. It is also possible to zoom in inside a single House and get its environmental parameters.

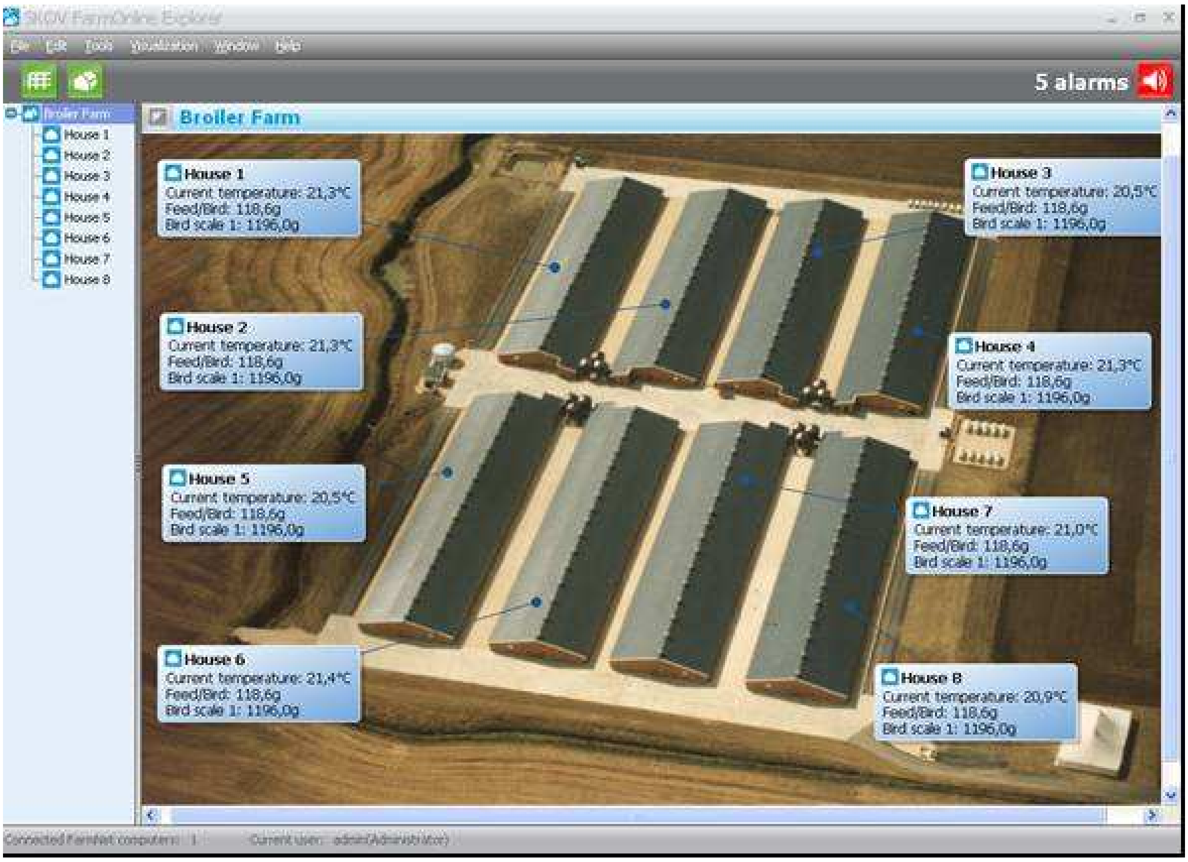


Figure 9: TNM application screenshot example

The hardware is set-up as seen in Figure 8, with optical fibre as a backbone to the farm operating central and LAN Ethernet or RS-485 within the different livestock houses. As all sows in EU shall be housed loose from 2013, there is an increasing interest on this type of farm scheme and the relative monitoring systems. With the implemented application it is possible to verify the water consumption and elaborated average data, for example the consumption per hour during 7 days, and then elaborate a profile of "normal" activity for the livestock. A comparison between the forecast vs. observation is able to highlight any discrepancy in the sows behaviour and to predict diseases or if a sow is pregnant, or other situations where an alert is recommended.

5.2.2 Prospect model in relation to Hydra

The most critical part of the architecture is represented from the sensing devices used inside the houses, better than the communication backbone. Thomas Nejsum Madsen, the responsible of TNM and the key note speaker at the workshop, reported that the interoperability aspect is the largest problem faced at this moment. Despite the fact that quite a number of technologies and solutions already exist, most of them are proprietary both on the hardware but especially on the software/interface side. The ideal situation would be to have sensors easily and seamlessly connectable to the central intelligence in farm management system. This would allow a wider market for different apparatus (sensors, devices, elaborators) because they would be able to communicate more efficiently, just as a plug&play component.

At the present this can hardly be done, but such a feature would open up the doors to several new business opportunities. In this context the Hydra middleware would contribute immensely by enabling heterogeneous systems to communicate and cooperate together. This represents the starting point for the first business case hypothesis, inspired from the TNM actual customer relation but oriented towards the future foreseen/desired market proposition.

TNM company's Business Development unit is proposing to install and offer a completely new farm management service based on the Hydra middleware. The service will be initially offered in Denmark to those livestock farms already managed by the enterprise, but the objective is to enlarge the customer base towards newcomers. Each farmer upgrading its actual management system will be provided with a new software platform where no change of hardware, central units or devices is necessary. In addition, new monitoring devices and actuators shall be seamlessly added to the system as necessary, without requiring any architectural change. Actually the most common devices are measuring climate parameters (temperature, humidity, ventilation, CO2 concentration), water flow and feeding data (quantity, frequency), animal status (weight, temperature, localisation), but with the new software evolution the interesting part is not just that each added device enters the system without major effort (just plug and play) but all the actual components already present in the farm houses reaches a much higher level of integration, allowing a simpler interaction among the different devices even if their communication/standard interfaces used from the OEM are not the same. This entails by itself a richer and more performing farm management application where there is both an optimisation of the code simplicity and the time spent to write it.

