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Hydra

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

D2.1 Scenarios for usage of HYDRA in 3 different domains

Integrated Project
SO 2.5.3 Embedded systems

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1. Introduction

1.1 Purpose and context of this deliverable

This document describes the work performed with the aim of establishing a set of plausible usage scenarios on 2015 involving the typical use of Hydra in three different domains: Building Automation, Healthcare, and Agriculture.

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

From the scenarios and storylines, a systematic formalisation of all relevant user requirements and subsystem functional, security and societal requirements will be derived. Functional user requirements specifications will involve the most important aspects of user expectations in the chosen application domains. The security requirements will be based on an analysis of the scenarios and formulation of trust and security perception. Societal requirements arise from correlating socio-economic, regulatory and policy issues with the deployment and use of monitoring infrastructures.

The functional, security and societal requirements derived will then be integrated and generalised to form a package of initial user requirements specifications that will be fed to WP 3 – Architecture design specification.

In line with the adopted Iterative Requirement Engineering methodology, results obtained during project progress will be used for a re-formulation of the initial requirements incorporating emergent requirements to be fed back to WP3 to enable the necessary modification of the design specification and subsequent re-engineering and re-validation of the affected modules.

At the end of the workpackage, the validation framework will be developed. The validation framework will serve as a baseline on how, when and by whom, validation is going to take place in WP 10 – Validation & business modelling. The framework guides the collection of information about the project specific objectives, requirements and constraints on user validation (different methods measure different quality dimensions).

1.2 Scope of this deliverable

The present document contains a discussion of the use of scenarios for planning the future. A brief survey of available mapping methods are presented and the choice of the IDON Scenario Thinking method is argued in chapter 3 followed by a detailed description of the IDON methodology in chapter 4, which has been adopted for the Hydra project.

After this introduction, the user scenarios are described. For each application domain: Building Automation, Healthcare and Agricultural applications, four scenarios are developed in chapters 5-6, 7-8 and 9-10. At least one scenario from each group will be used to develop the user requirements specifications.

Finally, in chapter 11 the scenarios have been interpreted and evaluated in order to facilitate the technical requirements to be derived from the scenarios and the final system architecture.

Building and populating the user scenarios will mark the successful completion of the Hydra project. The Hydra middleware will be used to develop successful and innovative end-user applications to demonstrate the selected scenarios. The user scenarios will be installed at specified locations and exposed to the validation described in the validation framework.

2. Executive summary

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

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

2.1 Scenario Thinking – The IDON method

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

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

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

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

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

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

2.2 The Building Automation scenarios

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

How do we develop and deploy intelligent, ubiquitous and secure networked products and services in buildings and facilities in 2015?

We have focused the scenario on the domain of building automation and facility management for commercial and residential buildings and we created the four scenarios from two clusters: "Interconnectivity" (in contrast to interoperability) and "Universal focus" (pointing to either end-users or developer users).

The four scenarios are:

1. Developer-user centric + Connected Systems (*Walking the Dog)*
2. Developer-user centric + Interoperable Systems *(The Beehive)*
3. End-user centric + Interoperable Systems *(Easy does it!)*
4. End-user centric + Connected Systems *(Daredevils)*

The scene shows a typical developer user or end users situation around 2015. The developer user is either employed in a manufacturing company that develops devices, products, embedded and networked systems or services, or he/she is working with system integration, either as a traditional system integrator, an engineering company or as a customer building in-house systems. The developer is faced with the task of creating new or improved embedded systems and applications, which is to be based on a high degree of networking capability of various devices.

The scenes highlights that smart home technologies are widespread and affordable to everyone. Most smart appliances have high value propositions and make the homes more attractive. With people moving frequently, there is a sound market for bundles of products and services. Preventative maintenance is one such service offered, which successfully is used to increase customer loyalty. Generally the manufacturers have a high influence on the way the products are installed and they are able to impose access control and authentication schemes on end-users.

2.3 The healthcare scenarios

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

How do we develop and deploy intelligent, ubiquitous and secure networked products and services for healthcare in 2015?

We have created the four scenarios from two clusters: "Technology Drive" (either in convergence or divergence with clinical drive) and "Clinical Innovation" (which can either be evolutionary or revolutionary). The possible combinations are the following:

1. Technology convergence + Clinical evolution *(Overload)*
2. Technology convergence + Clinical revolution *(Joining Hands)*
3. Technology divergence + Clinical revolution *(My way)*
4. Technology divergence + Clinical evolution *(Brain Trust)*

The scenes are typical healthcare situations around 2015. Lifestyle diseases are a very important societal concern. Everyone even remotely related to healthcare: Politicians, healthcare administrators, medical and non-medical professionals such as teachers, social workers and private employers, is strongly engaged in encouraging people to live a healthier lifestyle. This involves eating and drinking with reason, stop smoking, avoiding stress and exercising regularly. The methods involve information, training and more information.

Generally, patients are much more involved in their own health not least due to increased access to on-line information on health and lifestyle diseases, participation in virtual communities and availability of smart devices which is a significant tool for helping and motivating people to live healthier and manage their chronic conditions. However, on the flip side of the overall situation, patient compliance is still a serious problem because patients some times take matters into their own hands which ironically hinder effective self-management of especially chronic diseases.

Developer user is being presented with a series of requirements for new medical equipment and health care systems. Developing infrastructure for this domain has a series of unique requirements, such as safety, accuracy, 24/7 operation, data security and privacy, adaptability to legacy systems, configurability, usability for users and administrators, scalability, cost benefit, etc., etc. The complexity and the stringent extra-functional requirements often drive both development and manufacturing cost through the roof. The developers will therefore increasingly be met with the need to reuse existing devices or systems, use off-the-shelf components where possible.

2.4 The Agriculture scenarios

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

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

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

1. Hi-tech farming + The indifferent consumer *(The Piggy Bank)*
2. Hi-tech farming + The conscious consumer *(From Farm to Fork)*
3. Traditional farming + The conscious consumer *(Ye Ole Barn!)*
4. Traditional farming + The indifferent consumer *(There is no hurry!)*

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

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

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

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

2.5 Scenario interpretation and derived user requirements

Each scenario represents a unique set of technical, security and socio-economic requirements. To cover the broadest possible spectrum with the Hydra architecture, all requirements will be reflected in the requirements specification.

How the main topical requirements can be derived from the twelve scenarios is presented in a table in section 11.4.

3. Scenario planning of the future

3.1 Navigate the uncertainties of unknown futures

Accountable decision-making about future user requirements needs a high element of certainty - an adequate level of knowledge and confidence in our assumptions about that knowledge. But defining user requirements today is far more complex than ever before, taking place in a fast changing, highly uncertain information and technology driven environment. Compounding this, the illusive interlacing of shifting values and policies, social structures and behaviour increasingly undermine predictions on how the future will look. On their own, familiar planning and forecasting practices that have served us well in the past, cannot deliver the insights and answers we need now.

The process of Scenario Thinking (or Scenario Planning as it is sometimes called) is widely recognized as a tool for creating user requirements specifications under uncertainty.

Scenario Thinking is not about predicting the future and, surprisingly enough, not about choosing the best way forward, though it is indeed a powerful and invaluable tool, which helps this. Its primary value lies in the development of new skills for improving the definition and planning of user requirements.

Developing and deploying these skills enables us to transcend the specific or localised circumstance solution, to go beyond short-term or one-off successes and acquire a consistency and robustness in coherent long-term user scenarios. We come to know the right questions to ask and where to look for missing pieces to the puzzle; how to spot unique opportunities and choose the best way forward.

3.2 Context scenarios

The first step in Scenario Thinking is to fix ourselves firmly in the present. When thinking about the future, we do so within a context; a starting place or how things are now, gives rise to an opening array of ideas or facts, which in turn are related to some sense of a desired goal or objective for future user interaction.

As we convert this information into well defined stories of possible future situations and what our options for action in them are, we surface the inherent uncertainties facing us that need to be dealt with or overcome. An obvious fact often forgotten is that these uncertainties have sprung out of our original thinking, assumptions, omissions and commissions.

The quality and disposition of original input will strongly influence the flow of thought, handling of material and quality of output. In order to make the best use of scenarios it is important to clarify our intentions and identify the issues or areas to test with the multiple futures.

3.2.1 What is a scenario?

The future is awash with uncertainty. Scenarios are snapshots of possible/alternative futures that help us plumb that uncertainty. Scenarios provide coherent, comprehensive, internally consistent descriptions of plausible futures built on the imagined interaction of key trends. It essentially requires you to think from the outside in and takes you through a process that starts with creating context for the unknown.

3.2.2 What is the purpose?

The purpose of Scenario Thinking is to challenge the preconceived notions people have of the future, or their maps, and to afford people the flexibility to change those maps. The process is intended to open up the way you think about the future. Scenarios help identify threats, recognize opportunities and makes choices about issues of strategic importance. Scenarios illuminate the possible, what might be. It asks you to do something a bit counterintuitive, which is to go beyond the known into the unknown, outside your expertise.

3.2.3 How to use scenarios?

As you read the scenarios, think about how you might answer each of these questions:

- Is this even remotely possible?
- Would the world be a better place in this scenario?
- If you were a user in this scenario, what would you be doing differently?
- If you knew for sure that this scenario was to come true, what would you as a user do now?

In essence the Scenario Thinking process is designed to arrive at several parallel hypotheses about the future, which can be held at the same time. These hypotheses are given form and are able to be pictured by users by embedding them in a story or scenario. In turn this means that the same person can look at the evidence through different sets of glasses and see things in a different perspective.

3.3 IDON Scenario Thinking

Mapping approaches have received a great recognition in the education and business professional activities. Hexagon Mapping is part of visual facilitation approach, which combines dynamic representation with creativity using visual idea representing units, called idons. Idons afford manipulating, combining and rearranging as a continuous process of formulating thoughts. Hexagon mapping accepts some of the basic theoretical assumptions of system dynamic mapping and the principles of lateral thinking.

Having established the context of investigation, through a variety of information gathering techniques, dialogue and modelling methods, the knowledge is shaped into distinctive alternative stories of the future or scenarios.

IDON Scenario Thinking is based on the logical intuitive story-and-simulation approach to scenario thinking and was originally developed in consultation with Arie de Geus, author of "The Living Company" while head planning coordinator of Shell International.

IDON Scenario Thinking has a well-established track record in a wide variety of fields.

3.4 Development of scenarios in Hydra

The scenarios will in Hydra be used to derive detailed user requirements, to investigate the consequences of emerging new or disrupting technologies, as the basis for security and trust analysis and as a model for deriving user validation frameworks.

The scenarios have been developed in three one-day user workshops involving a varied group of experts from the selected domains. The workshops have been conducted in three different countries to stimulate the European dimension. Representatives from partners IN-JET, INNOVA and C-LAB have facilitated each workshop.

The workshop starts with a short introduction to the Hydra project and an overview of the IDON method for scenario planning. A short introduction was mailed to the participants prior to the workshop.

4. Implementing the IDON method

Using the IDON method step by step will result in a set of scenarios that all points to alternative use cases within a give user domain and at a given point in time. All scenarios will have the same frame of reference and – ideally – be equally likely to happen.

The IDON method consists of two parts: Scenario Development and Scenario Deployment. The scenarios are developed in the *Scenario Development* part using experts and based on knowledge and systematic analysis. The aim is to develop four mind-challenging scenarios by mixing inevitable trends with creative fiction.

In the *Scenario Deployment* part, technical experts and project decision makers interpret the scenarios and extract a framework for the functional and trust and security requirement specifications. By applying a systematic approach as is used here in Hydra, the interpretation of the scenarios becomes very convincing. The scenario deployment into user requirements takes place in WP3. They become the guiding specifications for the technical development work in Hydra. The validation of the resulting platform will also be linked to the scenarios.

4.1 Creating and writing scenarios with a group

Hydra 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 business and way of work. The scenarios will draw on both available research and application knowledge in the consortium and on the opinion of a divers set of experts form different parts of the domain.

The process and group dynamics is managed by a group facilitator, who is also responsible for the final documentation and write-up of the scenarios.

4.2 Environmental factors

The core of the IDON technique is to examine a set of wider environmental factors ambiguities and uncertainties identified by the group in order to resolve, which role they are likely to play in the unfolding of a variety of scenarios.

Some of the environmental factors that might be covered in the discussion process are:

- research and technology trends
- institutional and market trends
- social values and life-styles
- economic futures
- management and delivery systems
- ethical and value questions
- global political influences
- ecological and environmental issues

It can be difficult to move from such a set of factors to actually construct scenarios, but the IDON method and its systematic approach is a good way to do it and has proven its usefulness in many other projects.

4.3 The "Trigger Question"

The initial phase of the IDON method involves three steps. After this phase, a variety of environmental factors should have been identified, evaluated and ranked.

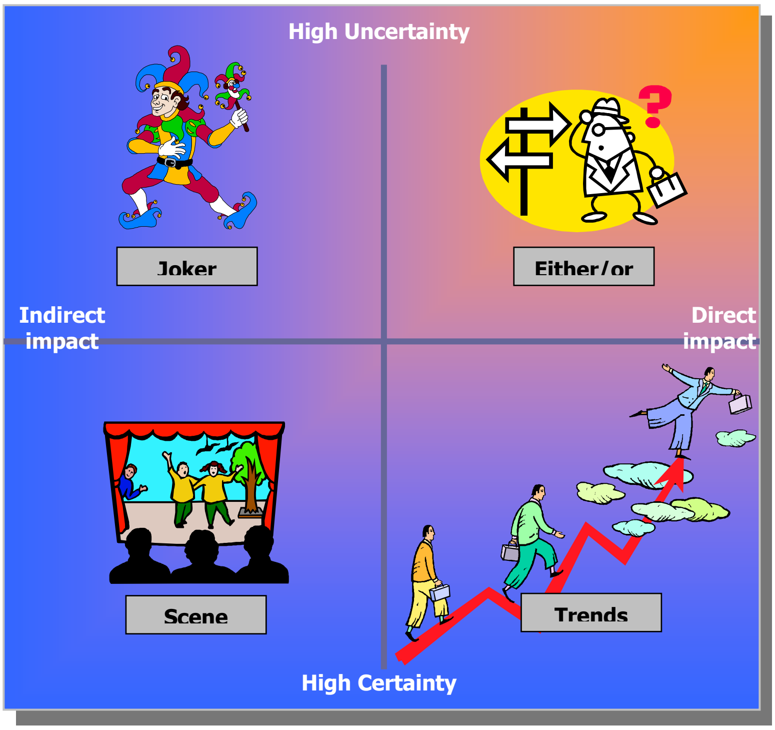
Step 1 – gathering environmental factors

The facilitator formulates a question designed to elicit responses from participants, which will cover the subject of either of the three user cases in Hydra. This is called the "Trigger Question" because it triggers a whole range of creative thoughts about the subject.

Step 2 – positioning on the grid

The next step is to group factors according to their degree of uncertainty and how direct their impact is likely to be on the user cases.

The method is visualized using a conventional two-dimensional grid:



The dimensions of the grid are introduced, without interpretation at this point. The idea here is to begin to sort the different factors, placing them on the grid, where the participants feel they best belong. Each factor is taken in turn and its position discussed and provisionally fixed according to its perceived "Higher" or "Lower" degree of uncertainty and "Indirect" and "Direct" impact in the user cases. Note that absolute positioning is not the point; it is the relative positioning that is important.

