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HYDRA

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

D9.4 Agriculture domain requirements

Integrated Project
SO 2.5.3 Embedded systems

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

The middleware will be validated in three application domains: Building automation, healthcare and agriculture. Typical HYDRA enabled agricultural applications are farm production management systems, sustainable agricultural production system, storage and product development for priority agronomic crops, genetic and feed improvement for ruminants, animal health programs, soil fertility management, agricultural machinery and structures management (machinery maintenance, irrigation and agricultural drainage system, pre and post harvest/agricultural processing) etc.

1.2 Purpose and context of this deliverable

The objectives of WP9 are to select, specify, demonstrate and validate user applications in three different domains using the HYDRA middleware. As such, WP9 is structured as follows:

1. Derive initial domain specific requirements for end-user applications based on the HYDRA middleware.
2. Define and describe demonstration use cases, which will address the user requirements
3. Build the use cases for inclusion in the first, second and third demonstrators (M12+M24+M36)
4. Test and validate the demonstrators with users
5. Feed back user responses and validation results to next step in the iterative phase
6. Close the loop with the final demonstrator (M48).

This deliverable will define the domain specific requirements to be included in the third set of user applications based on the HYDRA middleware, which will focus on the agriculture domain. It will hence address step 1 and 2 of this process. The next steps will be defined in the following paragraphs and will be detailed in the relevant deliverables.

1.3 Requirements engineering

The user-centric software development (UCD) approach in the HYDRA project incorporates requirement engineering processes that follow the principles of ISO 13407 "Human-centred design processes for interactive systems". The user-centric design approach implies an iterative approach with cycles that allow the project to advance from initial specifications and prototypes via experience and evaluation to updated specifications and improved prototypes.

To kick off the requirements engineering process, vision scenarios for the agriculture domain were first developed using the IDON method[1] with contributions from experts in agricultural systems and devices. The scenarios developed this way are visions of future deployment of HYDRA enabled systems providing coherent, comprehensive, internally consistent descriptions of plausible futures and are fully described in *D2.1 Scenarios for usage of HYDRA in 3 different domains*.

[1] The IDON method [Galt et al., 1997] tries to develop a set of scenarios that takes some uncertainties of the future into account by expressing different environmental factors in which the scenarios could take place.

From the vision scenarios, technical scenarios were derived focusing on the detailed workflow of developer users in HYDRA enabled environments and addressing technical questions referring to the middleware, both at device level and at runtime. The technical scenarios were evaluated by focus groups of developer users and a large number of requirements were gathered using the Volere template[2].

The functional and non functional requirements thus derived were finally integrated and generalised to form a package of developer user requirements specifications that was fed into the architectural definition. The full description of the requirement gathering process and the collected requirements is found in *D2.5 Initial Requirements*.

The complete set of functional and non functional requirements (including security and socio-economic requirements) finally formed the basis for the initial architecture proposed in *D3.3 Draft of architectural design specification*.

It is important to note that the present domain specific requirements are not new requirements in relation to the comprehensive set of requirements already gathered and reported in *D2.5 Initial Requirements*. All domain specific requirements are already included in the Volere template. Hence, the domain specific requirements constitute a subset of requirements that are most relevant to the specific domain. This exercise can be helpful in the requirements engineering process for prioritising, resolving conflicts and filtering for demonstrations of the large number of requirements gathered.

1.4 Demonstrator cycles

A total of four iteration cycles are planned in the HYDRA project. Each cycle leads to a demonstrator in a new domain, while the previous demonstrator is being updated. The first cycle is the demonstrator in the building automation domain. In the next cycle a demonstrator in healthcare is added, while the building automation demonstrator is augmented. In the third cycle a demonstrator for the agriculture domain is added and the two other domains are augmented.

The goal of this procedure is not to focus only on the evolution of the demonstrators but on the refinement of scenarios, requirements, specification of the middleware and its implementation. This iterative process ensures a gradual approximation to the final middleware.

The first demonstrator will be the "proof-of-concept-demonstrator" of the HYDRA middleware. It will be based on use cases and scenarios from the building automation domain. The deliverable *D9.5 Concept demonstrator* provides a full technical description of the first demonstrator including the scenario to be demonstrated, the sequence diagrams and the technical solution chosen.

Demonstrator two will focus on demonstrating the Software Development Kit (SDK). The demonstrator will aim to demonstrate how a developer user can build an application using the HYDRA SDK. The main setting of the second demonstrator will be the healthcare domain, but new aspects of the building automation scenario will also be demonstrated. The deliverable *D9.6 SDK demonstrator* will provide a technical description of the second demonstrator. It will be updated with new knowledge and new facilities in subsequent iterations following the progress of the project.

The demonstrator three will focus on demonstrating the Device Development Kit (DDK). This demonstrator will aim to demonstrate how a developer user can enable a device for networking using the HYDRA middleware. The main setting of the third demonstrator will be the agriculture domain, but new aspects of the building automation and the healthcare scenarios will also be demonstrated. The deliverable *D9.7 DDK demonstrator* will provide a technical description of the third demonstrator. It will be updated with new knowledge and new facilities in subsequent iterations following the progress of the project.

At the end of the project, a complete HYDRA middleware platform capable of demonstrating the use cases and scenarios in three different user domains will be produced.

[2] The Volere process provides a well-defined structure and guides as to which requirements content is appropriate for the project purposes. It is based on experience from worldwide business analysis projects, and is continually improved with input from the users.

1.5 Content of this deliverable

After the Executive Summary in the next Section, the document starts with an overview to the agriculture domain and its specific challenges imposed on applications in Chapter three.

Chapter four describes some of the new trends and innovative activities, which among other things, were discussed during the scenario workshops, and looks at the state of the art in commercial solutions available today.

In Chapter five the actors and target users are described and an initial set of domain specific requirements for the applications based on HYDRA middleware in the agriculture sector is derived from the work done in task *T2.1 Scenario thinking*. Moreover, both generic and specific requirements are derived from the vision scenarios and correlated to the Volere based requirements.

Finally, the chosen vision scenario "From farm to fork" is provided in Chapter six for reference and guiding example.