The appealing idea to have an easier integration of new modules, coming from different device manufacturers, also opens up new markets and customers attracted by lower infrastructure costs. Also other relevant sensors and hardware may be added later, as the entrance barrier for new hardware producers may be also lowered. The new service provided will allow farmers to monitor a large number of livestock parameters. The aim of the service is to provide highly reliable and robust feedback that will help the farm workers to better monitor and assist the animals and the farm houses.

The Danish agriculture association is largely in favour of this change, as it can represent a fundamental step towards a national (and European) farming monitoring system able to help the improvement and the control/certification of the entire agriculture value chain, including the smaller actors and the remote rural areas.

5.2.3 Stakeholders and value objects

Form the company description of the foreseen strategic business we identified the following major actors and stakeholders in the farm management business service:

- Farmers (livestock breeder)
- Device manufacturers
- The Hydra service provider
- TNM A/S
- The National authorities

Farmers (livestock breeder)

In Denmark, there are 8.000 farms potentially interested in an advanced farming management system. The estimation includes the actual group of farms that are already customers of TNM (2.000) and other 6.000 medium and large farms.

The initial target group for the Hydra enabled farm management service is the actual number of customers already managed from TNM A/S (2.000). After the service is installed into the actual group of customers, it is foreseen to achieve other 2.000 new customers that will request new installations in their farms. The customers who enrol in the innovative farm management service are expected to obtain substantial benefits due to the improved system integration and better control of their livestock. Farmers will also benefit in terms of receiving more efficient and convenient service due to software improvement and optimisation.

The value objects for the farmers are that the hardware is no longer dependent on the farm management system; they can buy the machinery at the manufacturer they prefer, adding new devices or releasing old hardware too expensive to be maintained. The substitution of the previous software components ensures continuity in the farm management and a smooth firmware change in the farm infrastructure, enlarging the information retrieved and monitored. From another point of view, an important value object for the farmer is the possibility to use the security features imposed from the Hydra farm management service for providing certified data to the National agriculture authorities, who are interested to be aware of any safety related aspect in advance as well as be able to gather statistical information on the national livestock production.

The relationship between the farmer and the device manufacturer becomes direct, and is no longer related to the farm management system provider.

The relationship between the farmer and the system integrator (TNM) is still direct. It slightly changes because it is related just to software and firmware components, and no longer related to the infrastructure for the farm management system. It is composed of two different value exchanges, the upgraded software and the facilitated reporting system elaborated for certifying and delivering the data to the public authorities.

The relationship between the farmer and the agriculture governmental agencies becomes even more direct than before, because the farm management service may provide a secure and direct link for delivering certified information (they can be certified because the devices are able to send the data to the central intelligence in a secure way and the elaboration from third party can be dropped or controlled).

In this last occurrence a possible financial assistance (or a de-taxation scheme) from the National authorities could be foreseen in case the farmer agrees to deliver information of his livestock that is useful to the governmental agencies.

Farmers would expect the supporting technology to work at all times and to be very simple to use.

Device manufacturers

The machinery producers for livestock monitoring in Denmark and elsewhere are not in great number, due to the specific market niche, which is not large enough to guarantee scale economies and drives to low technology diffusion. A wider market, hopefully in the same direction of the Hydra technology penetration, may decrease the entrance market barriers for new device producers and increase the economical benefits for the entire value chain.

The advantage for this category, which represents its value object, is a larger distribution of products not just as fully-featured integrated installations, which tends to be sold to greater farms but also single devices and components. This may enrich their commercial capabilities, not focussing only on the major players but also on a wider group of potential users.

The (unique) relation with the farmers could go towards a direct link where the device manufacturer sells directly to them without being forced to sell a complete package or to adapt their systems to other system integrators requirements.

The National authorities

The National Danish authorities are responsible for deciding the agriculture polices and monitor quality, quantity and safety of the food products available from the national land. The agencies must provide precise and robust information to the Danish and European citizens about the agriculture production. They operate with different entities which are considering different aspect of the food processing chain, from laboratory analysis to financial evaluation to food certification.

Their strategic interest shall be to collect seamlessly, remotely and without delay the enormous amount of data available from the farms located in different parts of Denmark. This would solve a sensible problem faced in relation to the correct collection of data in the agriculture (and at a later stage, to the food processing industry) domain. It is presumed that the overall savings in terms of less public expenditure for collecting agricultural figures would amount to 50% in case the penetration of such connected platform reaches large part of the Danish farms.

The relationship between the National authorities and the service provider is indirect, while it is direct towards the farmers, who are providing the data with means of the intelligent system provided by TNM.

TNM A/S – System integrator

This is the company who decided to implement a new service by using the Hydra technology. The new software release is able to interface with different hardware systems; any new device can be easily integrated into the farm management system with the help of the Hydra enabling devices team. TNM identified itself as the early adopter in the Danish agriculture domain for a Hydra based livestock management service. The developed business is being used to present the concept and the potential cost-benefits analysis as well as other supply chain benefits.

The business case is based on a re-engineered farm management service on the hypothesis of putting it in use for the farms already managed by the company. The business case will identify the value creation around this actor and to the different stakeholders and provide a basis for discussion and negotiations.

The Hydra service provider

As can be seen from the above discussion, the Hydra enabling service provider will support the system integrator in the interoperability aspect of the farm management platform with the aim of deploying a better performing and more integrated system for monitoring livestock and providing the farmers and farms' employees with a supporting platform that allows them to manage easily and time-efficiently the entire farm.

In order to offer the services, the service provider will have to develop new software modules for interfacing devices and components with the server infrastructure and facilities, ensuring security and access control systems, etc. This corresponds to the value object for the Hydra developer. The number of sensing devices to be Hydra enabled depends on the number of device manufacturers' actually supplying machinery for the TNM management software.