Step 3 – Survey all factors

When all the factors have been placed in position, the whole set is reviewed by the group and fine adjustments is made in relative positioning.

4.4 Characterization of the quadrants

Each quadrant has a different interpretation but that there is no sharp line of distinction either vertical or horizontal. The behaviour of each group of factors in broad terms is as follows:

<u>Top - right: Pivotal uncertainties (Either / or)</u>

These factors are likely to have a direct impact on the user cases, but their outcome is uncertain. They are pivotal in the sense that the way they turn out may have strong directional consequences. These factors will determine the shape of the different scenarios.

<u>Top - left: Potential jokers (Joker)</u>

These factors are pretty uncertain as to their outcome and maybe also less relevant to the user cases. However, it could be dangerous to treat them as merely noise. They represent factors that should be monitored in case they move strongly to the right, i.e. develops a direct impact on the user cases.

<u>Bottom - right: Significant trends (Trends)</u>

These factors impact more directly on the user cases and it should be possible to anticipate their effect.

<u>Bottom - left: Context shapers (Scene)</u>

These are relatively certain factors and are bound to shape the future context.

4.5 Use of the quadrants

In the scenario building we are going to explore the uncertainties from the "Either / or" quadrant to derive a set of different scenarios for the user cases. Each scenario will thus reflect the uncertainties attached to those environmental factors that have been grouped in this quadrant.

The environmental factors grouped in the other quadrants will be retained for reference and inclusion in the final stage of writing up the scenarios in the following ways:

> The factors in the context shapers quadrant are those that should be woven into every scenario, if it is written up fully. These factors will be used to describe a common scene for all scenarios.
>
> The significant trends will also run through each scenario but in a manner in which they manifest, will be different in each one. The factors in this quadrant can be said to constitute different sets placed on the scene.
>
> The potential jokers are useful factors to bring into the scenarios during the process, if the scenarios are starting to become too uniform.

A further description of the use of the various quadrants will be given in each of the Hydra user cases.

4.6 Creating prototype scenarios

Scenarios can be thought of simply having three levels. At base level there are the context shapers, which seem pretty inevitable and will tend to underpin all scenarios at a given time – these are changes that are common throughout, like the *stage* in a theatre.

At the intermediate level there are trends and these can be quite complex, because of the variety of ways they can interact with each other. These will be modified from scenario to scenario but still retain their basic condition. These can be likened to the changing scenery in a play.

At the differentiated level each scenario has some unique variances. These differences arise from the uncertainties we perceive. An uncertainty about something means at least things could go this way or go the other way. Uncertainties may be main line or they may be jokers.

As these uncertainties interact in different ways that affect how things turn out, the combinations of even twenty variables are astronomic. We need a way to simplify this information, without diluting its impact, into different emergent stories of the future. These may be perceived as the different dramas that might be put on in a theatre. In order to do this we go through the following stages in creating prototype scenarios from which a full set of scenarios can be developed.

We have chosen here a way to generate four contrasting scenarios. The purpose of this technique is to create simple scenarios that bring out distinct future challenges. At the end of the Scenario Development phase, one of the scenarios will be chosen for implementation as the Hydra user scenario in the respective user area.

Arriving at the prototype scenarios involve three steps.

Step 1 – Reframing the Pivotal Uncertainties as Questions

Looking at the factors in the quadrant marked "Either / or", participants are invited to think of each one as an uncertainty question for which there are two possible outcomes. We will call one outcome state the "flip" (e.g. Yes, education will be affordable) and the other contrasting outcome state the "flop" (e.g. No, education will not be affordable). When the factor in question has either "flipped" or "flopped", the uncertainty is resolved.

An example may illustrate the technique. Assume that the group is working on writing scenarios in a teaching environment. The group has identified a number of uncertain environmental factors (listed in column 1 in the table below). For each factor, a flip (+) and a flop (-) question is formulated (column 2).

Price of education How will the price of education develop in the future?	+	Education will continue to be affordable
	-	Education will become relatively more expensive than today
Access to information How accessible will information be?	+	Easy access to information
	-	Difficult to get access to information
Media types Which media type will proliferate?	+	Electronic media dominates
	-	Traditional media will be retained
Mobility How will people move around?	+	Commuting will be increasingly difficult
	-	Mobility will increase
Equipment Will people have access to the necessary equipment?	+	Access to learning equipment is facilitated
	-	Equipment is only available to few
Learning method What will be the dominant leaning method?	+	Emphasis on individual learning
	-	Emphasis on shared learning
Organizational How will organizational learning evolve?	+	No take-up of organizational learning
	-	Adoption of organizational learning
Collaboration Will people collaborate with co-workers?	+	Minimal collaboration
	-	Collaborative thinking at work

Step 2 – Grouping the factors

The group will now search for connections and associations between the various factors (uncertainties). Uncertainty areas connect because of the impact of their influence of each other, either because if one "flips" the other will "flop" or because they are likely to align by association. This is a kind of domino effect. The group will continue to work with the associations until there are two main clusters or at least two priority clusters out of a set.

In the example above there are 10 environmental factors (uncertainties) of which the first 5 have to do with how people will approach learning ("Learning Location"). The remaining five can be said to relate to the "Learning Culture".

Step 3 – Naming the sub plots

In the clusters we now have groups of questions. When one if the uncertainty questions resolves to, say, a "flip" side, it will tend to correlate with the "flip" side of all the other uncertainties in that cluster. This will end up resolving the entire cluster as a large scale "flip" or "flop". It is rather like a group of little magnets organizing themselves to a main N-pole and S-pole. The two outcomes of the whole cluster are called sub-plots, which will combine in different ways according to the "flip/flop" questions to give us different scenarios.

In the example we can now group the uncertainties in the "Learning Location" cluster as big "flips" and "flops":

Big Flip Cluster "Learning Location"	**Big Flop Cluster "Learning Location"**
• Education affordable • Easy access to information • Electronic media dominates • Commuting increasingly difficult • Access to learning equipment leads to the name: **REMOTE LEARNING**	• Education will be expensive • Difficult to access information • Traditional media retained • Mobility will increase • Equipment only for the few leads to the name: **LOCAL LEARNING**

In a similar way we can group the "learning culture" cluster:

Big Flip Cluster "Learning Culture"	**Big Flop Cluster "Learning Culture"**
• Emphasis on individual learning • No up-take of organizational learning • Minimal collaboration • Poor feedback system • Global pressure reducing leads to the name: **INDIVIDUALISM DOMINATES**	• Emphasis on shared learning • Adoption of organizational learning • Collaborative thinking at work • Effective feedback system • Global pressure for best in class leads to the name: **CORPORATISM DOMINATES**

Each name needs to express a coherent alternative view of the combined uncertainties – more than simply "good" or "bad" but suggestive of how things might develop. They should be imaginative and evocative, like good chapter headings of a novel, and easy to remember, because throughout the project, the names will project be used to quickly identify a tremendously complex set of future uncertainties in a large number of environmental factors.

4.7 Generating multiple images of the future.

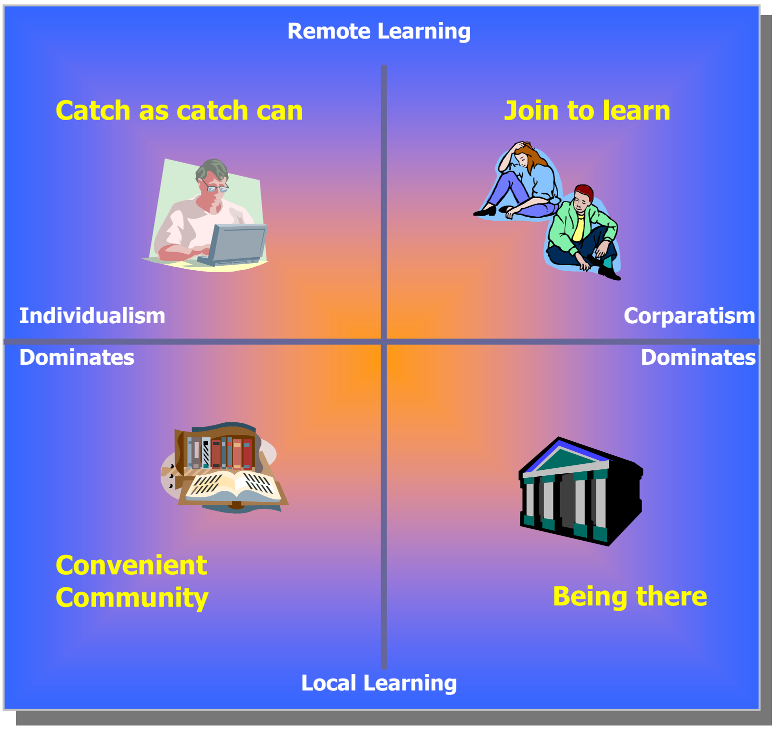
When the subplots have been generated using the "flip-flop" method, they need to be combined to form scenario structures. On the one hand this is a logical process in which there are a set number of combinations statistically. On the other hand it is an intense exercise of imagination and judgment where the participants are challenged to synthesize each set of combinations to formulate scenario stories, which are stimulating and relevant to the thinking task.

The purpose of this is to arrive at creating four scenarios generated from the two clusters, each of which has two states or sub-plots. The titles of these scenarios will represent four distinct possible futures extrapolated from the thinking done by the group and will hold rich meanings, which can be further fleshed out when the scenarios are written up after the exercise is completed.

The four outcomes from the two clusters can be combined in four different ways to form images of the future. In our example, the possible combinations are as follows:

1. Remote Learning + Individualism Dominates
2. Remote Learning + Corporatism Dominates
3. Local Learning + Individualism Dominates
4. Local Learning + Corporatism Dominates

The group now uses their imagination to form a mental picture of the world that emerges within each of the four combinations and formulate a provisional title for that world. The result will be presented in a two dimensional grid like this:



4.8 Writing up scenarios

At the end of the exercise the scenarios are written based on the group discussions and the imaginations and visions crated during the workshop. Group members usually perform the writing up of the stories after the workshop.

Step 1 – Development of the scene

When a scenario is written, the writers start with the scene, which is common for all scenarios. The elements for defining the scenes are found in the lower left "Scene" quadrant of the original grid of environmental factors. The scene must reflect the basic characteristics of the user area, for which the scenarios have been developed.

Step 2 – Building the set

The environmental factors in the lower right "Trend" quadrant constitute the changing sets that are built on the scene for each scenario. Trends have a direct influence on the story in the scenario, but only the environmental factors that are relevant to the scenario are used.

Step 3 – Defining the script

In the final step, the story is written from the prototype scenario so that the scenarios come to life as imaginative plays.

In writing the scenarios, it is useful to let the environmental factors enter the scene, set or script according to a simple grouping:

1. What is happening?
2. How is it happening?
3. Why is it happening?

The final scenarios are illustrated with pictures to stimulate the reader's imagination.

The entire IDON process can be illustrated graphically as in figure 1:

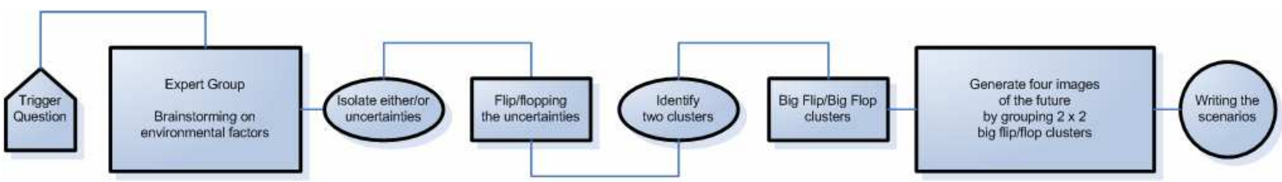


Figure 1 The IDON process

5. The Building Automation domain

5.1 Background of the Building Automation domain

One generally accepted definition of intelligent building technologies are "…integrated technological building systems, communications and controls to create a building and its infrastructure which provides the owner, operator and occupant with an environment which is flexible, effective, comfortable and secure".

The availability of new ICT solutions imposes a dramatic enrichment of the capability of Building Automation components and systems. The expectation among facility owners and managers is that control systems can be integrated and provide a high level of "building intelligence." This concept speaks to managing facilities as assets transforming building data into knowledge and using that to make intelligent business decisions in real time. The driver of building intelligence and many other major trends is economic pressure to increase efficiency and productivity continuously and to do more with less. Another major trend in building is the need for improved security systems, which can be supported by smart and integrated building automation systems. In addition to this, facility management agreements are more and more based on incentives about savings: this implies that facility managers strive to find opportunities for savings in order to share them with the end-users.

The trends affect both major players in the Building Automation market: The *users* (facility managers) and the *suppliers* (components manufacturers and industrial services companies).

5.1.1 Facility managers

The facility managers want plug-and-play interoperability. In fact, the concept of interoperability for facility executives can be traced back to three elements:

- Harmonic coexistence: in this case, what a facility executive wants for his buildings are products from different manufacturers that operate independently without interfering with each other
- Inter-changeability: in this definition of interoperability, all chillers operate so identically, for example, that only the nameplate distinguishes one from another
- Integration that allows for individuality: most facility executives, however, want interoperability somewhere between these two extremes. They want plug-and-play interoperability. They want products that can be integrated easily without using custom hardware or software. But they also want to leave room for supplier differences within product lines.

Facility managers are pushing Building Automation systems vendors to transform today's closed technologies into Web-enabled applications. Facility managers are driving Building Automation systems by demanding open systems. The open architecture approach means widespread acceptance and sharing of hardware and software designs, standards, and protocols and is seen as being critical to the successful spread of intelligent building technology. It will lead to a greater interoperability of various systems.

5.1.2 Products, components and service suppliers

Most product companies will thus soon realise that device networking isn't only possible, it's essential for their future business. Moreover, in a market where customers continuously ask for more complex and integrated services, it clearly results that these new applications and intelligent solutions can help to reduce the risk that product companies take by assuming a greater and greater management responsibility (from simple installation to global service).

A major challenge for most existing Building Automation systems is that they are not wireless. Consequently they are primarily installed in new buildings. Specialists must do all configurations and systems cannot be remotely controlled. Many users do not find that these systems give sufficient value for money. Consequently, the market today is quite limited, but with a great potential in existing buildings, once the proper products are introduced. By deploying an industry-wide Hydra middleware, all products can be service-enabled and made interoperable with just a few device drivers and supporting models for interoperable functions.

A survey conducted by the Wireless LAN Association and NOP World Technology showed that the average payback for a wireless installation is about nine months. The survey also concluded that the average wireless user is 22% more productive than his or her wired counterparts. Productivity benefits are quantified at 48% of the total return on investment of a wireless network.

5.1.3 Business opportunities

Internet-enabling of industrial products are bringing huge business opportunities, which we are only about to discover now. Everything from a pump, a building, an industrial machine, and an office's thermostat will have the potential to be networked thus creating a huge network of interconnected devices. Product companies can use their devices to enter into a customer service relationship that increases both revenue and customer management. In many ways, the product companies can use the networking technology to reduce the burden of Asset Management and reduce the total cost of ownership for the end-user. But it may not be the end-users that initially have the most to gain from the networking. It can well be the businesses that support them. Product companies can use device networking technologies to reduce costs, reduce installation time, improve effectiveness, neutralise learning differences, bridge knowledge gaps, gain more customers, and pursue new opportunities.