2. Executive summary

2.1 The process

The user-centric software development (UCD) process in the HYDRA project implies an iterative approach with cycles that allow the project to advance from initial specifications and prototypes via experience and evaluation to updated specifications and improved prototypes.

From the vision scenarios, technical scenarios were derived focussing on the detailed workflow of developer users in HYDRA enabled environments and addressing technical questions referring to the middleware, both at device level and at runtime. The functional and non functional requirements thus derived were finally integrated and generalised to form a package of developer user requirements specifications that was fed into the architectural definition. This deliverable will define the domain specific requirements to be included in the third set of user applications based on the HYDRA middleware, which will focus on the agriculture domain. It is important to note that the domain specific requirements are not new requirements in relation to the comprehensive set of requirements already gathered and included in the Volere template.

A total of four iteration cycles are planned in the HYDRA project. Each cycle leads to a demonstrator in a new domain, while the previous demonstrator is being updated.

The demonstrator of this Deliverable will focus on testing the Device Development Kit (DDK). It will aim to demonstrate how a developer user can enable a device for networking using the HYDRA middleware. The main setting will be the agriculture domain, but new aspects of the previous demonstrators on building automation and the healthcare scenarios will be also demonstrated. Details of all demonstrators are found in the corresponding deliverables.

At the end of the Project, a complete HYDRA middleware platform capable of demonstrating the use cases and scenarios in three different user domains will be produced.

2.2 The agriculture domain

Agriculture is the most ancient economic activity of human beings, therefore it’s commonly identified as a traditional sector and – unfortunately – very often considered a static sector, unable to actively enhance the economic and social development of our countries. Nevertheless, agriculture embodies a strong dynamism and will have to face, within the next years, many relevant and rapid changes due to external factors that are changing even more rapidly: globalisation, new regulations, competitive advantages, concern for animal welfare and environmental protection, new technologies, consumer rights are actually different aspects of a new role of farmers.

Today the farmer has to directly face the market and all the multiple requirements of society. The core issue is the following: how to allow agricultural enterprises to be compliant with legislation for environmental safeguard, food security, balanced development and animal welfare, avoiding that they lose competitiveness in the markets.

The pillar of the future agriculture trends should be to focus on quality productions, not as an end in itself, but as a means for a more efficient competition. The concept of quality is rather complex, and includes food security, hygiene, typical products, matching the taste of consumers, informative advertising, biological integrity, the link with the territory, traditions, culture, tourism and so on. Food quality and integrity can be seen as the great asset for Europeans for facing future global competition in the agribusiness market.

It is clear that combining the challenge of competition in the global markets with support for the multi-functionality of agriculture and society needs proper tools. Consumers make more demands for traceability and transparency of food histories, farmers will increasingly be seen as information managers. Nevertheless, though farmers and agriculture will of course continue to produce physical food as they have for millennia, but the information component of what, when and how they raise will be more and more important. For instance, there is a potential to barcode seed, thus enabling precise tracking from field to factory; producers can accumulate data on health, milk production and weight gain for each animal with a microchip embedded in the animal's ear. The number of possible examples is very large.

2.3 Domain specific requirements

The domain specific target group consists of all active or potential manufacturers, developers, customers and users of an application. A further differentiation between different target groups can be done by a classification on relevant criteria such as demographic or psychographic ones. The different actors identified in this way will have different expectations and will see the usefulness of the Hydra middleware from different perspectives. In other words, their requirements will not be the same for all groups.

The identified actors within the agriculture domain are:

- Developer user
    - Advanced technological application developer
    - Agricultural chemistry
    - Manufacturer of innovative agricultural machinery
- Facility manager / service provider
    - Advanced technological application provider
- End user
    - Farmer
    - Sharecropper
    - Cattle breeder
    - Agricultural institution and cooperative

The user requirements specifications include the most important aspects of user expectations in modern agriculture applications. Requirements serve as a reference to measure if the development within the project is in line with the functionalities and properties desired by the users. Functional, security and societal requirements derived are integrated and generalised to form a package of developer-user requirements specifications that will be fed into the architectural definition work and consequently map out the development work needed to realise a successful HYDRA middleware.

Deliverable *D2.1 Scenarios for usage of HYDRA in 3 different domains* contains a first description of the three different application scenarios and some basic design requirements, while *D2.5 Initial requirements* report addressed the overall requirements focussing especially on the first domain. As HYDRA is strongly committed to a user-centred-design approach this document provides the first basic set of requirements that are going to be refined in the next steps of the project.

The nine experts participating to the focus group concluded that the following specific requirements were most relevant for their domain.

Functionality

ICT technologies for agriculture is still in its infancy (compared to e.g. building automation) but it is rapidly becoming more and more important and more and more innovative. A sizeable share of Europe's farmers is still located in rural areas and use very traditional farming methods. However, consumers do in some cases favour the man made products in traditional farms over the results of hi-tech production in various food industries.

Advanced technology functionality and complexity will increase smoothly. The use of intelligent monitoring, metering (resource consumption reporting, etc.) or tracing devices using minimally invasive sensors is expected to raise soon. Food chain traceability will be more and more important for final user and market demand and public administration attention in healthcare. HYDRA middleware needs thus to support time-planned data processing, intelligent decision support and interconnectivity via heterogeneous networks. All systems must be flexible, adaptable, configurable, scalable and modifiable in order to take advantage of networking. The systems must also be easy and simple to use for the end-user. Various forms of wearable computers will increasingly be available for executing applications.

Some effort shall be spent for information and technical preparation of end-users, who especially in the agriculture domain not always have expertise with advanced devices and application.

Networking - Communication

A most imminent problem is to have systems reflecting the complexity of the domain, i.e. the various subsystems needs to be able to communicate with each other to a much larger degree than today, to match the farmer's know-how and experience. Most probably the market will respond with a strong growth in products that are able to communicate and interact. This will lead to an increased appearance of interoperability standards where device drivers, interfaces and applications may need a third party certification to be acceptable for other manufacturers when used for networking applications.