In addition, the product demands sizable fixed operational costs for support and administrative staff functions, software licences, maintenance and upgrades, etc. Finally the product has a series of variable costs for network communication, power, etc.

5.2.4 The value model

In order for the business case to be viable and sustainable, we need to look at the cost-benefit (or profit and loss) implications for all actors. According the discussion in D10.5 Business modelling concepts, the proposition needs to provide positive cost-benefit or profitable operations to all actors in order to be sustainable.

At present TNM offers monitoring systems mainly for pig breeding to approximately 2.000 farms that are using their software. Sensors and hardware are very expensive and most often not interoperable. The evolution of their business proposition by introducing Hydra is foreseen as two-folded. TNM may become completely independent from the device manufacturer and ask for an intervention of Hydra technicians in order to get the interoperability with all types of machinery and sensors in the marketplace. In this way the enterprise can adapt its current farm management service to make it more performing on one side, but also more attractive for the market on a parallel level. So there are two potential business drivers:

- expand the actual number of farms among the customers
- put new or additional software modules in the farms already installed with the TNM proprietary system

Farmers are enabled to decide independently which hardware vendors to choose, and install those they prefer. The value exchange model used is represented in Figure 10 where TNM is indicated as the "System integrator".

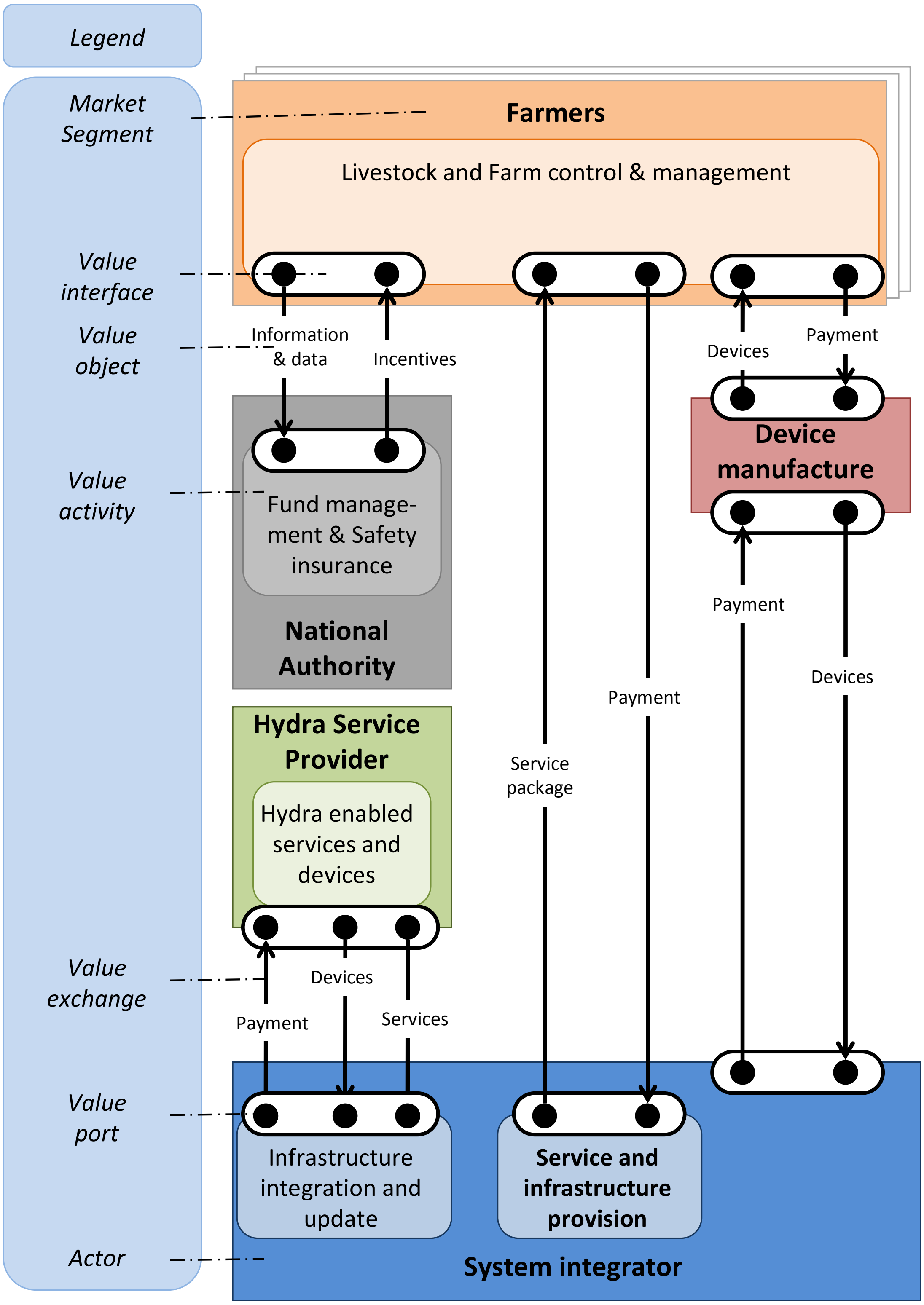


Figure 10: Agricultural domain Business Modelling

The actors exchange and the value objects constitute the various inner constellations. Most of the value exchanges are evident. As regards Funds management and Safety insurance, the farmer has the opportunity to install new applications that allow transferring certified information to the Public Authorities and in this last chance it is possible to foresee a contractual agreement where the automatic information retrieval turns into a tax remission. On another perspective the Device Manufacture is now able to send both to the system integrators but also directly to the farmers without pre-fixed selling schemes.

The effect of the business cases on the different actors has to be analysed by performing a calculation where we establish the economic value assigned to the value objects and then we instantiate the business case at two different points in time: before the service is applied (as-is) and after the advanced farm management system service is up-and-running. The following Tables show the results of such monetary exercise.