5.2 Organization of workshops

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

- Consumer behaviour expert
- Facility manager
- Appliance manufacturer
- Service company
- Security
- Smart house expert
- Telecom

The scenarios were developed through a one-day workshop held at C-LAB in Paderborn, Germany on 17 October 2006. Moderator of the workshop was Jesper Thestrup (IN-JET). Supporting roles were assigned to Christine Ludwig (C-LAB), Trine F. Sørensen (IN-JET) and Tommaso Foglia (INNOVA).

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

1. Markus Reichling, Grundfos GmbH, Germany (pump manufacturer)
2. Günther Ohland, Smart Home Initiative Paderborn, Germany (smart home lab)
3. Carsten Thomsen, DELTA, Denmark (technology provider in embedded systems)
4. Simone Moreali, McPerson, Italy (audio and video manufacturer)
5. Walter Schneider, Benq, Germany (device manufacturer and telecom services)
6. Robbie Schäfer, University of Paderborn, Germany (ambient intelligence expert)
7. Gernot Graefe, Siemens Business Services (consumer behaviour and market development)
8. Bert Plonus, Miele AG, Germany (appliance manufacturer)
9. Andres Marin, Universidad Madrid, Spain (security expert)
10. Heinz-Josef Eikerling, Siemens Business Services (device expert and partner)

5.3 Selection of application area and time horizon

As for the time horizon, the experts were concerned about the availability of complementary technologies and infrastructures, if the time horizon was too long. On the other side, a too short horizon would probably lead to less imaginative scenarios. As a compromise, the time horizon of 2015 was chosen. By the end of the Hydra project in 2010 there is plenty of time to deploy the platform and develop the business cases to roll out in time for the scenarios in 2015.

5.4 Trigger question

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

> How do we develop and deploy intelligent, ubiquitous and secure networked products and services in buildings and facilities in 2015?

5.5 Identification of environmental factors

Factors were identified from among all the possible environments that could influence Building Automation products and applications in 2015:

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

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

The workshop participants defined a total of 75 factors in all areas:

Technology trends (T)
Systemic concepts
One common interface
Information overflow avoided
New connectivity methods
Technical standards
Programming languages
Self-learning capabilities
Transferable personalised settings
Intelligence used proactively
Speech control
Transferability of systems
Firewalls
Security configurability
Interface constraints
Wearable computers
Flexibility
Device interaction
Network complexity
Interoperability standards
Simple touch pads
Predictability
Automatic upgrades
Multimodal interfaces
Prevention of misuse
Interacting systems

Market trends (M)
Structured access required
End-user programming
Warranty period
Business models
Business value creation
Imposed access control
Preventive maintenance
Bundling of services
Device networking required
Simplicity

Economic futures (€)
Energy costs neutrality
Interoperability costs
Smart home affordability
Increased costs for new functions
Energy savings
Affordable devices

Social values and life-styles (L)
PDAs available to all
Mobile phones available to all
End-user acting responsibly
Accepted value propositions
End-user confidence
Attractiveness of homes
High moving rate
eInclusion
Graphical interfaces for the disadvantaged
Trusted domestic environments
Agreed access rules

Ethical and value questions (V)
Third party authorization
Proper functioning
Trust models
Choice of biometrics
End-user configurability
Reputation of manufacturers
Transparency
Automatic updates
Suitability of terminals
System reliability
Clearly defined security responsibilities

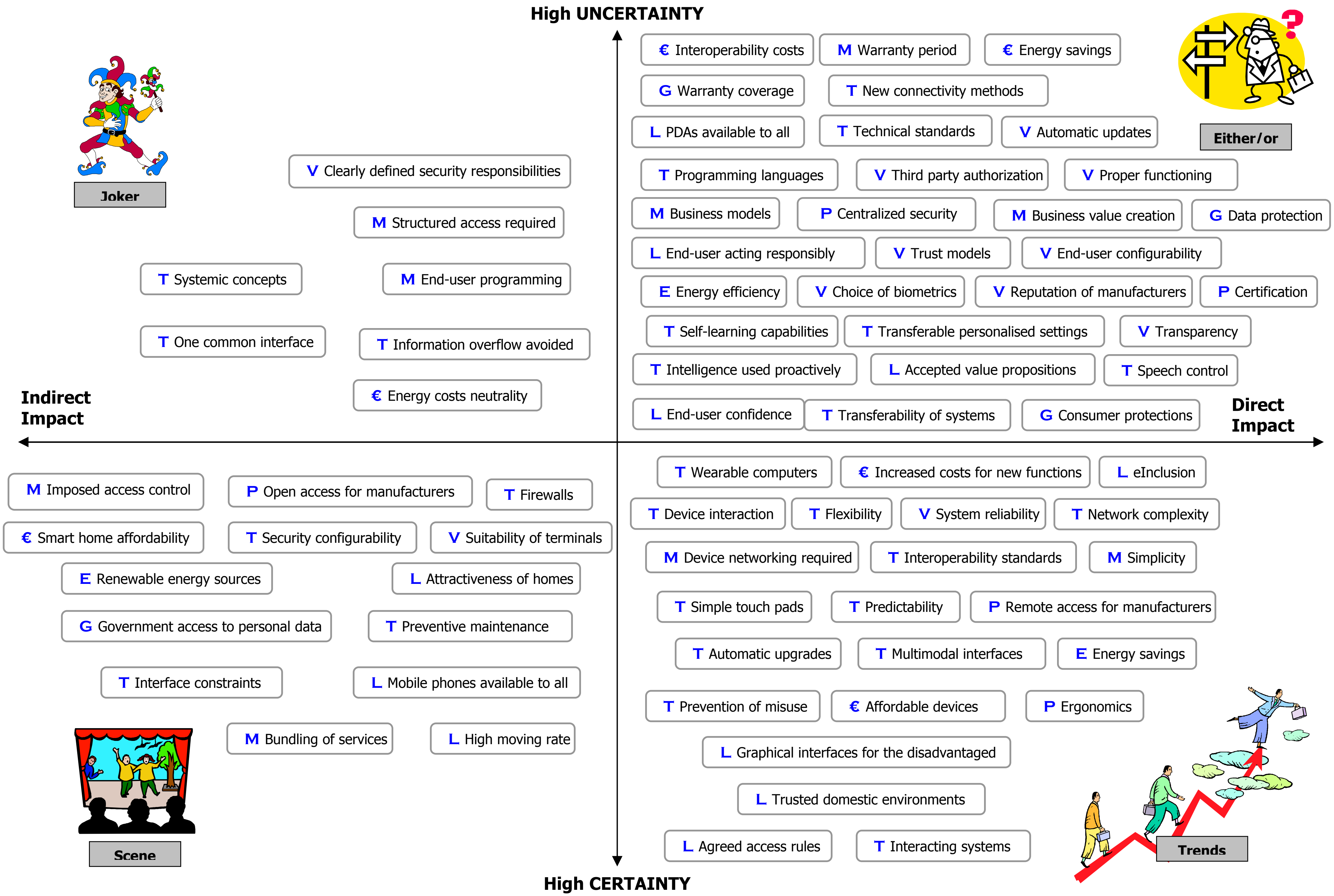
Products, production and logistic systems (P)
Certification
Centralized security
Open access for manufacturers
Remote access for manufacturers
Ergonomics

Ecological and environmental issues (E)
Energy efficiency
Energy savings
Renewable energy sources

Global political influences (G)
Warranty coverage
Consumer protections
Data protection
Government access to personal data

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

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



High UNCERTAINTY
High CERTAINTY
Indirect Impact
Direct Impact
Joker
Either/or
Scene
Trends
€ Interoperability costs
M Warranty period
€ Energy savings
G Warranty coverage
T New connectivity methods
L PDAs available to all
T Technical standards
V Automatic updates
V Clearly defined security responsibilities
T Programming languages
V Third party authorization
V Proper functioning
M Structured access required
M Business models
P Centralized security
M Business value creation
G Data protection
L End-user acting responsibly
V Trust models
V End-user configurability
T Systemic concepts
M End-user programming
E Energy efficiency
V Choice of biometrics
V Reputation of manufacturers
P Certification
T Self-learning capabilities
T Transferable personalised settings
V Transparency
T One common interface
T Information overflow avoided
T Intelligence used proactively
L Accepted value propositions
T Speech control
€ Energy costs neutrality
L End-user confidence
T Transferability of systems
G Consumer protections
T Wearable computers
€ Increased costs for new functions
L eInclusion
M Imposed access control
P Open access for manufacturers
T Firewalls
T Device interaction
T Flexibility
V System reliability
T Network complexity
€ Smart home affordability
T Security configurability
V Suitability of terminals
M Device networking required
T Interoperability standards
M Simplicity
E Renewable energy sources
L Attractiveness of homes
T Simple touch pads
T Predictability
P Remote access for manufacturers
G Government access to personal data
T Preventive maintenance
T Automatic upgrades
T Multimodal interfaces
E Energy savings
T Interface constraints
L Mobile phones available to all
T Prevention of misuse
€ Affordable devices
P Ergonomics
M Bundling of services
L High moving rate
L Graphical interfaces for the disadvantaged
L Trusted domestic environments
L Agreed access rules
T Interacting systems

5.6 Flip-flopping the pivotal uncertainties

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

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

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

Interoperability costs What are the additional costs for producers to make their devices interoperable?	+	The additional costs of providing interconnectivity are insignificant compared to the system price
	-	The costs of interconnectivity with other systems are prohibitive to most manufacturers
Warranty period Will the warranty period for products be decreased in the future?	+	The warranty period will increase due to market demand
	-	The warranty period will decrease due to lack of market demand and fast obsolescence
Warranty coverage Will the issue of warranty coverage for interconnected products be a regulatory issue?	+	Warranty coverage is a regulatory issue and is not related to specific products or services
	-	Warranty coverage is determined by the market forces for the products or services in question
New connectivity methods Will new technologies be introduced for interconnecting devices?	+	New technologies (e.g. the human body) will be introduced for interconnecting devices
	-	Only traditional technologies (i.e. wired and wireless) are used for interconnecting devices
PDAs available to all Will entire population use PDAs?	+	Most end-users own and wants to use PDAs
	-	Only few end-users own and use PDAs
Technical standards Will there be technical standards introduced and dominating?	+	Technical standards for interoperability of systems are introduced and globally accepted
	-	There are few or no technical standards for interoperability of Building Automation systems
Programming languages Will there be sufficient programming languages available?	+	There are common programming languages available for developing interoperable applications
	-	There are only traditional programming languages for embedded systems available
Certification Will device drivers, interfaces and applications need a third party certification?	+	Device drivers, interfaces and applications can obtain third party certification of interoperability
	-	Device drivers, interfaces and applications are solely based on manufacturers own descriptions
Third party authorization Will authorization be handled by third party authorization bodies?	+	Authorization will be provided by a mix of separated trust entities and third party
	-	Authorization will be provided only by third party authorization bodies
Proper functioning How well do systems function in their operating environments?	+	Interconnected systems generally function well in their operating environments
	-	End-users experience frequent problems with the functionality of interconnected systems

Business models Will it be necessary to introduce new business models?	+	Manufacturers will routinely introduce new business models that improve the value proposition
	-	Manufacturers will generally stay with the existing and well proven business models
Centralized security Will the security model be centralised across the network?	+	The security model will be distributed across the network and individualised for each application
	-	The security model will be centralised and all systems will use the same model
Business value creation Will manufactures introduce new products and services with sound value propositions?	+	Manufacturers will launch new offerings with sound value propositions based on interconnectivity
	-	Manufacturers are not able to introduce new products and services based on interconnectivity
End-users acting responsibly Will end-users feel responsible for using the devices/products correctly?	+	End-users expect manufacturers are responsible for correct use of connected devices/products
	-	End-user will accept responsibility for correct use of connected devices/products
Trust models Will manufacturers be able to impose trust models?	+	End users will demand to choose their own trust models
	-	Manufacturers will be able to impose their trust models on end-users
Energy efficiency Will smart homes provide more efficient use of energy resources?	+	Intelligent building concepts will be able to use overall energy resources more efficiently
	-	Intelligent building concepts will lead to an overall increase in the of use energy
Energy savings Will end-users focus on systems to save energy?	+	End-users will prefer systems that have the ability to save energy
	-	End-users will not always be able to choose energy saving system, but must accept what is offered
Choice of biometrics Do end-users want freedom to select the most suited biometric device?	+	End-users wants the freedom to select the most suited biometric device for security
	-	End-users cannot chose specific security devices beyond what is offered by the manufacturer
End-user configurability Do end-users want to be able to configure their system?	+	End-users will be able to fully configure their systems
	-	End-users do not want to and cannot configure their own system
Reputation of manufacturers Will reputation of manufacturers have any influence?	+	End-users choice of trust model is only marginally influenced by individual manufacturers' reputation
	-	Each manufacturers' reputation will dominate the end-users' choice of trust model
Self-learning capabilities Will systems have self-learning capabilities?	+	The systems will have self-learning capabilities
	-	The systems will not have self-learning capabilities
Transferable personal settings Will houses, hotels etc. be able to adjust to individual computing and ambient preferences?	+	New environments (e.g. hotel rooms) will be able to adjust to individual ambient preferences
	-	Every environment will have to be separately adjusted to individual ambient preferences
Transparency	+	End-users want full insight into the functionality provided by the system

Do end-users want full insight into the functionality provided by the system?	-	End-users are not concerned about the details of the functionality provided by the system
Intelligence used pro-actively Will system intelligence assumed responsibility?	+	Embedded AmI intelligence will often assume responsibility for part of the system's functionality
	-	There will be no network based functionalities outside the individual components and systems
Accepted value propositions Will the value propositions be clear and acceptable?	+	Value propositions for intelligent buildings will generally be clear and demanded by end-users
	-	Value propositions for intelligent buildings are often not so evident for the end-users
End-user confidence Are end-users confident that products work properly?	+	End-users needs continually to be made confident that products and systems work properly
	-	End-users are generally not informed and involved when products and systems work properly
Speech control Will the system be based on speech recognition and natural language premises?	+	End End-user interaction is based on new modalities (e.g. speech recognition and natural language)
	-	End-user interaction is based on traditional modalities i.e. with no speech control
Transferability of systems Will the system follow the end-user?	+	End-users can move the system when moving to new premises or homes
	-	The system is location specific and cannot follow the end-user to new locations
Consumer protections Are there laws and regulations to protect consumer interests?	+	Consumer interests are the sole responsibility of the consumers themselves
	-	There are strong laws and regulations in place to protect consumer interests
Data protection Are there laws and regulations to protect private data?	+	It is up to the end-user to make his own provisions to protect his private data
	-	There are strong laws and regulations in place to protect the privacy of end-users' data
Automatic updates Will automatic update require approval from end-users?	+	Automatic updates require approval from end-users and procedures for this are built into the system
	-	Automatic updates do not require approval from end-users but are immediately implemented

5.7 Clustering the uncertainties

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

When inspecting all 31 uncertainties it becomes obvious that about half of them are related to the identity of *the Universal Focus* that drives breakthrough changes in Building Automation technologies. Such breakthrough changes can be driven by a strong focus on user demands is called "Market Pull" and is characterised by technology development that is driven by end-user needs, rather than by ideas or capabilities created by technology developers and researchers.