There may not always be unlimited bandwidth available for any amount of data transfers, so the Hydra middleware must allow device manufacturers to design their devices to be adaptable to varying bandwidths.

Privacy and security

Agricultural technologies will need to have security features installed that can prevent any kind of intended and unintended misuse and the specific security model must be established as part of the development process. However, the responsibility for system security is not always clearly defined or assigned to specific actors; the security model can either be centralised or distributed across the network. The same observation arises for the access rules, which should be commonly understood and accepted among end-users, and for any authorisation process.

Power

End-users will increasingly demand products that use less energy, which can be seen as being in conflict with the increased demand for extended functionality. In some cases in the agriculture contest it will be possible to use new types of renewable energy sources thereby decreasing the need for traditional energy. Systems will e.g. be extendable with energy producing devices like bio-gas or solar panels forming parts of the network.

Design

During the expert workshop it was not possible to find a common understanding on the future outlook for a range of topics. The first cluster is thus called "Farming Method". This cluster of factors relates to how farming methods are influenced by the use of ICT technologies. One of the instances of "Farming Method" is the "Hi-tech Farming"; an agricultural production process dominated by innovative ICT solutions and where producers are active in applying ICT to optimise and improve production procedures. The second instance points to a future, in which the absence of hi-tech applications and solutions dominate the agricultural process.

Another cluster of environmental factors with an uncertain future relates to the consumer and her/his attitudes towards foodstuff. This cluster has been called "Consumerism". A first instance of the cluster describes a situation where innovative ICT developments enable to produce high quality products that meet the high demands of the market. Producers see clear advantages of using ICT to improve cooperation with other producers, as well as a mean to optimise the quality of their products. This instance was called "The Conscious Consumer". The other instance is centred on a market, where consumers are indifferent to almost anything but prices, and ICT developers are only focusing on innovations in production methods which can lower the cost of production.

The different cluster and approaches would bring to completely different design requirements.

In any case in the future user interaction should take place using multimodal interfaces. Devices and interfaces shall be designed according to ergonomic principles, taking into account the socially and physically disadvantaged end-users that should be supported with other modalities for easier interaction.

Business models

Agricultural production continues to raise general public and governmental concern about the environment and the use of natural resources. Issues of safe food, food history and animal wellbeing are quite unique to this domain and poses serious challenges to the developers. On the other hand, farmers are inclined to ask for proof of real cost benefit, before they invest in new ICT solutions.

Manufacturers will increasingly offer both products and services in value enhanced bundles and need new business models for this. Advanced techniques for relatively simple appliances may have a high value propositions in the agricultural domain.

3. Agriculture domain overview

3.1 The EU point of view

Food safety is a top priority in Europe. The EU's demanding rules have been further toughened since 2000 to ensure that Europeans' food is extremely safe. The new approach is more integrated: feed and food shall be carefully tracked from the farm to the fork. EU authorities carefully evaluate risk and always seek the best possible scientific advice before banning or permitting any product, ingredient, additive or Genetically Modified Organism (GMO). This applies to all feed and food, irrespective of whether it comes from inside or outside the EU.

Safety does not mean uniformity. The EU promotes diversity based on quality. European law protects traditional foods and products from specific regions by ensuring consumers can distinguish them from copies. The European Union is increasingly encouraging its farmers to focus on quality - not just in food but also in the rural environment.

The EU also respects the consumer's right to informed choice. It encourages public debate, it requires informative labelling and it publishes the scientific advice it receives, so that consumers can have confidence in the food they eat.

3.2 The agriculture market vs. population

Growth in global production of and demand for the main agricultural commodities is projected to grow on average by about 1.6 percent annually or 0.3 percent on a per capita basis during the period to 2010. This is a decline in aggregate and per capita growth from that experienced during the 1990s. Factors responsible for the slowing of world demand include reduced population growth, high current consumption and often saturated markets in the developed countries and, for some agricultural raw materials, increasing competition by synthetics.

The growth of world trade in agricultural commodities, which was so robust in the 1990s, is expected to moderate in the projection period despite the beneficial effects of policy reforms. The slowdown in the present projections is due to the sharp falls in growth foreseen for fats, oils, oilmeals, meat, fruit, tropical beverages and most agricultural raw materials. The long term trend decline in real prices, which show prices of all agricultural commodities declining relative to those of other major economic sectors over the 1970 to 2002 period, has averaged about 2 percent per year. Over the projection period, world market prices in real terms, that have recently been below longer term trend levels, are expected to return toward their trend levels. The United Nations estimates that world's population will expand by 1.3 percent annually till 2010, down from the 1.5 percent per year recorded in the previous decade. About 97 percent of the growth in world population originates in developing countries.

The analysis of historical trends reveals that the productivity growth in global agriculture has so far been sufficient to meet effective demand. Over the past three decades, world agriculture production has grown faster than population. Increased productivity stemming from the use of new technologies in many industrialised countries has been in part responsible for the long-term decline in real commodity prices. In practice, world agriculture has been operating in an environment where effective demand has been constrained by a number of factors. Limits on the demand side at the global level reflected three main factors:

- the slowdown in population growth from the early 1960s onwards;
- the saturation in the levels of per capita food consumption for a growing share of world population and
- the difficulty in improving consumption by those who were too poor to purchase it or did not have enough resources to produce it themselves.

The first two factors will continue to dominate in the future. Their impact will be reflected in lower growth of demand than in the past and, indirectly, also of production. The third factor will also play a major role, given that the overall economic outlook indicates that low incomes and poverty will remain widespread in the future (in the developing countries).

3.3 Agriculture scenario

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

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

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

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

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

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

4. Trends and Challenges in agriculture

4.1 Trends and challenges

Research and new technologies are an important challenge for agriculture and a fundamental base for the future well being within the European countries. Making an innovative, efficient and well structured research system available to the sector is therefore an essential venture. The sector shall reach a stage where process and product development are increasingly science based. In general terms, the sector is challenged also to base product developments on a more scientific understanding of its basic materials.