Value transactions between the different actors participating in the scenario

Actor / Market segment	Value object in	Value in	Value object out	Value out
Farmers				
System integrator	Service Package		Payment	€ 6.000.000
System integrator	Cost reduction			
National Authority	Incentives		Information & data	
Device manufacturers	Devices		Payment	
System integrator				
Farmers	Money	€ 6.000.000	Service Package	
Device manufacturers	Devices		Payment	€ 50.000
Hydra Service Provider	Devices & services		Payment	
Device manufacturers				
Farmers	Money	0	Devices	
System integrator	Money	€ 50.000	Devices	
National Authority				
Farmers	Information & data	0	Incentives	0
Hydra Service Provider				
System integrator	Money	0	Devices & services	0

Funding and revenues

Segment / actor	Revenues / savings	Payments	Expenses	Cash flow
Farmers		€ 6.000.000		-€ 6.000.000
System integrator	€ 6.000.000		€ 50.000	€ 5.950.000
Device manufacturer	€ 50.000			€ 50.000
National Authority	€ -			€ -
Hydra Service provider				€ -

Input data		Notes
Service Package	€ 3.000,00	Licenses, maintenance, etc.
Nr of farmers	2000	Existing customers
Devices purchased by the system integrator	€ 50.000,00	Estimation

Table 3: Economical values - BEFORE HYDRA

Value transactions between the different actors participating in the scenario

Actor / Market segment	Value object in		Value in	Value object out	Value out
		Farmers			
System integrator	Service Package			Payment	€ 10.800.000
System integrator	Cost reduction	€ 60.000.000,00			
National Authority	Incentives	€ 4.000.000,00		Information & data	
Device manufacturers	Devices			Payment	1.600.000 €
		System integrator			
Farmers	Money		€ 10.800.000	Service Package	
Device manufacturers	Devices			Payment	€ 50.000
Hydra Service Provider	Devices & services			Payment	€ 200.000,00
		Device manufacturers			
Farmers	Money		€ 1.600.000	Devices	
System integrator	Money		€ 50.000	Devices	
		National Authority			
Farmers	Information & data			Incentives	€ 4.000.000,00
		Hydra Service Provider			
System integrator	Money		€ 200.000,00	Devices & services	0

Funding and revenues

Segment / actor	Revenues / savings	Payments	Cash flow
Farmers	€ 64.000.000	€ 12.400.000	€ 51.600.000
System integrator	€ 10.800.000	€ 450.000	€ 10.350.000
Device manufacturer	€ 1.650.000		€ 1.650.000
National Authority	€ -	€ 4.000.000	-€ 4.000.000
Hydra Service provider	€ 200.000		€ 200.000

Input data		Notes
Service Package (FULL)	€ 4.000,00	Licenses, maintenance, etc.
Nr of farmers (FULL)	2000	Existing customers
Upgrade to Service Package (FULL)	€ 400	2.000 € in 5 years
Cost reduction	€ 30.000	400 hours * 40 €/h + 14.000 € saved on livestock medication and production loss
Service Package (BASIC)	€ 1.000,00	Licenses, maintenance, etc.
Nr of farmers (BASIC)	2000	New customers
Device purchased by farmers	800 €	4.000 € in 5 years
Incentives	€ 1.000,00	Estimation
Integration Hydra - SI platform	€ 200.000	1.000.000 € in 5 years
Devices purchased by the system integrator	€ 50.000,00	Estimation
Hydra services and devices	€ 200.000,00	Firmware or software adaptation of ontology/semantics for enabling the devices

Table 4: Economical values - AFTER HYDRA

Given the mentioned assumptions and the notes provided in each table, the business case foresees a positive return for all actors except the Public Administration. This is due to the lack of calculation (not envisaged for the purpose of this deliverable) of the benefits for the Public Authority embedded in an enlarged agriculture monitoring system, which as anticipated in the introduction would dramatically diminish the expenses for colleting data from farmers with paper based formulary and documentation but also with other IT services and would have a great impact on the citizen life, regarding the food and agriculture products safety.

Farmers would take advantage of a significant cost reduction, depending on the adopted pricing scheme. Device manufacturers and system integrators would increase their revenues because of the new hardware and services to be provided to the enlarged market. In Table 4, the Hydra service provider has somehow a limited “visibility” of the full business, so it could be worth adopting a different pricing scheme that is better than a single reimbursed intervention, where the Hydra service provider agrees a fee based on the system integrator actual revenues.

Even though the figures applied appear realistic and (even more important) they are based on the input received from the TNM management team, a change in the prices, assumptions and penetration rate would modify significantly the business case cash flows.

5.3 UNIBO-WHITEHALL

5.3.1 Introduction

The proposal from University of Bologna and Whitehall Srl represents more a business idea better than a structured business case. It emerged during the workshop discussion given the respective areas of expertise and the industrial relations that could be activated or reinforced through the business idea exploitation. As a consequence the business case is just at a concept stage and cannot be conceived at an implementation level, so the economical figures and cash flow analysis are not in place, while the general business scheme is outlined.

The University of Bologna is probably the first University in the western world and began to take shape at the end of the eleventh century, when masters of Grammar, Rhetoric and Logic began to devote themselves to the law. In the nineteenth century a committee of historians attributed the birth of the University to the year 1088. In recent years Bologna has been called upon to forge relationships with institutions in the most advanced countries to modernise and expand its activity, and among the many challenges, Bologna committed itself to adopting a new university system and a larger cooperation towards a European dimension. The Faculty of Agriculture and in particular the Department studying the soil science and pedology (see also www.pedologia.net, in Italian language) has been immediately interested in gaining a deeper insight of the Hydra technology and potentialities of distributed sensors systems.