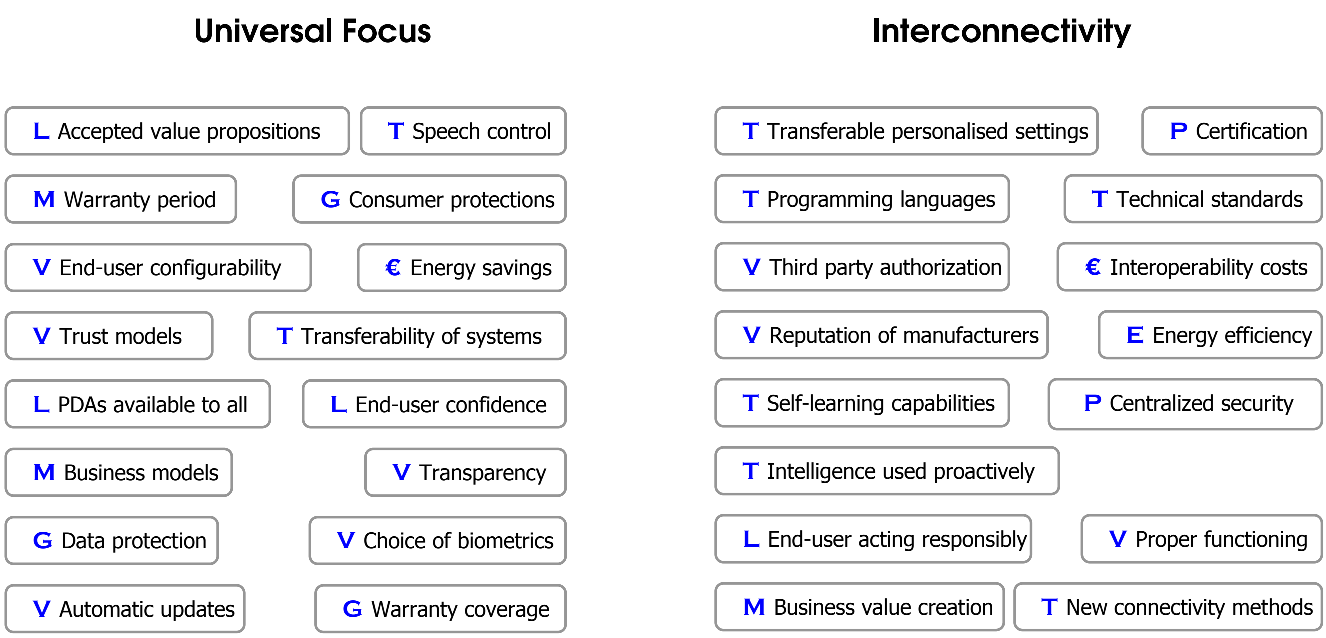
Conversely, "Technology push" is characterised by technology development that is driven by ideas or capabilities created by the technological advances with manufacturer and their developer-users in the absence of any specific customers needs. In "Technology Push", innovations are created and then appropriate end-user applications are sought that fit the innovation or the ambitions of the manufacturer.

A specific cluster of uncertainties related to future technologies in Building Automation is related to end-user configurability and transferability of ambient settings between locations, specific modalities for end-user interaction, end-user's attitudes towards security, trust and privacy and regulatory actions to protect consumers.

Clustering of uncertainties of this kind can be termed **"Universal Focus"** as shown in the figure below. Within the cluster, uncertainties tend to counter align in flip-flop questions so that if one flips, the other will flop (e.g. technology pushed or market pulled innovation).

The other cluster of uncertainties is related to the extent that Building Automation products are able to interconnect and create interoperable, intelligent networked systems. In this cluster, the uncertainties relate to how the products interconnect, the types of intelligent applications that can be supported, the security issues related to distributed and networked systems, and the way business models can be developed to create sustainable values.

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



5.8 Naming the sub plots

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

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

In the **Universal Focus** cluster we arrive at the following large-scale flips and flops:

Big Flip Cluster "Universal focus"	**Big Flop Cluster "Universal focus"**
• End-users will be able to fully configure their systems • End-users want full insight into the functionality provided by the system • End-users can move the system when moving to new premises or homes • End-users needs continually to be made confident that products and systems work properly • Automatic updates require approval from end-users and procedures for this are built into the system • End-user interaction is based on new modalities (e.g. speech recognition and natural language) • Most end-users own and wants to use PDAs • End-users wants the freedom to select the most suited biometric device for security • End users will demand to choose their own trust models • Value propositions for intelligent buildings will generally be clear and demanded by end-users • Manufacturers will routinely introduce new business models that improve the value proposition • End-users will prefer systems that have the ability to save energy • It is up to the end-user to make his own provisions to protect his private data • Consumer interests are the sole responsibility of the consumers themselves • Warranty coverage is a regulatory issue and is not related to specific products or services • The warranty period will increase due to market demand	• End-users do not want to and cannot configure their own system • End-users are not concerned about the details of the functionality provided by the system • The system is location specific and cannot follow the end-user to new locations • End-users are generally not informed and involved when products and systems work properly • Automatic updates do not require approval from end-users but are immediately implemented • End-user interaction is based on traditional modalities i.e. with no speech control • Only few end-users own and use PDAs • End-users cannot chose specific security devices beyond what is offered by the manufacturer • Manufacturers will be able to impose their trust models on end-users • Value propositions for intelligent buildings are often not so evident for the end-users • Manufacturers will generally stay with the existing and well proven business models • End-users will not always be able to choose energy saving system, but must accept what is offered • There are strong laws and regulations in place to protect consumer interests • There are strong laws and regulations in place to protect the privacy of end-users' data • Warranty coverage is determined by the market forces for the products or services in question • The warranty period will decrease due to lack of market demand and fast obsolescence
which leads to the name: **END-USER CENTRIC**	*which leads to the name:* **DEVELOPER-USER CENTRIC**

The "big-flip" of the **Universal Focus** cluster sets out very *end-user centric* scenarios where end-users have a considerable freedom to configure the systems to their own desire and generally be in control of the systems in most situations. Combined with many of the environmental factors with high certainty, it points in the direction of scenarios with very strong end-user participation.

The "big-flop" situation is similarly dominated by *developer-user orientation* and the view of manufactures of systems, components, devices and services for Building Automation. The system view often takes over from the end-user view.

In a similar way we can group the "Interconnectivity" cluster:

Big Flip Cluster "Interconnectivity"	**Big Flop Cluster "Interconnectivity"**
• Technical standards for interoperability of systems are introduced and globally accepted	• There are few or no technical standards for interoperability of Building Automation systems
• New environments (e.g. hotel rooms) will be able to adjust to individual ambient preferences	• Every environment will have to be separately adjusted to individual ambient preferences
• There are common programming languages available for developing interoperable applications	• There are only traditional programming languages for embedded systems available
• Device drivers, interfaces and applications can obtain third party certification of interoperability	• Device drivers, interfaces and applications are solely based on manufacturers own descriptions
• Embedded AmI intelligence will often assume responsibility for part of the system's functionality	• There will be no network based functionalities outside the individual components and systems
• The systems will have self-learning capabilities	• The systems will not have self-learning capabilities
• The additional costs of providing interconnectivity are insignificant compared to the system price	• The costs of interconnectivity with other systems are prohibitive to most manufacturers
• New technologies (e.g. the human body) will be introduced for interconnecting devices	• Only traditional technologies (i.e. wired and wireless) are used for interconnecting devices
• The security model will be distributed across the network and individualised for each application	• The security model will be centralised and all systems will use the same model
• Authorization will be provided by a mix of separated trust entities and third party	• Authorization will be provided only by third party authorization bodies
• End-users choice of trust model is only marginally influenced by individual manufacturers' reputation	• Each manufacturers' reputation will dominate the end-users' choice of trust model
• Interconnected systems generally function well in their operating environments	• End-users experience frequent problems with the functionality of interconnected systems
• End-users expect manufacturers are responsible for correct use of connected devices/products	• End-user will accept responsibility for correct use of connected devices/products
• Intelligent building concepts will be able to use overall energy resources more efficiently	• Intelligent building concepts will lead to an overall increase in the of use energy
• Manufacturers will launch new offerings with sound value propositions based on interconnectivity	• Manufacturers are not able to introduce new products and services based on interconnectivity
which leads to the name:	*which leads to the name:*
INTEROPERABLE SYSTEMS	**CONNECTED SYSTEMS**

The "big-flip" of the Interconnectivity cluster we have well developed frameworks for interconnecting and interoperable systems, components and devices. Not only is the technical foundation for interoperability present (standards, open drivers, network applications, etc.) but also the market demand and the business framework. This version of the cluster facilitates scenarios with *interoperable systems* featuring systems that work together to achieve a common goal and produce more value added services.

In the "big-flop" situation the technological advances do not support interoperability in the same sense. Focus is here on systems and components that are *connected to each other*, but are actually not operating together. Such scenarios are likely to involve a high degree of end-user participation.

5.9 Multiple images of how Building Automation systems are being developed in 2015

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

5.9.1 Developing the scene

In this process, we start with the scene, which is common for all scenarios. The elements for defining the scenes are found in the lower left "Scene" quadrant of the original grid of environmental factors. These factors are deemed to be rather certain by the experts and thus serve at the reference point for all four scenarios. The "Scene" factors are mostly related to end-user's attitudes to Building Automation in the future.

Smart home technologies are widespread and affordable to everyone. Most smart appliances have high value propositions and make the homes more attractive. With people moving frequently, there is a sound market for bundles of products and services. Preventative maintenance is one such service offered, which successfully is used to increase customer loyalty.

Since the large number of new devices increase energy consumption, local energy generating devices like solar cells and fuel cells connected to a local network have become increasingly popular.

Generally the manufacturers have a high influence on the way the products are installed and they are able to impose access control models and authentication schemes on end-users. In particular, all manufacturers have exclusive access to their own systems on the end-users' premises. Also various governments have introduced special anti-terrorist legislation which allows the government to access personal data information. Besides these cases, end-users are generally free to configure and manage the security issues themselves. Obviously, all systems have built-in firewalls for basic perimeter protection.

User interaction is performed using a wide variety of interfaces. Graphical interfaces are widespread, because traditional interfaces like keypads are too limited for serious interaction. Whereas all end-users will have and be able to use mobile phones, these terminals, as well as PDAs, are not regarded as suitable for all end-users.

5.9.2 Building the sets

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

One trend [1] concerns the increasing complexity of system integration, which puts a large pressure on developers, installers and system integrators. Since the complexity of networks increase rapidly with increasing number of devices there will be focus on using various interoperability standards. It must be possible for the manufacturers own system to interact and communicate with many different devices. Conversely, the system itself must be open to other systems.

Another trend [2] influences issues relating to facility management and the development of building and industrial automation infrastructures. Since end-users increasing will rely on a large number of services that are available in electronic form, e.g. service contracts and preventative measures, which can predict and thus prevent malfunctions of installations, they need their systems to have the capabilities to interact with users, with each other and with other manufacturers. A special challenge is that additional functionalities in appliances and device will lead to higher cost.

A third trend [3] points in direction of the emergence of highly integrated systems with extremely simple user interfaces. Target groups for such systems are the non-technical end-user requiring very complex functionality or assisted living support for elderly or chronically ill citizens. For this group of end-users, the systems must be easy and simple to use and system reliability is a particularly concern. The domestic environment must be trusted and secure. Devices and interfaces must also be designed according to ergonomic principles and will be equipped with graphical displays or perhaps familiar touch pads, which most end-users can use. Wearable computing devices, e.g. for healthcare application, supporting mobility is an essential feature.

The last trend [4] points in the direction of increased demand for affordable, networked devices, from which the adventurous end-user expects a high degree of flexibility. These end-users expect to be able to build their functionality and thus require all systems to be flexible, adaptable, configurable, scalable and modifiable. Devices will be upgraded automatically and will have preventative measures installed to prevent misuse by end-user. User interaction will take place using multimodal interfaces and access rules to devices and applications will be commonly understood and accepted.

5.9.3 Defining the script

In the final step, the four scenarios come to life as imaginative plays defined by scripts. In writing the scripts, the environmental factors enter according to a simple grouping: What is happening, how is it happening and why is it happening?

<u>What is happening?</u>

The scene shows a typical developer user situation around 2015. The developer user is either employed in a manufacturing company that develops devices, products, embedded and networked systems or services, or he/she is working with system integration, either as a traditional system integrator, an engineering company or as a customer building in-house systems. The developer is faced with the task of creating new or improved embedded systems and applications, which is to be based on a high degree of networking capability of various devices.

Some of the people involved are definitively employees of the manufacturer, either in the developing departments or on-site, but also personnel from the system integrator may participate. The skills of the people involved vary between the scenarios.

<u>How is it happening?</u>

The developer user will constantly rely on visualisation and analysis of imaginative end-user behaviour. The target groups are, on one side, end-users that do not have interest, ability or skills to be concerned with the operation and interior functioning of the systems. They just want secure, reliable and functional environments. Another target group is the technically competent end-users, who have strong desire to work with the system and build new functionality and applications. The aims and needs of the target groups thus have different priority and the script differs correspondingly.

In some cases, the end-users have strong and clearly defined requirements thus requiring the developer user to fulfil a specific set of market requirements in an optimum way (market pull). In other cases, the end-user requirements are more vaguely defined in terms of technology content and functionality, thus leaving more room for the developer user in the design (technology push).

<u>Why is it happening?</u>

The main thrust for the developer users script are the commercial benefits to be derived from the under laying business case. Developer users must develop products and services that satisfy the needs and expectations of the customers. By using the Hydra middleware, the developer users are capable of developing secure, interoperable solutions with high degree of functionality and precisely targeted the end-user group in question.

<u>Writing the scenarios</u>

The four scenarios have been written on the basis of the scenario thinking process with the group of international experts in smart homes, Building Automation and embedded systems. The scenarios have been illustrated with pictures and drawings to stimulate the reader’s imagination.

5.10 Writing up the scenarios

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

1. Developer-user centric + Connected Systems
2. Developer-user centric + Interoperable Systems
3. End-user centric + Interoperable Systems
4. End-user centric + Connected Systems

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

1. Walking the Dog

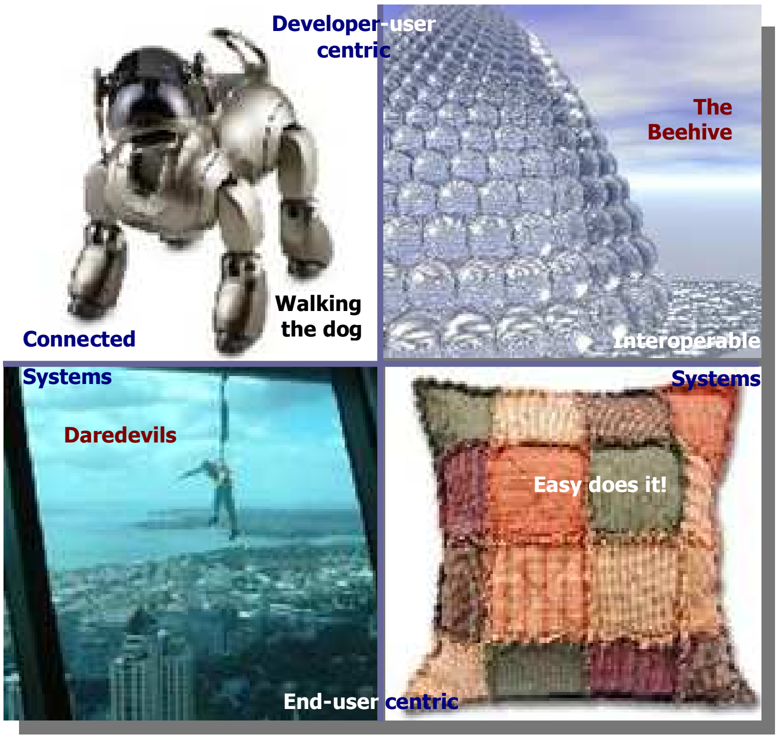
This scenario addresses the complexity of networks and the increasing number of devices to be networked, which poses a range of special problems for the developers. The scenario is set in public utility services, where a large number of proprietary commercial systems are deployed and controlled from a single control centre. The manufacturers must open parts of their systems for interconnectivity and at the same time maintain exclusive control over other parts in light of product liability, warranty issues, property rights and for the purpose of product differentiation.