Breakthroughs are needed in the processing area. One challenge is to develop more flexible and even smaller size production processes, including units for niche-type products. Production efficiency remains a key challenge. Another important undertaking will be to minimise, through radical process changes, the consumption of energy in all relevant production stages. To develop new environmental technologies is another task. As with product developments, process developments must take advantage of technological advances in such fields as control technology and materials technology. Again, better links with the scientific community are necessary.

Speeding up the transition of the sector for being more knowledge driven is integral to success. As a result, the sector needs to extend its knowledge base and to take upon itself to fully engage in education and training programmes, including communicating with the public. It must be able to attract young talent in all relevant fields of education and work. The development of new skills, both within higher education and within industry, needs greater emphasis. Skills development needs to address future diversity and interdisciplinary, providing the basis of knowledge development and entrepreneurship. The impact of the ageing workforce in Europe needs to be addressed, as well as the capability in industry to identify, absorb and manage technology and to serve a competitive global market.

Computing in the eighties was about mechanising existing processes. Farm accounting packages allowed easier tracking of performance, less of a scramble at the year end to provide data for the accountant and, most important of all, the ability to claim back VAT easily and quickly.

However, improved number crunching and tidy farm records are all very well but they are hardly inspiring; many farmers found the effort involved in consigning their data to a computer system was greater than the benefit they obtained and user numbers grew slowly to around 15% of farm businesses by the early ‘90s. New opportunities were needed to encourage a more general uptake of the technology where the benefits clearly outweighed the effort involved.

For now the main industry-related trends in the agriculture sector are:

Geographical monitoring.

Though there is increasing interest in Geographic Information Systems by agricultural producers, the main usage in the European market is for yield monitoring and mapping. This approach is used to evaluate the effectiveness of alternative management practices employed in the production of the crop (e.g., comparison of varieties, seeding rates, pest control measures, tillage systems, etc.) and to identify field problems (e.g., soil compaction, drainage problems, etc.). This yield monitoring approach is finding the greatest acceptance and this may be in part because the yield monitoring and mapping systems are common option on grain harvesting equipment. One of the real concerns with using yield monitoring and mapping systems relates to the issue of arriving at the correct inference of what causes the variation in yields noted. The potential layers of data (e.g., pH, precious crops grown, soil structure, planting date, nutrients applied, variety grown, pesticides used, rainfall, etc.) has been suggested to exceed 100. To be able to handle the large number of data layers in an effective manner would suggest a full-feature GIS might be needed. However, few agricultural producers have access to this kind of technology and/or training to utilise these systems, and there are substantial costs related to capturing and storing various data layers. Nevertheless, the more obvious observations originating from these systems (e.g., such as poor drainage and soil compaction) have resulted in sound investments being made in corrective measures. To a limited extent, some agricultural producers are starting to make use of remote sensing data to identify problems related to the growing crop such as an outbreak of a disease. Those using remote sensing feel they are able to more quickly identify the problems and take corrective actions, minimising the damage done.

Also in agrobiodiversity GIS techniques may be applied. Since man first domesticated wild varieties of wheat and barley, breeding techniques have focused on the selection of desirable physical traits to improve crop quality and productivity. These methods are still relevant today, but are being supplemented by the new technology represented by genetic research. To supply farmers and researchers alike with the genetic material to improve crop species under current and future conditions, scientists have collected germ plasm and acted as guardians for centuries. In situ conservation marks a new approach whereby useful germ plasm is maintained in its native environment as opposed to more traditional seed banks. GIS offers exciting possibilities that include the documentation of sites and locations of potential collection areas based on varying biophysical parameters and assessing risk to genetically diverse locations. Utilizing GIS in a coordinated manner has proven to be the ultimate management tool for the exploration, exploitation, and conservation of genetic material essential to the development of improved varieties of basic food commodities.

Precision agriculture applied to the animal industries is on a different scale. Information systems are playing a major role on the integrated mega-farms. When using information systems to carefully track genetic performance, balance rations, monitor health problems, facilities scheduling, control the housing environment and so forth, it is generally acknowledged that it is possible to achieve a fairly significant reduction in cost per unit of output (10-15%) over that of more traditional, smaller farming operations. These are proprietary information systems and the information from these systems are used to gain a strategic competitive advantage. Lastly, the general purpose spreadsheet is the most common software used for planning purposes.

Phytomonitoring.

In the last decade, comprehensive monitoring systems have been developed for real-time monitoring of the plant response to changing environmental conditions. The monitoring appliances are comprised of sensors positioned on, or installed in the proximity of a plant, a data collecting device and an information processing unit that receives and processes the data for determining the state of the plant/animal. Communication channels transmit the data from the sensors to the decision maker. Present available sensors are comprised of air humidity, air temperature, boundary diffusion layer resistance, solar radiation, soil moisture and soil temperature detectors. Vegetal sensors include leaf temperature, flower temperature, fruit surface temperature, stem flux relative rate, stem diameter fluctuations, fruit growth rate and leaf CO2 exchange detectors. Each sensor has a built-in transmitter for broadcasting data signals to a data logger (a data storage device) and a receiver for the command signals sent from the controller. The communication between the data logger and the controller may be by wire or wireless (infrared or radio frequencies). Phytomonitoring is yet implemented in limited scale, mainly in greenhouses. A vast amount of information and experience have been collected from these systems, but beneficial wide scale use of phytomonitoring in agriculture is yet doubtful.

Animal monitoring.

Dairy farming systems probably are the most complex of the agricultural production systems. In most other systems, involving plants and beef cattle, inputs and outputs occur a few times per year and they relate to one or two products. In contrast, the dairy system is one in which inputs and outputs are continuous: e.g. milk, births, deaths, sales or purchases of animals, feed and labour costs. The outputs of the dairy system are varied, milk, meat and surplus animals. They are the outputs of individual cows, the cost of which makes them individual production units that vary in

performance. Maximising revenue requires continuous decision making at both individual cows and herd levels, which can only be properly carried out on the basis of data evaluation, if one excludes situations in which freedom of choice is limited. The presence of such investments indicates that response to information flow is greater in the dairy farming system than in other components of the agricultural sector. This is true however only for certain categories of dairy systems and of hardware or software.

Embedded Systems and Automation in Mechanised Irrigation.