The other interested organisation, Whitehall Srl, is the SW development branch of Reply Group and its competitive positioning is based on cornerstones inspired by strong know how and dynamism: consulting approach, qualified international technology partnerships and R&D activities. Its major focus is on e-government proposition deployed with Public Administrations and on being able to produce measurable end benefits such as reduction distance between citizens and administrations, the adoption of friendly users technology platforms, the Public Administration management productivity, cost structure downsizing and policy consensus increasing. They develop novel solutions for e-government, substitutive storage, document automation software, dematerialization, solutions for URP (Citizens Communication and Complains Offices) and cooperative applications platforms. Among the covered e-government and policy governance sectors for the Public Administration, Agriculture is one of the most important.

5.3.2 Envisioned model in relation to Hydra

The work of University of Bologna is focussed on the early stage analysis of the soil (especially in the wine-yard sector) integrating heterogeneous sources of information. One of the experts representing the University at the workshop, Stefano Campagnolo, is also involved in the activities of the Agriculture National Council in Italy and he is a shareholder of a spin-off related to the same expertise. The actual process applied was explained from Mr Campagnolo, and it consists of a two-phase analysis:

- Digital-Satellite Imaging Analysis
- Analysis of the soil (nitrogen, water concentration, composition)

In the first part they collect (purchase) and elaborate high resolution images taken from the satellites, which are able to identify even small plots of land. The soil and / or crop colour analysis allows a first diagnosis of the terrain and tree conditions. In a later stage the researchers move to the selected allotment and perform a second more detailed terrain study, by using special instruments and laboratory and chemical analysis able to evaluate the nitrogen saturation, water concentration, and ground composition. The following Figure 11 gives an idea on how the 3-D soil model is elaborated and then graphically represented.

After the two-step investigation is completed, the crop experts shall decide how and where to intervene for improving the cultivation.

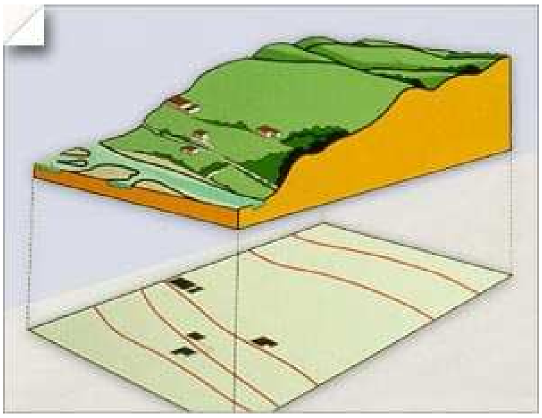


Figure 11: Soil analysis model (source: I.TER P.S.C.A.R.L)

The great added value, as defined by University of Bologna, of a distributed monitoring system where interoperability is assured from the Hydra technology would be the possibility to have a single centralised elaboration and as a consequence a unique comprehensive model instead of several models which focus on single specific aspects of the wine-tree cultivation problems. In this way the different monitoring devices would be able to seamlessly interact with each other, to convey useful data to the central intelligence and to output complex analysis based on data fusion techniques.

The University of Bologna experts believe that such an interoperable system would highly diminish the elaboration time for obtaining terrain modelling, augment the data robustness and increase the capability to foresee what type of intervention is better suited for the soil given its actual conditions and the parameters' historical data.

Whitehall Srl given its specific consulting experiences and technology know-how is interested in initiating and managing large projects to be deployed for relevant Public Administration Customers. The focus of the proposition is based on vertical applications, development capacity and new solutions for applications and service management. Their objective is to build a project where farmers and Public Administrations are able to communicate easily and in real time, with strong impacts on the user's life. The system shall aim to promote an efficient multilevel policy model adoption, managed by new technologies, for Regional Government and local bodies, a proper balance between budget resources, citizen satisfaction and policy consensus. The enabling technologies are based on Open Source and Web 2.0 tools, integrated with vertical development solutions tailored on end user needs. Whitehall has a large experience in Content Management Platform development, integrated with Web Portals in accordance with national and European accessibility guidelines. The ideas for the usage of Hydra highlighted from the Whitehall management during the workshop are in the following two areas:

- Automatic detection of rifle usage by hunters (bullet counts and localisation)
- Certification of olive oil / wine production

Especially as regards the second idea and as a potential business proposition, the enterprise reported the possibility to cooperate with the Italian Confederation of Agriculture enterprises and farmers (Confagricoltura), by approaching together one of the Italian public administrations (also at regional level) and verify the interest in activating a collaborative test bed project where the prominent idea to be evaluated consists of a soil and terrain based analysis, with means of sensor networks, able to perform:

- Automatic collection of data in the tree yard

- Elaboration of data for both the farmer and the local farmer's association (often a public institution, entitled to certify the agriculture production and products)

The common interest over the same domain and the draft business ideas permitted to identify a liaison between the University of Bologna proposal and the company objectives, despite the first one is based on a consolidated analysis model already existing and applicable on wine-yards better than other types of cultivations.

6. Conclusions

The major outcome of the present deliverable is the attempt to instantiate a reasonable value based business model where value objects and value exchanges between stakeholders are analysed and evaluated in the case of an advanced farm management system service offering, where a high level of technology integration is assured by means of the Hydra enabled devices for monitoring and controlling the crops or livestock. The business modelling workshop organised from the Hydra WP10 partners selected two principal use cases for further investigation, one on livestock management and the other on crops and soil monitoring. As a result of the workshop, a basic framework emerged in relation to the value constellations for one of the use cases (TNM) where the value propositions and the actors' advantages are clearly identified:

Farmer(s)

- obtain substantial benefits due to the improved system integration and better control of their livestock or crop
- hardware is no more dependent on the farm management system
- possibility to use the security features ensured from the Hydra farm management service for providing certified data to the National agriculture authorities for financial assistance (or a de-taxation scheme)

Device manufacturer

- decrease the entrance market barriers for new device producers
- larger distribution of products not just as fully-featured integrated installations, which tends to be sold to greater farms, but also as single devices and components

National Authority

- collect seamlessly, remotely and without delay the enormous amount of data available from the farms located in different parts of Denmark

System integrator

- the business case is based on a re-engineered farm management service on the hypothesis of putting it in use for the farms already managed from the company or from the enlargement of the customers basis. The business case shall identify the value creation around this actor and to the different stakeholders providing a basis for discussion and evaluation.