2. The Beehive

The second scenario is dealing with the development of interoperable building and industrial infra-structures. In facility and plant management, the main focus is on automatic interoperability of various manufacturers' systems and configurability and accessibility by the management company's staff. Systems must be self configurable, fault tolerant and provide the functions needed for facility management, e.g. energy control, while at the same time supporting a trouble free transfer of responsibilities from facility owner to facility manager, including service level monitoring and accountability. The actors in this scenario are manufacturers and system integrators developing interoperable systems for facility management based on Hydra middleware.

3. Easy does it!

Highly interoperable systems capable of delivering intelligent ad-hoc applications relying on extremely simple user inter-faces is the theme for the third scenario. The end-users are technology illiterate, elderly and chronically ill citizens. The scenario is set in an integrated social institution where apartments for senior citizens are integrated with homes for assisted living and full scale nursing homes. Actors in this scenario are the employees of a system developer and a facility manager responsible for the maintenance of technical installations.



4. Daredevils

This scenario focuses on end-users, who want to have affordable, networked devices, from which they can set up integrated applications. The actors are the typical manufacturers of home control systems for private homes, e.g. alarm systems, heat control, media and information networks and similar systems. The challenge for the developer-user is to make the systems configurable and modifiable by the end-user, while still maintaining product integrity.

6. Building Automation scenarios

6.1 Walking the dog

Walking the dog

The increasing number of devices and the complexity of system integration put a great deal of pressure on developers, installers and system integrators to bring about open, secure and reliable solutions. It must be possible for the manufacturers own product to interact and communicate with many different products. Conversely, the product itself must be open to other products. Since the complexity of networks increase rapidly with increasing number of attached devices there will be focus on open interfacing standards, at the expense of true interoperability and dynamic development of intelligent applications.

Such applications are developed by manufacturers and system integrators, literally driving the application from one system to another through the network. We call this scenario "Walking the dog".

Forty per cent of The Netherlands' surface lies below main sea level. Since the late Middle Ages the Dutch have been making mud flats and sections of the ocean habitable by draining the water, but at a high cost. Countless people have lost homes and lives to the sea. Nearly everyone in the Netherlands knows that every square meter of soil came at a high cost, yet giving up is not an option.

It comes as no surprise that one of the most valued and prestigious institution in this country is the Rijkswaterstaat, the national organisation responsible for coastal monitoring in all sectors of the Netherlands. Working with and for RWS is highly attractive, but also extremely challenging.

Jaap Van Beyl knows this. Jaap is a software engineer working for Redenbeek b.v. a leading international supplier of speciality pumps and water treatment equipment. Jaap got a degree in software engineering at the TU Delft and for the first six years of his career, he developed embedded systems for a company making heating and cooling equipment.

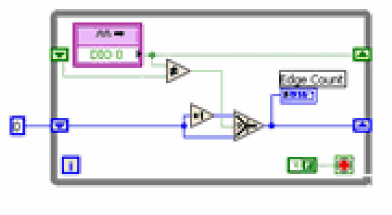
One of Redenbeek's biggest customers is RWS. Redenbeek has more than 9.800 submersible pumps deployed in the Delta Works in the province of Zeeland and participates in several projects on water protection and warning systems together with other manufacturers and institutes under the RWS.

Four years ago, Jaap was offered a newly created position as technology manager of Redenbeek. His responsibility would be to head the technology department and act as external scout and gatekeeper for new, emerging technologies, which could impact Redenbeek's product programme and market. Jaap gladly accepted this challenging position.

The pumps have over the years become increasingly intelligent. Embedded systems are used to reduce energy costs and increase the product life time by optimising operating conditions to actual load. Other systems are logging operating data and handles error conditions. Even before Jaap joined Redenbeek, several product lines had been equipped with various kinds of remote interfaces. Due to increased demands from customers like RWS, Redenbeek is now considering how additional, intelligent functionalities can be made remotely available for external services, customers and other manufactures, without compromising the core product.

Lately, a new middleware tool has been attracting a great amount of attention from the community. The Hydra middleware, as it is called, will allow Redenbeek to communicate with other systems in an open, intelligent and secure way and allow customers and other manufacturers to fully access and utilise the Redenbeek core functionalities using new and emerging interface standards.

Jaap has proposed to management, that his group should undertake a pilot project together with the RWS with the aim of investigating how the Hydra middleware can be used to enhance their products. Since he graduated, Jaap has been a dedicated user of NI LabVIEW and last year he was named chair of the Dutch LabVIEW User Group. Logically, Jaap now wants to use the Hydra SDK module for LabVIEW to develop the Hydra middleware.



One project that Jaap has in mind is the "Hoogwaterinformatie Systeem" (HIS), High Tide Information and Early Warning System. In this project, RWS and their partners are developing an advanced system for early warning and prepared readiness for high tides. The HIS system interfaces with a large number of local and national measuring systems, widespread sensor networks, low altitude aerial and satellite based meteorological and oceanographic surveillance systems as well as several large-scale computer modelling systems. Applications are being developed that automatically collects data and information from these systems, cross-correlate the information using models and historic data and performs real time predictions of tide levels in each sector under RWS authority. Further, the HIS information will be used to investigate actual de-watering conditions in the affected areas in light of the predicted needs and to eventually fuse data for automatic operational control of unmanned sluices and water levels in dams and polders. The challenge here is to develop applications that can interface in real time with networked, heterogeneous systems, to make them fault tolerant, even under extreme conditions, and to provide the necessary security for the systems to avoid terrorist and similar malign attacks on a life saving infrastructure of national importance.

The RWS has posed a series of requirements on the Redenbeek pumping systems. The HIS application requires first of all that external applications will know and be allowed to read data from the pumps and pumping systems. The external requestor must present the necessary credentials before obtaining the information and there must be a trust model for how these credentials are evoked and maintained. Secondly, the flow rate must be remotely adjustable, which requires careful monitoring to protect the pump from physical damage. To minimize overload and the so called downthrust problem (due to lack of sufficient cooling flow), the pump must be run within its specified maximum and minimum flow range, which is a function of the actual head (groundwater height) and temperature. External applications should be closely monitored as to how the pump is affected by the imposed controls.

Jaap is also conceptualising a comprehensive logging and authorisation systems. His idea is that every external service must not only be authorised to access the pump, but he will also log every access for tractability and accountability. Redenbeek management thinks that remote access and controllability of their products carries a value in itself, which should be compensated by the beneficiary owner and have requested that Jaap considers these aspects also in his product design.

Finally, Jaap has to consider how he shields off the core of the embedded control system from external services, while still allowing his own organisation (including independent service organisations) to enter these sacred parts. Another issue is that the embedded applications are becoming so large, that the developers have serious problems with computing power and especially the burden of constrained memory space. To overcome this, Jaap is considering distributing the applications across the pump network and automatically performing system optimisation using the GRID network support in Hydra. There is also a need for automatic discovery and configuration of new pumps being deployed by the local RWS sector authorities, so that they instantaneously enters the HIS warning network. Jaap is thinking of using web services frameworks and in particular, the standardised description languages available.

The LabVIEW Hydra SDK module has been installed and they are currently building the security platform, which shall form the core of the pilot project. The management of Redenbeek gives the project top priority because they see this as a great opportunity to develop new business models, in which Redenbeek can deliver e-Business services directly to new customers. Jaap is definitively looking forward to very interesting and challenging development tasks in the coming year.

6.2 The Beehive

Development of interoperable building and industrial infrastructures impose serious challenges to the participating manufacturers' products. The products must provide all the functions needed for automatic, interoperable performance like self- properties, fault tolerance, trust and security frameworks, ambient intelligence, etc. and at the same time offer ease of use and support trouble free transfer of responsibilities from one end-user to another, including accountability and activity monitoring.*

Such system will need to have build-in capabilities to monitor and proactively manage the application, to learn from previous situations and be able to interoperate a large amount of devices, networks and embedded functions in a secure and standardised way. We call this scenario "The Beehive".

NCC is one of the largest building companies in Denmark. They operate globally, but have large contracts with the Danish government for building housing projects. One such project is the "Krøyers Plads" housing complex in centre of Copenhagen. This project consists of 5 apartment blocks with at total of 120 apartments. In addition, the project contains a medium sized shopping mall with a fitness complex and two social service centres e.g. a kindergarten and an activity centre for the old people. The project was designed by the Dutch architect Erik Van Egeraat and is renowned for its highly unusual architecture. The first apartments were ready in late 2014 and the rest are being finished in the coming few months.

The management of the housing complex is in the hands of ISS, Europe's largest facility management company. ISS manages buildings and facilities all over the world. The technical control centre in "Krøyers Plads" was originally planned as a central facility located in one of the blocks from where, a team of six caretakers could monitor all the technical installations. With the emergence of many new control systems based on Hydra middleware, it is foreseen that most systems will be able to work together and perform intelligent, interoperable tasks so that no human intervention is required. Consequently, the central control centre has been abandoned and the rooms transformed into a community day care centre.

Being responsible for the technical and building maintenance, ISS will undertake to specify the advanced monitoring systems for control and maintenance of technical installations such as electrical distribution, heating and cooling systems, water supply and wastewater. The actual applications for controlling the building and the installations will be designed by TAC Danmark, a market leader in system integration and Building Automation. As facility manager, ISS has clearly stated that they are not interested in how the system works, as long as it lives up to the requirements specification. This is a proven business model, which both ISS and TAC are comfortable with.

Klaus Jensen is the lead engineer in TAC's system integration unit and responsible for the "Krøyers Plads" project and is a very experienced in all aspects of system integration. Today, system integration is mostly performed through dedicated TAC networking applications that connect various subsystems through a central control platform. With the emergence of the Hydra middleware and a common, open interface standard, Klaus expects to be able to develop effective applications operating directly on the network itself, utilising the interoperability of the connected systems. Last year the International Device Interoperability Verification (IDIC) body was inaugurated, so in the future, Klaus and his colleagues will probably only use systems and devices certified by IDIC.

TAC applications must have extensive provisions for all sorts of services, such as meter reading, so that the consumption of electricity, water and heating can be remotely read from each apartment and automatically transferred to the administrative system. TAC applications need further to be capable of learning from the individual user's behaviour and to create suitable user profiles for monitoring of adverse consumption patterns, which may indicate faulty installations. This kind of embedded intelligence is one of the reasons that Klaus has selected the Hydra middleware, because he sees great potential in letting the large constituency of manufacturers develop a wide range of useful and interoperable solutions, and letting TAC develop only the customer oriented application.

TAC applications should also have extensive end-user features allowing residents to remotely access and control things, when away from their homes e.g.: in-house lighting, burglar alarms, camera surveillance, booking of laundry room, control of heating, supervision of windows, doors, stove, etc. A major concern here is how the user will be authenticated, which credentials to use and how the trust model should be developed.

The newest service to be requested by ISS is a vendor access system that requires all authorised vendors, subcontractors and service organisation to access the building management system through a new authentication procedure. The purpose of this is to have a better security in the maintenance process, including the integrity of logged data, e.g. water temperature, which is required by law. There has been an example of data being lost during service, which is not very welcomed by the Danish Building Inspections Bureau. ISS also wants to use the system to check accuracy of the service costs they are being billed under the current service contract.

John Hansen is a senior service technician with Siemens Denmark, the main vendor of the electrical power automation and climate control installations. Since ISS is not prepared to accept responsibility for the correct use of interconnected devices and products, John has a full time job looking after the service contract that Siemens has entered into with ISS. When John starts his day, all service and maintenance jobs are automatically distributed on available service technicians and downloaded to their mobile devices in their cars. All the building systems automatically locates the manufacturers central maintenance systems and reports faults and corrective actions taken, so John can immediately get updated information from the Siemens system.

Today John needs to perform maintenance on the "Krøyers Plads" heating system. When John arrives at the apartment building, he is automatically recognised and cleared by the security clearance system to enter and move around freely in the building complex. The standard TAC system comes with access control based on identity card authorisation, but ISS have chosen to utilise a more intelligent system based on a distributed security model and individualised authentication provided by a mix of trust entities and third party authorisation. Although the basic trust model is an integral part of the TAC system, the choice of security model can be completely independent.

All systems in the building interoperate, not only in respect of access control, but it also to provide John with a specific personalised environment in terms of access to equipment and data sources.

John has now received all data on his mobile web tablet about history and service records for the heating system. From Siemens' own database, he has also downloaded the product information and tutorials he needs, so he can go directly ahead and perform the maintenance. Every device is available to him and he has the possibility to perform different kinds of tests, check the current status and to upgrade software components, if needed.

As he goes through the procedures, one heat exchanger does not perform as he expects it to. He can see in his service record that the Siemens support centre in Germany remotely updated the software 2 weeks ago, so he assumes that there might have been some problem with the operating conditions of this device. Instead of trying a range of different approaches, he decides to buy technical support directly from the Siemens support centre in Germany. The support is ordered and within 3 minutes, a service support person from Siemens is online with John and the device.

After the successful completion of his work, John checks his web tablet again and heads off for another job. He finds life much easier now, because the intensive decision support provided by all the systems gives him time to think through the really important and critical elements in his job. He finds this very un-stressing.

6.3 Easy does it!

Highly interoperable, self configurable, fault tolerant and secure embedded systems capable relying on extremely simple user interfaces is the need for non-technical target groups such as elderly or chronically ill citizens.

Developers need to build self-configuring systems that automatically can take part in and deliver ambient intelligence applications with semantic and leaning capabilities. Mobility is an essential design feature and trust, security and reliability are of particularly concern. The systems must be extremely easy to use and special requirements are put on design of terminals and their interfaces.

Such requirements force developers to think strictly user centric. We call this scenario "Easy does it!"

"Park View Homes" is a large building complex located 50 miles north of London. It comprises individual apartments and semi-detached houses for elderly or people with long-term conditions needing assisted living as well as a full scale nursing home. The individual apartments are designed for the residents to live as independently as possible while at the same time having assistance near at hand if necessary. The entire building is fitted with a large number of embedded systems which supports both residents and healthcare and social workers in their daily work. Each apartment or house can have any number of devices helping to care for the individual residents' needs and desires. Healthcare applications are automatically created or launched according to needs and are fully interoperable with the residents' networked devices, the building infrastructure, the healthcare staff's monitoring and administrative systems as well as the county's healthcare provisioning and guidance systems.

Mr. and Mrs. Klein are both in their early 70's. They have lived in Park View Homes for 2 years now. Mr. Klein was diagnosed with diabetes II nearly 15 years ago but it is only recently that he has learnt to control his condition properly thanks to new self management programs. However, because of inefficient control in the past, there have been several incidents where his blood glucose level was too high sending him into hypoglycaemic shock. He has also had serious problems with his feet and now requires frequent treatment from the podiatrist. Mrs. Klein suffered a heart attack 3 years ago. This is what really motivated them to move into the Park View Homes. They didn't feel safe in their own home and wanted the comfort and security offered by the assisted living environment in Park View Homes, which in many ways resembles the way, every other UK citizen is living.