Mechanised irrigation, using centre pivots and lateral move machines had been extensively expanded since the mid-fifties. It is generally used for wide-scale irrigation of field crops, saving labour and solid-set equipment. In the last two decades, mechanised irrigation harnessed the power of computerised controllers to improve water distribution and machine performance. Sensor units installed at the lateral distal ends, guarantee repetitive passage on the same track in consecutive irrigations. The controllers match the application rate to changing velocity of the machine due to change in slope on its way. Alerts on malfunction and crashes are sent by wireless to the operators that can be located far away from the irrigated area. Automatic readings of soil moisture and canopy temperature are used for scheduling of the operation of the irrigating machines. Dedicated software is used for calculation of the diverse flow rate to be assigned to each emitter along the distributing pipes in centre pivots. Since the centre pivot is irrigating by radial movement, emitter's flow rate has to be gradually increased from the centre to margins, keeping the same application rate in the whole irrigated circle. The growing diversification of the emitters in mechanised irrigation, the introduction of low flow (LEPA) application technology and the expanded demand for precise pressure and flow control, increase the essentiality of ICT and Automation in mechanised irrigation. Since the price of addition of automation is negligible, compared with the cost of mechanised systems and the high cost-benefit ratio, it seems rational that most of the mechanised systems will be equipped with automation in the near future.

Biomass and bioenergy-production

The production of bioenergy from local biological resources is a major topic of research in recent years. It is important to reduce the reliance on fossil fuels and decrease greenhouse gas emissions in organic agriculture, especially in the context of enhanced integrity of food source.

Bio-fuels like biogas, bioethanol, plant oils, wind energy, and biomass for combustion can be produced in organic agriculture and contribute renewable energy for self-sufficiency. Plant oils (biodiesel), biogas and bioethanol can be used as fuel for diesel engines and can be produced on-farm. The bio-fuels can be used in different kind of engines and its production is requires other equipment (such as heat exchanger, catalyst, gas engine, fuel cell). The technologies for cleaning the biogas can be classified into technologies using iron oxides (filters containing iron oxides or iron hydroxide), technologies working with feeding of iron sludge or iron salts into the substrates, high pressure water scrubbing technologies (absorption), pressure swing adsorption (adsorption) or

biological desulphurisation units converting H2S to elemental sulphur using oxygen. Also molecular sieves are used for gas cleaning and to enrich the methane content in the gas.

Presently oilseed crops are difficult to cultivate in organic farming, due to many pests and a rather large area is required to substitute e.g. diesel in organic farming. Biogas can be produced in on-farm and co-ordinated medium or large-scale plants from animal manure and energy rich wastes. Grass-clover crops commonly grown in OA have a great potential as raw material for biogasification. Due to several barriers, biogas is not readily available as a fuel for diesel engines, but can be used to produce electricity and heat. Bioethanol produced from starch can be used as a substitute for diesel with addition of an ignition improver.

Food-processing techniques

There are several ongoing trends or research and development activities within the food-processing community in the areas of pollution prevention and clean technology implementation. This aspect is closely related also to the industrial sector, but it is important to give a short overview.

The first Solid Waste Reduction. Companies will continue to look at ways to reduce solid waste generation, use less or reusable packaging, and use biodegradable packing products. Excessive packaging has been reduced and recyclable products such as aluminum, glass, and High-density polyethylene (HDPE) are expected to continue being used to a wider degree in packaging situations.

Mechanical Versus Chemical Processing. Companies will show increased consideration for using mechanical methods for food processing (e.g., the fruit and vegetable sector). Mechanical processing can be used to perform many of the same functions as chemical processing. The costs and benefits of using mechanical versus chemical processing will be further quantified to aid in decision making.

Pretreatment Options, Water Conservation, and Wastewater Reduction. Pretreatment opportunities and water conservation will continue to be principal targets for pollution prevention source reduction practices in the food-processing industry. Pretreatment options look to minimize the loss of raw materials to the food-processing waste streams. Water used in conveying materials, facility cleanup, or other noningredient uses will be reduced, which in turn will reduce the wastewater volume from food-processing facilities. Wastewater treatment will continue to be the pollution prevention treatment focus for food-processing companies. The industry will continue to implement advanced innovative techniques to lessen the environmental impact of food-processing discharge wastewaters.

The key factor for food industry is to continuously monitor the demands of consumers, investors, environmental compliance, as well as competitiveness of both the domestic and global marketplaces.

5. Domain specific user requirements for agriculture

In this section, we deduct the specific technical requirements for the agriculture domain. We set off by identifying the users and analysing the future scenarios created by the external experts and the specific requirements that can be deducted from the scenario thinking process and from the scenarios themselves.

During a full day workshop, nine external domain experts discussed the most critical applications for ICT technology in agriculture in the future, how existing process and production devices can be improved and what type of new and better instruments could be developed to advance concepts like products tracking and crop and animal monitoring. The main focus was primarily on intelligent, ubiquitous and secure networked products and services in agriculture and the food industry, primarily emerged from sector experts rather than farmers directly involved in the agriculture production or consumers (end users).

It was not possible to give a precise time horizon (selected for year 2015 in the other two applications), as participants didn't feel confident to forecast how agricultural systems would be developed in the far future (it is more difficult to foresee the future development or scenario in a traditional domain like agriculture, than in much more recent and advanced technologies!).

5.1 Actors and target users

In order to derive domain specific requirements for the design process, it is useful as a first step to define the main target users that will develop and eventually utilise agricultural applications supported by HYDRA middleware.

A target group consists of all active or potential designers, manufacturers, developers, customers and users of an application. The aim is to create actor segments that are internally sufficiently homogenous to render synchronised behaviour in all relevant aspects (usage patterns, buying behaviour, etc.) while at the same time to be sufficiently large to be economically viable for exploitation.

The different actors identified in this way will have different expectations and will see the usefulness of the HYDRA middleware from different perspectives. In other words, their requirements will be different.