Hydra service provider

- support the system integrator in the interoperability aspect of the farm management platform, developing new software modules for interfacing devices and components with the server infrastructure and facilities

In the use cases reported and in other contexts, the Hydra technology could intervene fundamentally in the interoperability aspect. This means integrating different technologies to communicate and creating a homogeneous mean where the data can flow easily, allowing smart equipments to get and process even single data in a heterogeneous environment.

7. References

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http://www.iso.org/

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Council of Europe website (in particular: http://www.coe.int/T/E/Legal_affairs/Legal_co-operation/Biological_safety,_use_of_animals/Farming/)

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ANNEXES

Annex I: Workshop agenda

Meeting Subject:	Agriculture vs. ICT technology? Business ideas for integrating the Hydra middleware in the agriculture sector
Venue:	INNOVA Spa, Via Giacomo Peroni n. 386, Roma (Italy)
Date:	27 January 2010
Chair:	Andrea Guarise, INNOVA Spa
Distribution:	Invited participants, Hydra WP10 partners

Time	Subject	Topics to be covered	Time (mins)	Lead participant
09:30	**Welcome**	Arrival and coffee	10	INN
		Welcome and introductions	5	
09:45	**Key note lecture**	Interoperability and security issues in networked applications for agriculture	20	TNM
10:05	**Technologies for innovative agriculture**	Overview of the Hydra middleware	25	In-JeT
		Discussion	5	
10:35	**Use case 1**	ICT added value in food traceability	15	INN
		Discussion	5	
10:55	***Break***			
11:00	**Use case 2**	WSN use in the agriculture domain	15	INN
		Discussion	5	
11:20	**Agriculture of the future**	Discussion of potential scenarios for innovative agriculture management	40	Moderator Siemens
12:00	**Business idea drafting**	Selection of a specific use case including Hydra's technological contribution	20	INN
		Open discussion	10	
		Characteristics of the business constellation involved in the use case	60	
13:30	***Lunch***			
15:00	**Business Modelling**	Discussion of the stakeholders' roles, potential added value and cooperation strategies in the agriculture scenario	90	Moderator INN

Time	Subject	Topics to be covered	Time (mins)	Lead participant
16:30	**Summary**	Summary, conclusions, identified business cases, possible actors and revenues, next steps	30	INN
17:00	***Close of day***			

Annex II: List of participants

Name	Organisation
Experts:	
1. Thomas Nejsum Madsen	TNM A / S (Denmark)
2. Alessandro Zacchei	Whitehall Reply (Italy)
3. Corrado Ciotti	Whitehall Reply (Italy)
4. Eduardo Rispoli	Whitehall Reply (Italy)
5. Domenico Spinelli	Reply Spa (Italy)
6. Alfredo Picano	Labor Srl (Italy)
7. Maura Bernardini	Labor Srl (Italy)
8. Paolo de Stefanis	Labor Srl (Italy)
9. Stefano Campagnolo	PANNOVA S.n.c. (Italy)
10. Marco Bittelli	Università di Bologna / Agricultural Research Council (Italy)
Hydra consortium:	
11. Gernot Graefe	Siemens IT Solutions and Services, Paderborn, Germany
12. Jesper Thestrup	In-JeT ApS, Denmark
13. Alessio Gugliotta	Innova SpA, Italy
14. Andrea Guarise	Innova SpA, Italy
15. Elena Gervasio	Innova SpA, Italy

Annex III: Workshop minutes

Meeting Subject:	Agriculture vs. ICT technology? Business ideas for integrating the Hydra middleware in the agriculture sector
Venue:	INNOVA Spa, Via Giacomo Peroni n. 386, Roma (Italy)
Date:	27 January 2010
Chair:	Andrea Guarise, Innova Spa
Distribution:	Invited participants, Hydra WP10 partners
Rapporteur:	Elena Gervasio, Innova Spa
Distribution:	Alessandro Zacchei, Whitehall Srl, Italy Alfredo Picano, Labor Srl, Italy Corrado Ciotti, Whitehall Srl, Italy Domenico Spinelli, Whitehall Reply, Italy Eduardo Rispoli, Whitehall Srl, Italy Maura Bernardini, Labor Srl, Italy Paolo de Stefanis, Labor Srl, Italy Stefano Campagnolo, PANNOVA Snc / University of Bologna, Italy Thomas Nejsum Madsen, TNM A/S, Denmark Gernot Graefe, Siemens IT Solutions and Services, Germany Jesper Thestrup, In-JeT ApS, Denmark Alessio Gugliotta, Innova Spa, Italy Elena Gervasio, Innova Spa, Italy

1. **Welcome and introduction to the workshop objectives**

2. **Round-table of the participants**

3. **Key note lecture from Thomas Njesum: "Interoperability and security issues in networked applications for agriculture"**

    - A Denmark best practice in the use of ICT within the livestock sector

General overview of the State of the Art of the ICT applied to the agriculture sector in Denmark and presentation of the country best practice related to the livestock field, especially regarding pig-breeding.
During the presentation it has been underlined the recent shift in technology which is leading toward a broader use of LAN network installations inside the farm.