One of the things they like is the totally non-technical appearance of Park View Homes their apartment and in community buildings. Even though there are – so they are told – all sorts of monitoring and support systems in operation, they really don't notice them. No computer widgets are seen around; no technical gadgets are disturbing their eyes in their neatly furnished apartment. There is nothing to remind them of hospitals and other sad reflections. But when they need assistance, it is always there.

Last week, Mr. Klein woke up in the middle of the night and felt ill. Having eaten a little too much the night before, the diabetes monitoring system told him to increase his evening Metformin dose, but he forgot and now he needs help. The Park View Home has offered all residents a new cognitive alarm system based on semantic speech analysis that automatically interprets dynamic situations, caters for natural and artificial changes in the environment and adapts to different topologies, to different infrastructure and types of sensors. The manufacturer thus claims that the system is able to find and automatically interface to telephones, hearing aids, or any other device containing a microphone within reach of its network and use it to pick-up speech. If the end-user has agreed, the system is able to semantically process the captured sound, detect signs of stress and in some cases extract the specific circumstances of an emergency situation. Necessary information is then fused to appropriate support systems identified and configured on an ad-hoc basis.

Despite all the ubiquitous technology, the Klein's are particularly happy about having a dedicated nurse, Mrs. Rickert, assigned to them even if they are not living in the nursing home section. When Mrs. Rickert is off duty or unavailable, there are three other healthcare workers assigned to Mr. and Mrs. Klein as backup. There is a systemised prioritising scheme in place which automatically calls on the next nurse in line depending on the actual situation and the skills and location of the staff. As soon as a support nurse has been located, the Klein's are automatically informed who will be coming and approximately when. If there are audio channels available (e.g. a radio, a hearing aid, etc.) the message is given in natural language. If visual communication is available, the system formats the message for the appropriate terminal (e.g. a TV, a clock-radio, etc.).

Because of her heart problem, Mrs. Klein carries a wearable heart monitor device with wireless communication from which she can call for assistance 24 hours a day. The device she wears is able to pick up changes and thus send out warnings before anything actually happens. But if she wants to, she can increase the urgency by pressing a simple key pad on the device.

For diabetes patients, control of their blood pressure is extremely important, since high blood pressure can cause kidney failure. The Park View has bought a cognitive monitoring system that automatically detects and connects to available BP monitors on the Park View Homes compound. The system records and monitors the progress of consented patients according to the thresholds and limits set up by the health care professional. When a new device is located, the owner is asked to identify himself. The manufacturer of this system has provided the possibility for different trust models, according to the patient's preferences. If the patient agrees, the data can be stored in the relevant Electronic Patient Record and a healthcare professional can attach an individual monitoring scheme to the person reporting significant deviations from the clinical pathway.

Mr. Klein also uses a mobile device, with which he monitors his blood glucose levels 4 times a day. If his glucose level increases and stays above a trigger point, the wireless device searches the surroundings for communication access points, but means of which it can communicate the stored measurements and detected abnormalities to the relevant health professionals. Wherever he may be, Mr. Klein's device thus automatically identifies and securely sends the request to the Park View Homes diabetes care centre, where Mr. Klein's daily insulin intake is also registered. If the system indicates hyperglycaemia, a message is returned to an available devise in the vicinity of Mr. Klein requesting him to check today's insulin intake and immediately administer the needed dose.

At home, Mr. Klein's keeps his insulin pens either in the fridge in a special box with wireless connectivity. The box records every time the insulin pen is removed. If he does it within 10 minutes of the glucose alarm, no further action is taken. If not, a second alarm is triggered on the wearable device to remind him. The alarm system will now alert the nurse on duty, as well as Mrs. Klein, with information that he has not responded to the hypoglycaemia alarm. The insulin box is powered by a small battery and the manufacturer has had to make very special provisions to overcome the power constrains. The box thus searches for a suitable proxy, which can provide both communication and computing support. At home, Mr. Klein's set top box for his TV is often used for this purpose, but when he is out, the box sometimes finds an un-trusted host, such as a cash register in a restaurant or, if necessary, a mobile phone. The alarm and communication application provided by the manufacturer automatically adjusts itself to the available resources.

6.4 Daredevils

With the increasing number of affordable, networking devices on the market, many end-users can and will set up interoperable applications in e.g. homes, in order to realise the dream of "smart homes". Developers have to provide solutions to end-user issues such as user interaction, configurability, prevention of faulty usage, data protection, privacy and security, and access to devices and applications.

This poses a real challenge for developers, who want to make their products or embedded systems connected and programmable by the user, and still put a reliable and secure product on the market. The manufacturers, who want to satisfy this growing market of do-it-yourself enthusiasts, will need a flexible, fault tolerant and reliable, secure and trustworthy middleware. We call this scenario "Daredevils"

Wolfgang lives with his girlfriend in the outskirts of Hamburg. He is a computer specialist and loves to try out every conceivable new gadget on the market. If it appears in PCWorld, Wolfgang is sure to get it within weeks! His girlfriend Marlene is less enthusiastic due to possible intrusion on their privacy, but she supports Wolfgang, because she sees that some of the things he can do are actually quite sensible. However, Wolfgang has promised her, that she can put full trust in the system and that their privacy is not at risk. No one outside their home can interfere with their private lives. Above all, Marlene accepts it because it seems to please her cat Robinson that Wolfgang has installed an automatic cat feeding device.

When Wolfgang and Marlene return from work, they are looking forward to having a romantic dinner at home, because they both like to cook. Wolfgang opens the compartments of the delivery box. Excellent! The food service has delivered fresh vegetables, chicken and even the Chinese bean paste that Marlene ordered from her cell phone earlier today.

Wolfgang recently bought a new security systems for his home delivery box, which is outside their entrance but accessible from within. The manufacturer provides a full set of biometric security devices for the home delivery box and Wolfgang can select, which types offers the most appropriate level of security. His choice is either to use an ID card or a biometric device. To enhance security, any of these devices must used in combination with his newly acquired voice recognition system.

Using a secure Internet connection, Marlene checked their refrigerator earlier today and discovered that they were running low on several items. Although it does make life easier, Marlene is not too keen on this feature. She fears that someone from the government may sneak around and demand to see what they have in the fridge.

In the back yard, the automatic lawnmower is droning through its last few rounds. The robotic window cleaner has also finished up its chores. The manufacturers of these devices provide their own wireless drivers, but with open interfaces. Wolfgang has programmed his own control platform, using one PDA to control all of the devices. When he looks at the status, he notices that the lawnmower manufacturer has announced a firmware update that cuts the energy consumption by 12%. The upgrade, which costs 18 €, is offered for immediate download. A great offer which Wolfgang gladly accepts since his electricity bill continues to rise with all the new gadgets. Wolfgang has chosen to always trust offers from this manufacturer, because they have good products, excellent support and extended warranty. He uses his national digital signature to sign the purchase.

In the kitchen, Wolfgang again uses voice input to access his electronic cookbook and calls up the Chinese recipe that Marlene says she loves so much. The publisher of the cook book offers a web services with recipes and on-line delivery to appliances that are capable of handling such information. Wolfgang mixes the ingredients, relying on the automatic system in his stove to cook everything, while he heads for the bathroom to freshen up.

Wolfgang is particularly happy about his kitchen. The appliance manufacturer has recently introduced the new range of household goods, all with network access and value-added services. The different functionalities are fully transparent and Wolfgang is considering having the kitchen system automatically record which ingredients he uses, record the weight on the integrated kitchen scale and learn how he cooks them, so that he gradually could build a knowledge base of personalised cooking habits to augment the online cooking book. Although he gets inspiration from the on-line cooking books, he prefers to be in control of the process when it comes to cooking.

Not so when it comes to security. He is very concerned about Marlene being home alone, which happens quite often, when he goes to the company's headquarters in Munich. Wolfgang has programmed fancy alarms, using the electrical smart home systems and various devices he picked up in the local hardware store. One alarm turns on two lamps upstairs and a CD recorder plays sound bits of a barking dog (Robinson doesn't like this at all), when someone moves around the house after Marlene has gone to bed. Lately, several break-ins in the neighbourhood had worried Marlene slightly, so Wolfgang gave her an outside door camera for birthday. Now the camera takes pictures of everyone ringing on the front door when they are not in. The pictures are stored on the house server and later, they can see everyone, who called at their house. Only one week ago, one of their friends had been burglarised during daytime. The police had told them that had they installed a camera system, they most likely would have apprehended the burglar the same day.

After having started the cooking cycle, Wolfgang heads to the bathroom to refresh. On the way, he tosses his clothes into the washing machine, which determines the ideal cycle from the RFID's in the clothes. In the bathroom, Wolfgang is regularly informed, in natural language via the build-in speaker system, of the cooking progress in the kitchen and what he needs to do next and when, in order to prepare a perfectly timed Chinese meal.

Wolfgang starts to think of the project he just finished; a green house for Marlene. She loves roses and Wolfgang has built a green house for her in the back yard. He installed a sprinkler system by connecting thin water tubes to all the flowerbeds from three large rainwater reservoirs. Each reservoir is equipped with a controllable pump, so that the water can be turned on and off automatically. One manufacturer has delivered humidity sensors for the flowerbeds, temperature sensors, and a sunlight sensor outside the house. The manufacturer has developed a large program of self-configurable sensors with wireless connection. They are so inexpensive that he just spreads them in the flowerbeds. If one sensor is failing, another will take over. Another manufacturer provides electrical systems for controlling the windows and shades. For optimum operation, the system uses rules based decision support and relies on external sensors for micro-weather monitoring to handle unstructured and conflicting data. For example, the temperature sensors may require outdoor shades to open, but the wind sensors require them to be closed. Marlene's roses can now be kept in optimum conditions.

After bathing and dressing, Wolfgang looks and feels very sharp. He heads over to the living room to set the table. As he sits down to enjoy the music and await Marlene's home coming, he reflects on all the things he has been able to achieve with very little efforts. He is very happy about it and is determined to take the entire system with him if and when they move to a new house.

7. The Healthcare domain

7.1 Background of the Healthcare domain

Healthcare services across Europe face enormous challenges in the future as the European population is growing older, more and more people have chronic diseases and the general needs and expectations for efficient and effective healthcare services increase. These challenges concern both the quality of healthcare and the availability of resources – human as well as economic resources – to deliver healthcare services. European Member States are likely to face a severe shortage of healthcare staff to care for the growing number of patients.

ICT for health (eHealth) can improve the delivery of healthcare services by securing higher quality of treatment, improved access to care, avoidance of unnecessary hospitalisation and more efficient delivery of healthcare services at lower costs. In the EU, the development and implementation of eHealth is an important strategy for dealing with the future challenges for healthcare services. The Lisbon Strategy recognised the importance and potential of ICT and with the launch of the eEurope 2005 Action Plan in 2002 a first strategic initiative towards an information society for all. Health was an important focus of the eEurope 2005 Action Plan which sets out a number of policies and target for both the European Commission and the EU Member States concerning eHealth services.

Following the eEurope 2005 Action Plan, the i2010 – European Information Society 2010 which defines a package of proactive policies to harness the potential of the digital economy to deliver growth, jobs and modern, on-line public services. The i2010 Action Plan states that ICT can contribute strongly to improvements in the quality of life. ICT are capable of improving the health of our citizens via new ICT enabled medical and welfare services. In light of the demographic challenges facing Europe, ICT can help make public health systems more efficient and effective[1].

This chapter provide a brief introduction to some of the demographic and lifestyle challenges that the healthcare sector is facing followed by a short overview of some clinical aspects of relevance for implementing ICT technologies in for eHealth solutions. The purpose of this is to give a framework for understanding the scenario process, its discussion and its outcome.

7.1.1 Demography

According to statistics from Eurostat, the demographic development in EU-25 (25 EU Member States) show a decrease in the life birth rate and increase in the life expectancy rate. The birth rate in EU-25 fell from 10.8% in 1995 to 10.5% in 2004[2]. In particular, the new Member States in EU-25 (Cyprus, Malta, Lithuania, Poland and Hungary) have witness a significant drop in the life birth rate but also countries like Denmark, UK, Luxemburg, Sweden and Germany have had a notably fall in live birth rates. At the same time, the European population is living longer and longer. The life expectancy rate in EU-25 for men was 74.4 years in 2000 and 75.8 years in 2005, while for women it was 80.8 years in 2000 and 81.9 years in 2005[3].

The demographic development means that we will have an aging society in EU; the proportion of elderly people (65+ years) will continue to rise while the proportion of the working population will decline. This will have a significant impact on issues related to health and the delivery of healthcare. Elderly people need more care compared to the younger generation and at the same time a lack of healthcare professionals, not least due to a smaller working population, will put enormous strain on the healthcare systems in Europe.

From the economic perspective, a smaller working population means less tax revenue to finance the public healthcare system, thus placing additional strain on the resources within public healthcare delivery. Public healthcare systems face a serious challenge in controlling and managing healthcare

[1] http://europa.eu.int/information_society/eeurope/i2010/docs/communications/com_229_i2010_310505_fv_en.doc
[2] http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-EI-06-001/EN/KS-EI-06-001-EN.PDF
[3] http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-NK-06-016/EN/KS-NK-06-016-EN.PDF

costs while at the same time meeting healthcare needs. At the same time, the general public is likely to have higher demands requiring an efficient healthcare system. Public demands of high quality care, easy access and fast and reliable treatment are most likely to become even more firm and influential in the future.

7.1.2 Lifestyle and chronic diseases

A serious problem facing all EU Member States is the increasing number of people with chronic diseases. This factor is closely related to an unhealthy lifestyle. However, cultural and socio-economic factors are also linked to development of lifestyle diseases and importantly also to how well the disease is managed. A striking example of this is found in Birmingham, UK, where the suburban, affluent and mainly white population constitutes the by far largest group who have diagnosed coronary heart disease. However, this group manages to live long with their condition. By contrast, the inner-city, poor and largely Asian population is rarely diagnosed with coronary heart disease; however, this group constitutes by far the largest group who actually dies from this condition. In general, heart disease is much more common in deprived areas, while treatment and care is often best in affluent areas.

A similar example is found in Denmark where research has demonstrated that how well you live with a condition, or whether you actually die from it, depends to a large degree on where you live, your ethnicity and socio-economic background. This clearly demonstrates the cultural and socio-economic aspect of health but also that good management (such as healthy lifestyle and proper monitoring) of a certain condition can be a matter of life and death. In the UK, coronary heart disease is one the biggest killer despite the fact that it is a preventable disease[4].

There should therefore be no doubt that the so-called lifestyle diseases have serious consequences and may be life threatening if they are not treated and handled correctly. Lifestyle diseases include type 2 diabetes, stroke, obesity, heart disease and atherosclerosis and diseases associated with smoking and alcohol and drug abuse[5]. In fact, according to the World Health Organisation, an estimated 80% of heart disease, stroke and type 2 diabetes, and 40% of cancer, could be avoided if common lifestyle risk factors were eliminated. Moreover, up to 86% of deaths in Europe are caused by largely preventable chronic diseases[6].