5.1.1 Developer user perspective

As previously said, ICT technologies for agriculture is still in its infancy but it is rapidly becoming more important. The farmers are historically inclined to ask for proof of real cost benefit, before investing in innovative solutions. As a consequence, for the HYDRA middleware in the agriculture domain it is necessary an even greater effort from developers to identify those really interesting technological areas where real needs from farmers or cattle breeders emerge. The requirements and needs of all stakeholders and application users have to be thought in the design process. The needs of the users must be determined and these needs must be reflected in the overall design.

A most imminent problem is to have systems reflecting the complexity of the domain, i.e. the various subsystems need to be able to communicate with each other to a much larger degree than today, to match the farmer's know-how and expertise. The Hydra middleware for the agriculture domain in this sense will allow developers to develop high-performance applications for heterogeneous physical devices and is thus extremely well positioned to help developer users meet most of the challenges. As example we have two application develop fields:

Tracking, authenticity and labelling of products

The application developer user is responsible for the design and development of tracking functions and devices. He has to develop them with respect to user needs and usability design aspects and in the HYDRA project of course by the usage of the hydra toolkit. The developer has to be in close contacts with equipment manufacturers and eventually end-users. The needs of all these stakeholders must be reflected in all areas of the design process. Due to the low level of technology access in this domain, the initial design may be modified considerably during the process. Necessary changes must be identified quite early, so that it is easy to adapt the system.

The design process must be divided into different steps; to describe scenarios and use cases helps the designer to determine how the technology can benefit the person in the different situations. The needs of the stakeholders inform the design process and determine the level of interaction that is required between the user and the technology.

Crop and animal monitoring devices

In the market for intelligent sensing applications, for example humidity quantifier, devices or alert systems are combined in order to facilitate the farmers activity. Therefore manufacturers of technological agriculture devices have to follow new field of research in the domain and must prepare and equip their devices for an easy and seamless integration and implementation into typical applications.

5.1.2 Agriculture facility manager / service provider perspective

In the area of agriculture there is a not diffused presence of specific facility manager or service provider figures, even if relevant exception could be found in GIS solutions, bioenergy production and of course biogenetic or chemical research and food processing techniques. The farmers' custom to exploit "hand-made" or "own-made" devices has always characterised this sector, so most often advanced technological application providers are working in particular sectors or directly come from farmers who changed their activity. Some IT companies decided to move towards the enormous market of the farmers and breeders (amongst them IBM). Most of those companies soon realised that there were no fast bucks to be made and numbers fell back quite quickly to four or five specialist operators. However the approach is not coincident throughout all EU countries: software and systems can be provided from education and research sector, but also from software house.

Among the possible interesting topics, management information systems tool allows for elaborate farm planning, easy tracking of performance, e.g. dairy cow programs providing analysis of individual animal performance data. One of the biggest drivers to use for farming management systems has been the increasing emphasis on recording for statutory purposes, quality assurance and traceability. 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. Other typical applications to date have included pest management in grain stores, arable crop disease control and grass seed mixture formulation. The systems have to deal with a lot of different functions (sensing and actuating systems, lighting devices, etc.) and specific requirements have to be regarded for the several part of a farm / cattle breeding.

The facility manager shall be especially trained and skilled in accordance to the specific application system he is responsible for. He installs the system and has a direct contact to the user of the system. He is aware of the combination of the different end-user devices and the specific demands and wishes of each customer. An important task is to adapt generic and already developed applications running on different devices to the specific requirements of farms and farmers, greenhouses etc. In this contest it is not fundamental that the system he/she develops is easy to use because the facility manager should give a proper coaching program of the implemented system to the end user. These users are not technically experienced, so the systems have to run quite stable. It is important that this system can be monitored and easily operated and it must at least be understandable for the facility manager, due also to the requested networking capabilities.

5.1.3 End user perspectives

The perspective of the final users, i.e. farmers, was partly reached at the HYDRA workshop organised to gather the basic set of agriculture requirements and identify the most important scenarios of use. In fact among the participants to the workshop, the category of stakeholders of academic researchers were mostly represented, while a few representatives of agro-manufactoring issues participated to the event. In this report it is important to give a basic but consistent view of the needs of the farmers and cattle breeders representing the final users, even if collected via experts' brainstorming. As a second step the requirements shall integrate the identified needs into development projects in order to arrive at effective and really needed agricultural instruments.

Measuring user requirements during agricultural device development will result in successful products that improve farm sustainable agricultural production, storage and product development for agronomic crops, animal health, soil fertility, irrigation and drainage.

Using computer systems to assimilate information and provide advice is perhaps the most exciting opportunity for the future use of ICT in agriculture sector. The fundamental issue with ICT adoption in agriculture – as in most other industries as well – is the lack of real and perceived benefit to the user, i.e. the effort required to use a piece of hardware and/or software must be less than the benefit derived from its adoption. As a consequence, the success of new solutions for agriculture domain will strongly depend on highlighting the beneficial effects that could arise to the farmers and their products while approaching the selling market. This means also a study on the user acceptance (user intended as the person who buys food or drink at the market). Usability and acceptability depend on various factors: adequate design, financial resources, work circumstances, personal attitudes and experiences, marketing and the advantages and practicality of the devices.

5.2 Generic requirements derived from the scenarios

From the scenarios, the following high-level developer user requirements for HYDRA enabled devices can be derived:

"The Piggy Bank" scenario *(in which the farmers together with developer users optimising the production)*

- configurability, heterogeneous networks, accountability, interconnectivity, standard interfaces, scalability, intelligence needed with resource constrains

"From Farm to Fork" scenario *(in which high quality food and niche products come from a market demand)*

- interconnectivity, heterogeneous networks, scalability, configurability, accountability, secure and regulated environment, compliance monitoring, reliability and trust

"Ye Ole Barn!" Scenario *(in which farmers and developer users works primarily for a local market)*

- hiding complexity, accountability, standard interfaces, configurability, secure and regulated environment, registration and monitoring, sustainability

"There is no hurry!" Scenario *(in which end-users are provided with safe food products)*

- hiding complexity, standard interfaces, centralised control, network architecture, configurability, secure and regulated environment, intelligence needed with resource constrains, reliability and trust

5.3 Specific requirements derived from the scenarios

From the scenarios outlined during the workshops and sketched in *Deliverable 2.1 - Scenarios for usage of HYDRA in 3 different domains*, the discussion revealed a number of high-level generic requirements for future agriculture applications, devices and systems. These requirements will be addressed in the HYDRA middleware so that it will allow the development users to develop exactly the innovative agriculture applications that are needed. From the storylines, a systematic formalisation of all relevant user requirements and functional, security and societal requirements has been derived.