The actual technology consists in the usage of LAN switches for animal housing control processing inside the farms, in order to monitor: climate (temperature, humidity, ventilation, CO2 concentration), electronic feeding systems, water flow management, animal status (weight, temperature, localisation), all accompanied by a centralised management software (resident on a dedicated server). The collected data are extensively used for calculating statistics and obtaining predictions. For example sows have a certain drinking behaviour, so it is possible to detect special diseases due to this change 24h earlier than before.
The system architecture in a modern farm is often constituted from 50 up to 100 local controllers on the LAN, 5 to 10 PCs and 1 mainframe.
Up to 20% - 25% of the farms in Denmark are adopting this type of application and it has been forecasted that in a few years up to 80% of the farms in the country will turn to this technology, having been absorbed by the bigger farms.
All the farmers who need information for their production can apply to a Central Database existing in Denmark for all registrations, which is used by the Government to make statistics on the production itself. This process started recently, but it is foreseen to have a big impact on the sector in the next future. An added-value represented by this service consists in the guarantee of real-time information.
The technology is going forward the direction of putting sensors directly into the LAN to be able to communicate with the controller, with no need of intermediaries. So the final aim is the creation of a General Sensor Application, addressed, we could say, to a target constitutes by a farm where the livestock population is, at least, 2.000 (heads of cattle).
The technology also includes small sensors put on the animals (sows), able to transmit a 3D monitoring measurement to the central controller as well as new electronic ID for animals, based on UHF – RFID, able to read a distance of 2/3 meters. It has been also individualized the possibility of monitoring pigs' growth, but not animals' temperature for instance, by computer vision.

A major issue is to integrate equipment from different hardware vendors, so the actual limit consists in the lack of a Central System in the farm able to gather all the different data. ISO (International Organization for Standardisation) only covers 50% of the needs now. There is the standard from ISO with reference TC23 / SC19 which considers the electronic devices compatibility in the agriculture domain, but it appears as a relatively old reference. The most recent widely used communication protocols in this domain are the Agricultural Data Interchange Syntax (ADIS) for broadcast communication and Simple Object Access Protocol (SOAP) for web-services based architectures. An unresolved issue with the actual communication interfaces is represented from the security aspect.

4. Introduction of the Hydra Middleware

- The new revolution upcoming with the Internet of Things and Services
- The Hydra middleware: vision and fact sheets

5. Example scenarios

Food traceability

- Supply chain improvements mainly aim to reduce
    - Inventories
    - Waste
    - Costs
- Increase efficiency
- A healthy fish in our meal: example scenario from the post-harvest fishing industry (Ugandan Nile)
    - ICT applied for the semi-automated collection of data
    - Methods originally designed by NASA

Wireless sensor networks

- Precision agriculture

    - providing the means for observing, assessing and controlling agricultural practices
    - Wide range of agricultural concerns, from daily herd management through horticulture to field crop production
    - Pre- and post-production aspects of agricultural enterprises
- Example scenario from the COMMON Sense project
    - precise agriculture in the rural semi-arid areas of developing countries
    - provide poor farmers with a decision-support tool (DST) based on an improved knowledge of the conditions prevailing in the field, and on well-established models of crop prediction

6. General information on the agriculture context

The priority of the Common Agricultural Policy (CAP) should be to ensure that agricultural products are healthy and safe, promote the respect of the environment, protect medium or small sized farms and help farmers to adapt their production to consumer expectations. Some major issues are:

- Sustainability
- Food quality
- Animal welfare
- Food safety
- Control mechanism

Producers of devices and components are increasingly facing the need for networking their own and complementary products. The interoperability aspect emerged as an input apart from the key note speech also from the experience reported by the other experts present at the workshop. The enormous amount of heterogeneous devices with embedded systems are already in place, but the diversity of the producers and manufactures, without a proper standardisation framework on place, put many difficulties to the selection of the right technology and devices to be installed in the farm. Often different clock speed of technology deployment is an issue, and there is a large need for hardware and tools that easily can add, implement and exploit the intelligence embedded in the devices.
As regards Europe, the most active countries in the development of new strategies and methodologies in the agriculture and food chain sector are: UK, Germany, France, Denmark and the Netherlands.

7. Potential innovative applications using Hydra

TNM A/S

- Interoperability (sensors seamlessly connected to the central intelligence) in farm management

This would allow a wider market for different apparatus (sensors, devices, elaborators) because they would be able to communicate more efficiently

University of Bologna

- Early stage analysis of the soil in wine-yards integrating heterogeneous sources of information

It consists in two-phase analysis:

  - Digital-Satellite Imaging Analysis
  - Analysis of the soil (nitrogen, water concentration, composition)

The great added value of such a system would be the possibility to have a unique comprehensive model instead of several models which focus on single specific aspects of the wine-tree cultivation problems

Whitehall Srl

- Certification of olive oil / wine production
- Automatic detection of rifle usage by hunters (bullet counts and localisation)

- Interested in the cooperation with the Italian Confederation of Agriculture enterprises and farmers (Confagricoltura)

The prominent idea consists of a soil and terrain based analysis, with mean of sensor networks
  - Automatic collection of data in the tree yard
  - Elaboration of data for both the farmer and the local farmer's association (often a public institution, entitled to certify the agriculture production and products)

Claas
- The company produces harvesting, soil and crops machinery and they have a strong focus on functionalities for connecting machines with mean of Car2Car and Car2Infrastructure communication (R2B and RFA initiatives)

Their intention is to implement a multi-hop communication system able to intelligently distribute information to the different machines placed and working in the fields, so that the cultivation production is optimised

In all use cases reported the Hydra technology could intervene in the interoperability aspect, which the projects are still lacking. That means to integrate the technologies pointed out above and create a homogeneous mean where the data can flow easily, allowing a smart (or unique) central equipment to get the single data converged and processed into the central elaboration system.

8. Business drivers / elements of a potential business model

The major challenges to be faced in this sector are an increased regulatory pressure, which turns into a need for documentation creation, but goes in parallel also to a request of increased economical efficiency.
The potential enablers are the environmental efficiency which could be obtained by optimising the ICT use, the innovation in farming techniques and improved technology together with improved methods.