Lifestyle diseases are also increasingly affecting the younger population. An obvious consequence of this trend is that this group will need lifelong healthcare in order to manage their conditions. If not managed correctly, it can lead to serious health problems that may affect the group's ability to work, thus indirectly contributing to a further shrinking of the workforce.

The gravity of lifestyle diseases is becoming more and more visible and is widely recognised by the authorities. More information about healthy living and the negative affects of unhealthy foods, lack of exercise and stress on the health is becoming available. However, there is still a great deal of imbalance in relation to the availability and access to this type of information between different EU Member States, as well as within different regions of specific countries. Likewise, concrete initiatives to promote a healthier lifestyle are still lacking. Most initiatives, guidance and advice are directed towards people who have already been diagnosed with e.g. diabetes or coronary heart disease.

In the UK, for example, the charity Diabetes UK, provides support for people with diabetes. This includes advice on how to live healthy with diabetes but also emotional support is provided for both patients and their relatives. There are support groups and a day-time call line people can call (for a normal charge) as well as specific advice for pregnant women and teenagers with diabetes. Cancer Research in the UK provides similar support for patients and their relatives. Similar support organisations are found in other EU Member States. In Denmark, the Diabetes organisation has a special focus on self-management which includes how to measure the blood sugar level at home and detailed guidelines on diet.

[4] Department of Health, UK
[5] http://www.medterms.com/script/main/art.asp?articlekey=38316
[6] http://www.euro.who.int/mediacentre/PR/2006/20060908_1

7.1.3 eHealth and self-management

The development and implementation of ICT in healthcare requires willingness to invest large sums without expecting to see the economic benefits immediately. In fact, an EU project, eHealth Impact[7], has demonstrated that there is at least a 4 years payback period of ICT investments in eHealth. After this period, there will be a 2:1 ratio between costs and benefits, thus illustrating the overall benefits of investing in ICT in healthcare. eHealth services cover access to reliable, high-quality health information for professionals and for the general public and use of information, as well as communication technologies to strengthen various aspects of health systems, such as eLearning for development of human resources and support for delivery of care services. This includes developing electronic systems for health records, patient identifiers and health cards, and the faster rollout of high speed internet access for health systems to allow the full potential of e-Health to be delivered. Health information systems must be interoperable in order to allow for health data and medical information to be transmitted across heterogeneous networks and information systems. Importantly measures must be in place in order to avoid comprising data protection issues and legislation.

eHealth opens up for new possibilities for home-care and self-management. eHealth services and the development of sophisticated personal wearable and portable medical devices can improve the management of chronic conditions considerably. It is important, however, that sophisticated and intelligent medical devices that can be used by people at home or on the road must be developed according to the needs and demands of both patients and healthcare professionals. Intelligent devices must be interoperable allowing them to interact with other devices and services. When these basic requirements are fulfilled, eHealth and medical devices will allow patients and healthcare professionals to become more mobile, as well as enabling a more efficient monitoring and management of diseases.

In line with this, self-management of chronic conditions is gaining impetus in many EU Member States as evidence points to its benefits for both patients and healthcare providers. For self-management to be truly effective certain requirements must be met. Patients must receive proper education on how to manage their condition and they must have easy access to information. Remote monitoring by professionals, for example their GP, is a crucial factor in ensure good self-management plus it allows for the patient to remain mobile. Remote monitoring should offer two-way communication, automatic feedback and risk assessment in order to keep the patient constantly aware of his/her health status.

With these standards in place, self-management will lead to more informed and involved patients, allows them to remain mobile and active, saves on healthcare personnel resources and may reduce healthcare costs as diseases are managed better thus preventing serious complications to develop as a consequence of lack of monitoring and disease management.

The implementation of eHealth services faces a challenge in ensuring interoperability of heterogeneous systems and devices. Interoperability is essential for the effectiveness of eHealth services and the Hydra middleware offers a solution to this challenge.

7.2 Organization of workshops

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

Equipment Manufacturer	Patient Organisation
Doctor	Healthcare administrators
Nurse	Health information institution

[7] eHealth-Impact, EU funded project under the 6th Framework Programme, www.ehealth-impact.org

The scenarios were developed through a one-day workshop held on 12 December 2006 at DELTA, Hørsholm, Denmark.

Moderator of the workshop was Jesper Thestrup (IN-JET). Supporting role was assigned to Trine F. Sørensen (IN-JET).

The users participating in the workshop were selected because of their personal expertise and their reputation. The participants were:

1. Jens Branebjerg, Microsystems, DELTA, (Equipment Manufacturer)
2. Ole Strange, OS Management (Equipment Manufacturer, Healthcare Management)
3. Hrönn Sigurdardottir, IT University (Nurse and PhD student in Pervasive Healthcare)
4. Margit Kristensen, University of Århus (Nurse and PhD student in Pervasive Healthcare)
5. Thomas Riisgaard Hansen, Århus University (PhD student in Pervasive Healthcare)
6. Jacob Skjødt Nielsen, Alexandra Instituttet (Health Information researcher)
7. Rashad Elsubani, Silicide ApS, Denmark (Equipment Manufacturer)

Unfortunately, last minute cancellations were received from the following experts:

8. Prof. De Rosa, Ospedale San Camillo, Italy (Doctor)
9. LABOR, Italy, (Health information institution)
10. Mr. Hein, Siemens Medical, Germany
11. Berit Müller, Patient Organisation Denmark (Patient Organisation)
12. Jannick Hilsted, Rigshospitalet, Denmark (Healthcare administrator)
13. Jane Clemensen, Århus University, Denmark (Health Information Institution)
14. Finn Kensing, IT University, Denmark (Health Information Institution)
15. Finn Tønnesen, Kræftens Bekæmpelse – Cancer Research Center, Denmark (Doctor)
16. Kurt Godsk, Embedit A/S, Denmark (Equipment Manufacturer)
17. Nanna Mik-Meyer, Copenhagen Business School, Denmark (Health information Institution)

As these cancellations were received between 1 and 3 days before the workshop it was not possible to find substitutes. It was also found that it was too late to cancel and postpone the workshop. A postponement would, furthermore, have meant that this deliverable would have been delayed significantly as it would have been necessary to postpone the workshop until late January 2007. The WP2 consortium therefore decided to go ahead and carry out the workshop as planned.

As a result of the cancellations, input from a few important profiles was missing, e.g. practicing doctors and patient organisations. Further, the expert group lacked cross European participation because all experts from Germany and Italy had cancelled. However, the participating Danish experts all had a highly international background and large knowledge of clinical and organisational healthcare system across Europe and the USA. Further, our previous research into the healthcare domain has a clear European perspective, all of which contributed to the scenarios.

7.3 Selection of application area and time horizon

The experts started by discussing the most critical application area for ICT technology in the future, how existing medical devices can be improved and what type of new and better devices could be developed to improve concepts like self-management and monitoring of chronic conditions. The main focus was on devices that are used by patients themselves and are used in support of self-management of various diseases.

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

7.4 Trigger question

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

How do we develop and deploy intelligent, ubiquitous and secure networked products and services for healthcare in 2015?

7.5 Identification of environmental factors

Factors were identified from among all the possible environments that could influence healthcare in 2015:

- Technology trends
- Clinical trends
- Economic futures
- Social values and life-styles
- Ethical and value questions
- Organisation and logistic systems
- Environmental issues
- Global political influences

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

The workshop participants defined a total of 63 factors in all areas:

Technology trends (T)
Support industry
Non-battery solutions
2-in-1 devices
Energy constraints
Bandwidth
Traditional methods prevail
Real time performance
Wireless solutions
Traceability
Multifunction devices
Automatic semantic translation
Security models
Near field communication
Automatic processes
Device design
Predictive technology
Virtual communities

Clinical trends (C)
Health check-ups
Conditional treatment offers
Remote diagnostics
Body sensors
Robot surgery
Monitoring limits
Remote treatment limits
Self-monitoring

Economic futures (€)
Economic incentives
Public/private financing
Reimbursement across borders
Long-term public investments
Cost of WAN
Expensive battery-driven solutions
Limited health costs

Social values and life-styles (L)
Healthy lifestyle
Social pressure to be healthy
Lifestyle change
Paying for "safety"
Invisible health support devices
Empowered patients
Individualised motivation
Private health insurance
Lifestyle information
Smart devices motivate

Ethical and value questions (V)
Radiation risks
Quality of life
Attitudes to ICT
Ownership of data
Personal data issues

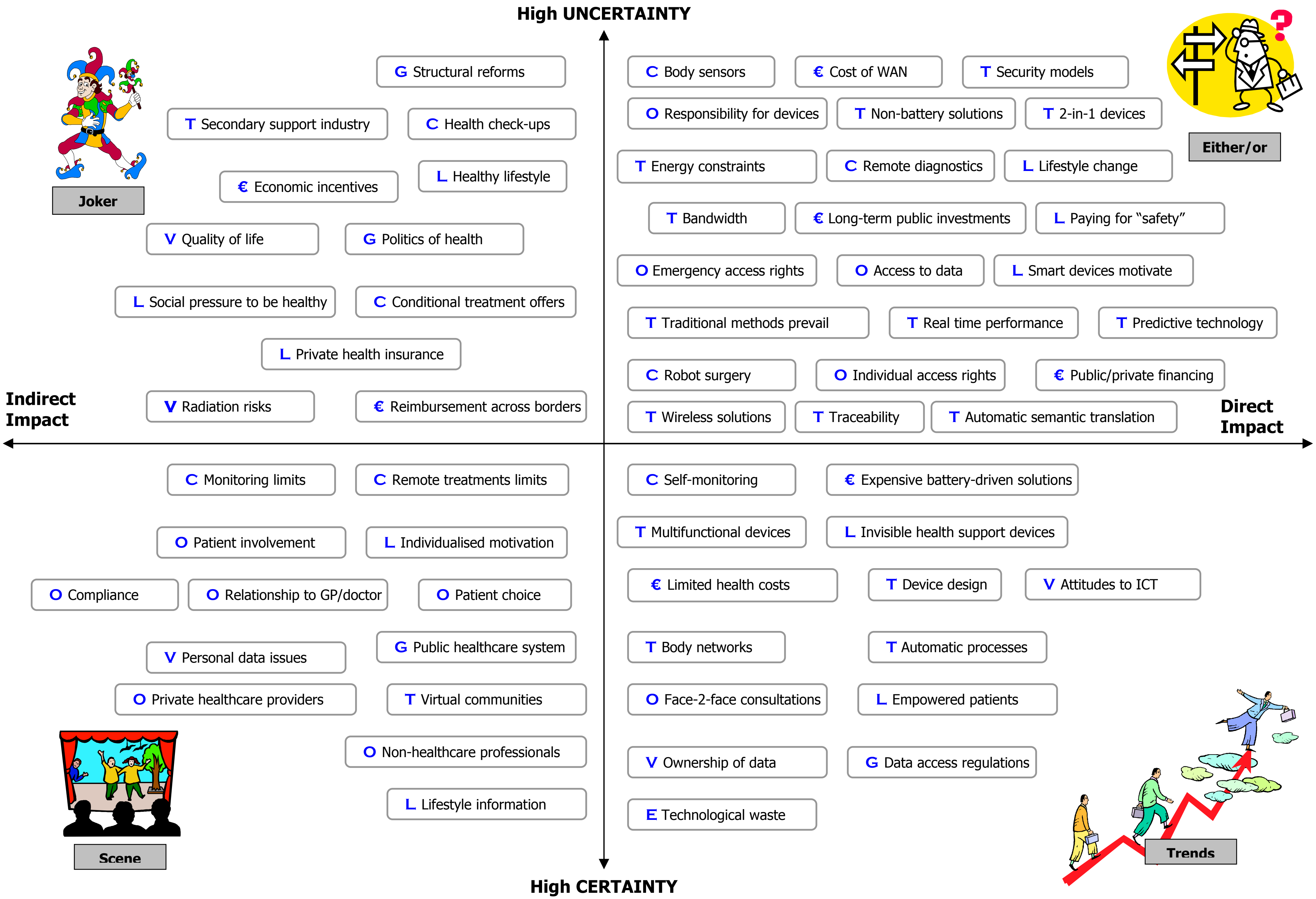
Organisation and logistic systems (O)
Responsibility for devices
Access to data
Emergency access rights
Individual access rights
Patient involvement
Patient choice
Private healthcare providers
Non-healthcare professionals
Relationship to GP/doctor
Compliance
Face-2-face consultations

Environmental issues (E)
Technological waste

Global political influences (G)
Politics of health
Structural reforms
Public healthcare system
Data access regulations

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

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



High UNCERTAINTY
High CERTAINTY
Indirect Impact
Direct Impact
Joker
Either/or
Scene
Trends
G Structural reforms
T Secondary support industry
C Health check-ups
€ Economic incentives
L Healthy lifestyle
V Quality of life
G Politics of health
L Social pressure to be healthy
C Conditional treatment offers
L Private health insurance
V Radiation risks
€ Reimbursement across borders
C Body sensors
€ Cost of WAN
T Security models
O Responsibility for devices
T Non-battery solutions
T 2-in-1 devices
T Energy constraints
C Remote diagnostics
L Lifestyle change
T Bandwidth
€ Long-term public investments
L Paying for "safety"
O Emergency access rights
O Access to data
L Smart devices motivate
T Traditional methods prevail
T Real time performance
T Predictive technology
C Robot surgery
O Individual access rights
€ Public/private financing
T Wireless solutions
T Traceability
T Automatic semantic translation
C Monitoring limits
C Remote treatments limits
O Patient involvement
L Individualised motivation
O Compliance
O Relationship to GP/doctor
O Patient choice
V Personal data issues
G Public healthcare system
O Private healthcare providers
T Virtual communities
O Non-healthcare professionals
L Lifestyle information
C Self-monitoring
€ Expensive battery-driven solutions
T Multifunctional devices
L Invisible health support devices
€ Limited health costs
T Device design
V Attitudes to ICT
T Body networks
T Automatic processes
O Face-2-face consultations
L Empowered patients
V Ownership of data
G Data access regulations
E Technological waste

7.6 Flip-flopping the pivotal uncertainties

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

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

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

Responsibility for devices Responsibility for the functionality of medical devices has not been assigned to specific party	+	Healthcare providers have assumed responsible from manufactures for the proper functioning of medical devices.
	-	It is unclear if the healthcare provider or the manufacturer is responsible for ensuring that proper functioning of medical devices.
Long-term public investments What is the political attitude towards long-term investments in ICT in healthcare?	+	Long-term investments in ICT in healthcare are regarded as necessary for improvement of the healthcare system and self-management initiatives.
	-	It is difficult to convince politicians to make long-term investments in ICT for improvement of the public healthcare system.
Non-battery solutions What types of energy solutions are available for medical devices?	+	Non-battery driven solutions are widely available, significantly improving the performance level of medical devices.
	-	No real developments in this area have been achieved and medical devices are still battery-driven.
Energy constraints To what extent is the performance level of medical devices on energy consumption?	+	It is possible to secure a high level of performance independent on energy source and consumption.
	-	To achieve a high performance level medical devices have a very high energy consumption.
Remote diagnostics Is remote diagnosis used within healthcare?	+	Most GPs practice remote diagnostics on an increased number of patients.
	-	All patients must be seen by a GP in person before they receive a diagnosis.
Body sensors Is it possible to use body sensor for healthcare purposes?	+	Body sensors are used to predict and prevent development of diseases.
	-	Body sensors have not been developed sufficiently and cannot be used for medical purposes.
Cost of WAN What kind of impact will WAN telecommunication networks have on ICT in healthcare?	+	Healthcare systems use the low cost WAN telecommunication networks for mobile medical devices in healthcare.
	-	The cost and availability of WAN telecommunication networks inhibits the use of mobile medical devices.
Access to data Will there be restrictions on access to data?	+	Medical companies have free access to personal health data.
	-	Medical companies may not access personal health data.
Traditional methods prevail To what extent will ICT change healthcare system and practice?	+	ICT solutions and methods of treatment will be an important supplement to traditional non-ICT healthcare treatments, improving healthcare overall.
	-	ICT is still limited within healthcare and its advantages for improving healthcare and self-management have not been realised.
Real time performance Is it possible to make any guarantees regarding data transfer time?	+	The transfer of health data within real time or set time frames will be guaranteed.
	-	It is not possible to guarantee that health data transfers will occur in real time.