The following table list the generic and specific agriculture requirements, which have been identified in the four scenarios. The requirements are reflected, either directly or indirectly, in the technical requirements reported in *D2.5 Initial requirements*. The process of re-engineering of requirements are described in *D3.3 Draft of architectural design specification*.

No.	Scenario fragments	Derived requirements	Impact
	3.1 The Piggy Bank		
58	*Consolidation over the last fifteen years has resulted in fewer but even larger swine operations..*	Industry on this sector is well established; implemented applications should consider existing standard and interfaces	Device view Runtime view
59	*There have been many environmental problems with these large industrial operations.*	The large amount of possible operations request a robust and scalable design	Device view
60	*Regulations have now been put in place to limit ..* *A new law requires..*	The application has to fulfil the different applicable law regulations	Runtime view
61	.. *other means to reduce his operation costs.*	The need of low cost devices and low cost maintenance is essential	Device view Runtime view
62	*the stable control system is fully integrated with other subsystems controlling doors and windows*	Applications must be able to interface to highly heterogeneous systems	Runtime view
63	*The sensor system will facilitate other monitoring activities..*	There is the need of logging running application and also performance evaluation data	Runtime view
64	*..the widespread use of standardise interfaces..*	Applications must have standardised communication interfaces	Runtime view
65	*..he will have to operate the system in learning mode.. it requires Jeffrey's close monitoring and attention..*	Applications must be configurable and scalable; the graphical interface may require complex and iterative use	Device view
	3.2 From Farm to Fork		
66	*The woman holds a small PDA-like computer in her hand.*	The application is PDA based	Device view
67	*..when the screen starts to fill up with information.*	The graphical interface is suitable to content data in different format (text, icons, figures, tables,..)	Device view
68	*..first fully automated, integrated and networked system for tracking foodstuff "from farm to fork".*	The application is highly integrated and inserted in a networked framework; scaling is mandatory. The application must operate communicating with external devices and store huge amount of data in different media or supports.	Runtime view

No.	Scenario fragments	Derived requirements	Impact
69	*..very close cooperation between government regulators, industry and consumer associations, farmers and technology developers.* *.. This data is requested by law..*	The application has to fulfil the different applicable law regulations	Runtime view
70	*..the PDA screen and cameras are zooming in.*	User friendly graphical interface are needed	Device view
71	*..extract the vast amount of private data..* *The site links to the historical information database..*	The application must collect data from sources over the net in a secure mode	Runtime view
72	*The privacy of data is preserved, because none of the data ever leaves the repositories of the data owners, unless specifically provided for by law, until the consumer specifically asks for it in the store.*	The system must be able to operate a security model, where data privacy is preserved	Runtime view
73	*The value to the farmer is that the farm site also allows the farmer to advertise his products*	Economic incentives drives business models	Business model
74	*The Hydra tracking systems can perform automatic searches in these databases and extract information*	Applications must be able to semantically locate necessary data sources, and repositories, especially in real time	Runtime view
75	*All systems are equipped with elaborate trust models..* *..embedded security framework..*	The system must have secure access, actions performed and logging; identity management system is present	Device view Runtime view
	3.3 Ye Ole Barn!		
76	*.. successful sustainable for local rural products..*	Local market is preferred in this application business models	Business model
77	*They all agree that traditional farming methods must prevail.*	The intervention made from the developer user has to be “transparent” in respect to the traditional farming techniques	Device view Runtime view
78	*The farming methods must align with the demand of customers, so human safety, environmental concern, and animal welfare is unquestionable values.*	Application has to be scalable; product traceability has to be allowed	Runtime view
79	*..about 70% of their sales come from internet trade.*	System integration and networking are mandatory.	Runtime view

No.	Scenario fragments	Derived requirements	Impact
80	*.. use advanced ICT systems and irrigation automation to enhance water use efficiency..*	Implemented applications should consider existing standard and interfaces, in order that the system may interact with existing devices	Runtime view
81	*The system has complex irrigation models with an expert system for advanced scheduling and decision support and dynamic search for up-to-date weather information.*	A centralised control and monitoring is preferred, able also to gather information from external sources (connection to the net)	Runtime view
82	*The sensors are spread on the fields and ploughed into the ground.*	A distributed architecture for the sensing nodes and actuators is preferred	Device view Runtime view
83	*The system acquires real-time acoustic signals..*	Real time application must be operated	Runtime view
84	*The central irrigation control system uses and advanced optimisation algorithm..*	The central intelligence must implement advanced (genetic) algorithms for actuators use optimisation	Runtime view
85	*These yield maps will then be correlated with irrigation history..*	The application must collect and store data in different media or supports	Runtime view
	3.4 There is no hurry!		
86	*The family has always produced wines here for the high quality market segment, using vinification methods developed over centuries.* *..* *ICT use in wine industry has mostly been about mechanising existing processes.*	Methods and techniques in this sector are well established; implemented applications should consider existing standard and interfaces	Device view Runtime view
87	*.. they do not necessarily see the need for detailed information..* *.. One exception, though, is the high end wine business..*	The application must be configurable, in order to adapt to the requested output	Runtime view
88	*.. collecting the information and writing informative descriptions. This work is highly computerised and they maintain their own web site..*	The application must collect data from sources over the net, and also distribute product information over internet	Runtime view
89	*Georges has invested in several PCs already.* *.. he now has a software package that can calculate the expected yield for each of his fields..*	The application should have a high level of integration with existing SW platforms	Runtime view