In summary the following important drivers for the development of ICT in agriculture must be considered:
- Regulations and legal constraints
  - at level of policy makers, in terms of constitution of the Legal Framework
  - at regional level, in terms of regulatory organizations responsible for control and verification
  - changing regulations requires flexible technologies
- Farms' economic optimisation (e.g. animal growth monitoring, monitoring diseases, benefit from benchmark to other farms by getting more information about their production processes)
- Healthy food: food safety, food quality (animals not treated with medicine), traceability
- Quality assurance and maintenance (including taste?; place of origin certification)
- Eco-sustainability and environmental aspects (preference for local products, using less water, using less fertilizer, …)
- Predictive models (clustered, targeted groups)
- ISO Standards (i.e. 'Ontology of the Food' program, developed by the FAO)
- European / public aids to farmers

Constraints and risks
1. Security?
   - Data access shall be regarded as a fundamental requirement, as the information collected and processed in the food production and logistic chain are very sensible
2. Bandwidth / broadband?
   - Broadband could be an issue in the communication to the "external" world, in respect to the farm universe

3. Always-on / low power consumption?
    - The need to have a consistent and constant knowledge of the farms' building blocks appears as a problem for the sensors' power consumption
    - It is a complementary problem to the previous one, as it is related to the inner farm management instead of external communication
4. Business Intelligence?
    - Smart systems have been implemented, but they are covering single aspects of the farm management rules and are closed or proprietary applications
    - They are related to both the inner management of the farm and its openness to external entities
5. Usability / easy of use?
    - In a questionnaire not too recent (1999) prepared from the European Federation for Information Technology in Agriculture (EFITA) it emerged that the three most important factor determining a low penetration of IT into the agriculture sector were (i) the inability of farmers to use IT, (ii) the low perceived benefits - economic and others – and (iii) the difficulty to use or unfriendly interaction; cost was only at the fifth place.
    - Also nowadays it appears that the usage of modern ICT systems in the farms is often ruled from external experts or specialised consultancy, which know the software interfaces and the possible operations (this regards also the HMI) and algorithms
6. Cost?
    - As said before the cost of the IT (ICT) technology seems not the major problem faced from farmers. It is worth observing that even though the sensing and communication devices could be found at cheap prices, most probably the need to call external expertise for ICT configuring, operating and maintenance can be perceived as a relevant expenditure
    - As a consequence it is observed that only bigger farms can afford the first investment cost for setting up the stables or crop fields infrastructure

9. Potential Stakeholders for Hydra

The experts' discussion session drafted a basic business model focussed on the collected experiences and proposals, whose building layers for the value creation would be composed of the following items:

6. Usage of information in the further value chain
5. Feedback to the vendors of production process
4. Feedback the information to the production process
3. Business intelligence/ information processing (certification of data is important)
2. Integration (machines, sensors, …) to collect and aggregate information e.g. in a farm management system
1. Production process
0. Vendors (machine, food, seeds, …); providers of information and content (weather databases, geographic information systems, satellite pictures, …)

The layering is organised so that it represents also the actors/tasks present in a simplified agriculture value chain. Each stakeholder/function is necessary for the layer above. The final user dimension is not indicated, but it would be of course at the top of the stack.
In a potential use case discussed at the workshop where Hydra could be extensively applied, a preliminary list of the key stakeholders to be involved could be identified as follows:

- Farms' employees
- Farmers' associations and local consultants
- Governmental agencies and authorities (also health-care)
- Software producers for livestock / crops management
- Data modelling experts
- Database / content providers

- Device / machinery manufactures

A first result where the external experts and the Hydra partners agreed is the idea to realise a prototype to be showcased for verifying the potential market accessibility of the application and its impact towards early adopters and interest groups.

10. Next steps

- TNM A/S is interested in a joint meeting with Claas for investigating the R2B initiative (event organised together with Jesper)
- University of Bologna (Agricultural Research Council) developed models for wine-yard management, e.g., satellite pictures are assessed to derive information on the quality of the soil. He is interested in integrating data from machines into his models, hopefully in cooperation with Claas and Komatsu Forest (in contact with Siemens)
- Whitehall Srl is interested in knowing how the multi hop-communication is realised (R2B)
- The working group will develop a showcase able to demonstrate the Hydra capabilities. The construction of a pilot project in order to fully exploit the interoperability potential embedded in the Hydra platform will follow

Annex IV: CLAAS interest towards Hydra

CLAAS is a well recognised German agricultural machinery manufacturer founded in 1913. It is based in Harsewinkel, in the region of North Rhine Westphalia, but it has branches and factories worldwide. Their brand comprises the CLAAS name, but also LEXION (in North America) and the Renault Agricultural tractor division. The product range includes combine harvesters, forage harvesters, balers, mowers, rakes, tedders and other harvesting, soil and crops machinery.

Hyrda WP10 partners from Siemens and University of Paderborn (where CLAAS opened a factory in the mid 50s) had the occasion to meet CLAAS representatives and to discuss with them the opportunities offered from the Hydra technology and how to integrate it into their machinery with the desired requirements.

CLAAS has a strong focus on functionalities for connecting machines with mean of Car2Car and Car2Infrastructure communication (R2B and RFA initiatives). Harvesters are usually running for the entire day without many stops. The tractors but also other machinery are more flexible in the usage, as they do not usually concentrate their work on a single agriculture filed for an entire day, but they can be used in different places at different times. This dynamism characteristic of part of the machinery gave them the idea to implement a store&deliver mechanisms similar to a multi-hop architecture (see Figure below), where the moving vehicles collect useful information for example from stables or storage bins for then spreading (intelligently distribute) the data away while they come closer to the communication range of the static machinery, as harvesters, but also the opposite situation, where the information flow goes from the field (remotely located vehicles) towards the farm's central intelligence and/or other entities; so that the cultivation production is optimised.

The multi-hop system could rely on the Hydra architecture, as the preference would be on low-range communication devices better than long-range, and using Hydra enabled devices the information storage&delivery would be highly facilitated.