No.	Scenario fragments	Derived requirements	Impact
90	*.. he also finds the effort involved in consigning data to a computer system is greater than benefit he obtains.*	Hiding complexity is mandatory; the application should be user friendly and not over demanding in terms of time spent to learn how to use the system	Device view Runtime view
91	*.. use the emerging decision support tools to be a little more intelligent..* *.. facilitating and enabling existing trading processes is more successful than re-engineering the way a whole industry does business.*	The application should try not to invent particular technologies, but to augment the performances of simple and most used cultivation instruments	Device view Runtime view
92	*.. vine growers are unlikely to move too quickly until they fully understand the implications and costs.* *.. developers' perception of value (environmental benefits or software intended to save manual labour for example) may not always be shared by the wine growers.*	The system implementation should consider resource constrains	Device view Runtime view
93	*.. the use of ICT, also in rural area, will eventually become more widespread.*	The application should be scalable	Runtime view
94	*One important application he sees for ICT is in wine fraud.*	The system should already take into consideration (during the design phase) the possibility to implement elaborated trust models, so that secure access, logging and identification are easily integrated to the system	Runtime view

6. The agriculture vision scenario

To illustrate the vision scenario in this domain we choose the "From Farm to Fork" scenario. After a view to the completeness and complementarity of domain high-level requirements, this can be chosen for inclusion in the demonstrator development.

Parts of this scenario vision can thus be incorporated among the technical user scenarios throughout the Project, which in turn may consist in a demonstrator of the progress of the project and the use of the HYDRA middleware in the agriculture domain. At different iteration levels, various aspects of the scenario will be integrated for the demonstration as defined in the technical scenario. The precise content of agriculture applications in each demonstrator will be determined during the course of the project and will strongly depend on the availability of HYDRA components at the time of implementation and demonstration.

The aim is that the final demonstrator (M36) is capable of providing a demonstration of a developer user technical scenario, which will be able to generate applications such as those foreseen by domain experts in the vision scenario.

6.1 The "From Farm to Fork" scenario

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

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

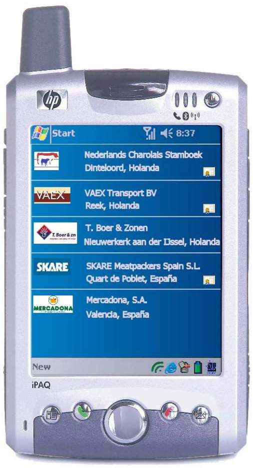
The woman is the Spanish Ministra de Agricultura, Pesca y Alimentación Christina Ramos. She has just inaugurated Spain's and Europe's first fully automated, integrated and networked system for tracking foodstuff "from farm to fork". For the first time ever, consumers will now be able to see the entire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

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

The minister now looks at the PDA screen and cameras are zooming in. What is so exciting? On the screen is displayed a list of the entire value chain that the product has gone through in its lifecycle. The minister took a product randomly off the shelf, which is in fact a package of four steaks. With th… DA, the minister reads the entire history of these four steaks from the R… tag. The screen displays the steps that the meat has passed from the fa… se, the meat packager, the wholesaler and until it reaches the retailer. C… y see that the meat left the farm in DInteloord in The Netherlands on 17 F… he slaugtherhouse in Valencia on 20 February, but she can also see the e… he authorised actors in the value chain.

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

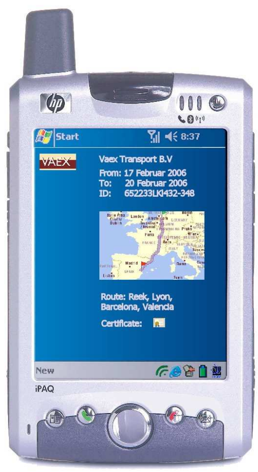
The minister turns around and urges a tall man standing in the back to come forward. He presents the man to the press as Pedro Ramarosa, the chief architect of the project and asks him to show how the system can give detailed information of the farm.



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

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

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



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

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

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

7. References

International Standards Organisation, Agricultural Electronics website http://www.iso.org/iso/en/CatalogueListPage.CatalogueList?COMMID=999

Carroll, J. M. (2000): *Making Use: scenario-based design of human-computer interactions*. MIT Press.

Galt, M.; Chicoine-Piper, G.; Chicoine-Piper, N.; Hodgson, A. (1997): *IDON Scenario Thinking: How to Navigate the Uncertainties of Unknown Futures*. IDON Ltd

Robertson, S.; Robertson, J. (2006): *Mastering the Requirements Process - Second Edition*, Addison-Wesley. ISBN 0-321-41949-9.

Hickey, A.M.; Dean, D. L.; Nunamaker, J. F. (1999): *Establishing a Foundation for Collaborative Scenario Elicitation*. The DATA BASE for Advances in Information Systems. 30, 3-4, pp. 92-110.

Hickey, A.M.; Dean, D. L. (1998): *Prototyping for Requirements Elicitation and Validation: A Participative Prototype Evaluation Methodology.* Proceedings of the 1998 Americas Conference on Information Systems, Baltimore MD, pp. 798-800.

ISO (1999): *Human-centred design processes for interactive systems*. International Organisation for Standardisation.

Dertouzos, M. (1997): What Will Be: How the New World of Information Will Change Our Lives. Harper-Collins, New York, NJ, USA.

Dey, A. K., Salber, D., and Abowd, G. (2001): A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications. Human- Computer Interaction, Vol 16.

HYDRA (2006a): D2.1 Scenarios for usage of HYDRA in 3 different domains. HYDRA Project Deliverable, IST project 2005-034891.

HYDRA (2006b): D2.5 Initial Requirements Report. HYDRA Project Deliverable, IST project 2005-034891.

HYDRA (2006c): D3.3 Draft of architectural design specification. HYDRA Project Deliverable, IST project 2005-034891.

MacLean, A., Carter, K., Lövstrand, L., Moran, T.P. (1990): User-Tailorable Systems: Pressing the Issue with Buttons. In Int. Conference on Computer-Human-Interation (CHI'90), (Seattle, WA. USA, 1990), ACM Press, pp. 175-182.

Rozanski, N. and Woods, E. (2005): Software systems architecture : working with stakeholders using viewpoints and perspectives, Pearson Education.