Robot surgery Will robot surgery be a widely used practice?	+	Robot surgery is a widely used practice within secondary healthcare.
	-	There have not been sufficient developments within robot surgery to be able to offer it to patients.
Wireless solutions How well-developed will wireless solutions be?	+	Wireless solutions are so reliable that they can be used in any kind of healthcare situation.
	-	Due to reliability risks, wireless solutions may only be used for non-critical healthcare matters.
Bandwidth Will bandwidth be an issue when it comes to data transfer	+	There will always be enough bandwidth available for data transfers.
	-	Data transfers are problematic due to insufficient bandwidth.
Emergency access rights Is it possible to have set rules that determine access rights to health data in emergency situations?	+	Access to a person's health data is based on the particular context and situation.
	-	It is not possible to base access rights to a person's health data on context and situation.
Individual access rights How may individual access rights to health data be granted?	+	There is a system in place which is able to automatically sort data access according to each healthcare professional's individual rights.
	-	It is not possible to ensure that healthcare professional's individual data access rights are automatically granted.
Traceability Will it be possible to trace people's health state?	+	ICT makes it possible to trace people's health state anytime and anywhere.
	-	There is no system in place which allows for tracing people's health state.
Paying for "safety" What characterises elderly people's attitude towards private payments for healthcare monitoring services?	+	The elderly wants to be able to buy more and better monitoring healthcare services as well as invest in medical devices for home use in order to feel more secure in their homes and on the road.
	-	The elderly will rather live without the added security monitoring and medical devices provide than paying for these services and devices themselves.
2-in-1 devices Will 2-in-1 devices be widely available?	+	Support/health devices have been merged with lifestyle devices thus creating a 2-in-1 device that meets the needs of the market.
	-	Despite market demands, a 2-in-1 device merging lifestyle devices with support/health devices has not been developed.
Security models What kind of security models will be available?	+	Security models are designed and adjusted to individual needs and specific contexts.
	-	Only general and generic security models are available.
Lifestyle change What is the general attitude towards healthy lifestyle?	+	Overall, people will be serious about changing their lifestyle to live healthier in order to avoid or managed lifestyle diseases.
	-	Despite health problems most people are not making any real efforts to change their unhealthy lifestyles.
Public/private financing What will the future financing of healthcare look like?	+	The costs of healthcare services are split equally between public and private funding to secure sufficient resources for improved healthcare.
	-	The majority of healthcare services will continue to be financed publicly thus placing some financial restrictions on the availability of healthcare services.
Predictive technology Will it be possible to use technology to	+	Technological developments have made it possible to predict diseases and changes in health status, e.g. oncoming heart attacks can be discovered.

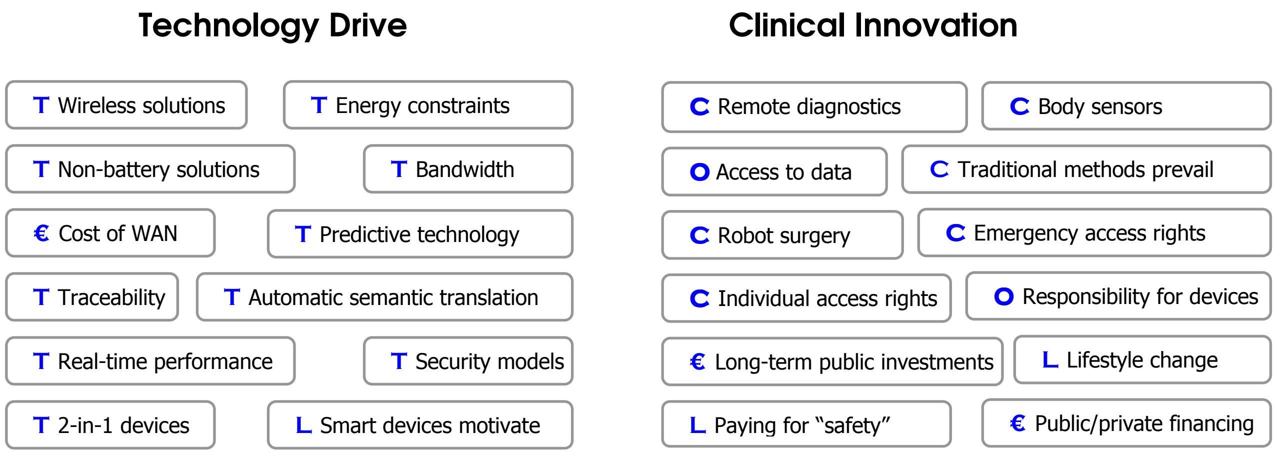
predict changes in health?	-	Insufficient research and development in the field of predictive technologies have meant that these are not available on the market.
Smart devices motivate Are there any extra benefits of smart devices besides the technological possibilities they offer?	+	Smart devices motivate people to live healthier as they include a competitive element, e.g. tracking weight loss or counting number of steps walked per day, thus setting fun goals for people.
	-	Most people have little knowledge of the countless functions smart devices offer and therefore fail to use the smart device as a motivator towards better health.
Automatic semantic translation Will automatic semantic translation be in place?	+	It is possible to use semantic translation in relation to e.g. patient journals and other health data.
	-	Automatic semantic translation of health data is not available.

7.7 Clustering the uncertainties

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

When inspecting all 24 uncertainties it becomes obvious that they can be separated into two distinct groups. The first group of uncertainties is related to the information and communication technologies that are used in healthcare and the economic aspects of the implementation of ICTs in healthcare. We have named this cluster "**Technology Drive**".

The second group of uncertainties is related to the clinical trends and the organisation of the healthcare system and how these are influenced by the technological developments and the use of ICT. ICT opens up for new ways of ways to treat patients and of delivering healthcare. We have named this cluster **"Clinical Innovation"**.



7.8 Naming the sub plots

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

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

In the **Technology Drive** cluster we arrive at the following large-scale flips and flops:

Big Flip Cluster – "Technology Drive"	**Big Flop Cluster – "Technology Drive"**
• Wireless solutions are so reliable that they can be used in any kind of healthcare situation • It is possible to secure a high level of performance independent on energy source and consumption • Non-battery driven solutions are widely available, significantly improving the performance level of medical devices • Technological developments have made it possible to predict diseases and changes in health status, e.g. oncoming heart attacks can be discovered • Healthcare systems use the low cost WAN telecommunication networks for mobile medical devices in healthcare • There will always be enough bandwidth available for data transfers • ICT makes it possible to trace people's health state anytime and anywhere • It is possible to use semantic translation in relation to e.g. patient journals and other health data • The transfer of health data within real time or set time frames will be guaranteed • Security models are designed and adjusted to individual needs and specific contexts • Support/health devices have been merged with lifestyle devices thus creating a 2-in-1 device that meets the needs of the market • Smart devices motivate people to live healthier as they include a competitive element, e.g. tracking weight loss or counting number of steps walked per day, thus setting fun goals for people	• Due to reliability risks, wireless solutions may only be used for non-critical healthcare matters • To achieve a high performance level medical devices have a very high energy consumption • No real developments in this area has been achieved and medical devices are still battery-driven • Insufficient research and development in the field of predictive technologies have meant that these are not available on the market • The cost and availability of WAN telecommunication networks inhibits the use of mobile medical devices • Data transfers are problematic due to insufficient bandwidth • There is no system in place which allows for tracing people's health state • Automatic semantic translation of health data is not available • It is not possible to guarantee that health data transfers will occur in real time • Only general and generic security models are available • Despite market demands, a 2-in-1 device merging lifestyle devices with support/health devices has not been developed • Most people have little knowledge of the countless functions smart devices offer and therefore fail to use the smart device as a motivator towards better health
which leads to the name: **TECHNOLOGY CONVERGENCE**	*which leads to the name:* **TECHNOLOGY DIVERGENCE**

The "big-flip" of the **Technology Drive** cluster describes an efficient healthcare system with a high performance level due to the convergence of new ICT technologies and clinical demand. Patients are highly engaged in their health and actively use high-tech medical and health support devices to achieve a healthier lifestyle and quality of living.

Development and implementation of new ICT technologies in healthcare have enabled better health practise to be put in place and innovative healthcare services have been developed using techno-logical innovations. Conversely, ICT innovations have been spurred by new clinical practice and medical discoveries (the virtuous circle). This version of the cluster facilitates scenarios featuring ICT technology that supports and complements clinical practices to achieve a common goal.

On the other hand, we have the "big-flop" situation where ICT developments and implementations in healthcare are out of synchronisation and technology supported solutions are very expensive.

The general public is unaware of the technological possibilities of smart devices and home medical devices in relation to improving their lifestyle. Take-up of new ICT technologies in medical practice and healthcare administration is slow or sometimes avoided, so the full potential of ICT in healthcare is far from being realised. Developers have not responded adequately to market demands, so the clinical and medical value of the solutions is often unclear. Conversely, medical practitioners and healthcare authorities have not been sufficiently interested in trying out new ICT technologies and have not created a basis for synergetic cooperation (the negative spiral). This version of the cluster facilitates scenarios with little uptake of ICT and continued focus on traditional clinical practises.

In a similar way we can group the **Clinical Innovation** cluster:

Big Flip Cluster – "Clinical Innovation"	**Big Flop Cluster – "Clinical Innovation"**
• Most GPs practice remote diagnostics on an increased number of patients	• All patients must be seen by a GP in person before they receive a diagnosis
• Body sensors are used to predict and prevent development of diseases	• Body sensors have not been developed sufficiently and cannot be used for medical purposes
• Medical companies have free access to personal health data	• Medical companies may not access personal health data
• ICT solutions and methods of treatment will be an important supplement to traditional non-ICT healthcare treatments, improving healthcare overall	• ICT is still limited within healthcare and its advantages for improving healthcare and self-management have not been realised
• Robot surgery is a widely used practice within secondary healthcare	• There has not been sufficient developments within robot surgery to be able to offer it to patients
• Access to a person's health data is based on the particular context and situation	• It is not possible to base access rights to a person's health data on context and situation
• There is a system in place which is able to automatically sort data access according to each healthcare professional's individual rights	• It is not possible to ensure that healthcare professional's individual data access rights are automatically granted
• Healthcare providers have assumed responsible from manufactures for the proper functioning of medical devices	• It is unclear if the healthcare provider or the manufacturer is responsible for ensuring that proper functioning of medical devices
• Long-term investments in ICT in healthcare are regarded as necessary for improvement of the healthcare system and self-management initiatives	• It is difficult to convince politicians to make long-term investments in ICT for improvement of the public healthcare system
• The elderly wants to be able to buy more and better monitoring healthcare services as well as invest in medical devices for home use in order to feel more secure in their homes and on the road	• The elderly will rather live without the added security monitoring and medical devices provided than paying for these services and devices themselves
• Overall, people will be serious about changing their lifestyle to live healthier in order to avoid or managed lifestyle diseases	• Despite health problems most people are not making any real efforts to change their unhealthy lifestyles
• The costs of healthcare services are split equally between public and private funding to secure sufficient resources for improved healthcare	• The majority of healthcare services will continue to be financed publicly thus placing some financial restrictions on the availability of healthcare services
which leads to the name:	*which leads to the name:*
CLINICAL REVOLUTION	**CLINICAL EVOLUTION**

The "big-flip" of **Clinical Innovation** cluster illustrates a future where revolutionary new medical methods and clinical processes supported by high public investments and successful implementation of ICT technologies have brought about new highs in disease prevention and treatment. Citizens are deeply involved in their own health and are willing to invest time and resources in achieving a healthier lifestyle, but they are also in getting more extensive healthcare services with better support and more focus on preventive and predictive care. Healthcare services are still mainly publicly financed to secure free access for all. This version of the cluster facilitates scenarios featuring ICT technology that is embedded in clinical practices to achieve a superior and ambitious goal.

The "big-flip" cluster describes a situation where medical and clinical practise still is much more evolutionary than revolutionary. New methods and processes are mostly developed in response to eminent demographic or financial threats rather than proactively in anticipation of future needs.

Insufficient and improper implementation of ICT solutions in healthcare has made it difficult to optimise clinical processes and methods to improve healthcare services. There is an overall reluctance to take advantage of the possibilities ICT offers, both among authorities responsible for healthcare provision, among healthcare providers and even among the general public. This version of the cluster facilitates scenarios featuring ICT technology used to bridge gaps in medical practices and repair non-functional or inefficient traditional clinical processes, rather than proactively to secure a healthcare system that can match future challenges.

7.9 Multiple images of how healthcare systems are being developed in 2015

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

7.9.1 Developing the scene

In this process, we start with the scene, which is common for all scenarios. The elements for defining the scenes are found in the lower left "Scene" quadrant of the original grid of environmental factors. These factors are deemed by the experts to be rather certain and thus serve at the reference point for all four scenarios. The "Scene" factors are mostly related to non-technical influence on healthcare in the future, such as organisation and logistic systems and clinical trends.

Lifestyle diseases are of important societal concern. Everyone even remotely related to healthcare, politicians, healthcare administrators, medical and non-medical professionals such as teachers, social workers and private employers, is strongly engaged in encouraging people to live a healthier lifestyle. This involves eating and drinking with reason, stop smoking, avoiding stress and exercising regularly. The methods involve information, training and more information.

Healthcare systems are primarily publicly financed but more and more patients seek individual private treatment to avoid waiting lists. In general, patients have a less authoritative relationship to their GP/doctors than today. Patients also want to have more influence on their treatment such as free choice of GP/doctor in both the primary and secondary healthcare sector.

Generally, patients are much more involved in their own health not the least due to increased access to on-line information on health and lifestyle diseases, net doctors, virtual communities and availability of smart devices which is a significant tool for helping and motivating people to live healthier and manage their chronic conditions. However, on the flip side of the overall situation, patient compliance is still a serious problem because patients some times take matters into their own hands which ironically hinder effective self-management of especially chronic diseases.

7.9.2 Building the sets

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

One trend [1] concerns the increased number of patients, as a result of both demographic factors and rising number of people with chronic diseases, combined with increased demands from citizens for timely, high quality care. This means ever increasing healthcare costs. Politicians must constantly try to contain the costs through various initiatives, even if it leads to degradation of service, because there is a limit to how high a proportion of GDP can be allocated to health. Healthcare professionals have developed a positive attitude to ICT technologies and tend to use it in patient administration and case management, in order to meet the demands for cost containments and efficiency.

Another trend [2] points towards the use of well-developed self-management schemes for people with chronic conditions. Self-management of chronic diseases has shown remarkable results over the years and is one of the most successful case management techniques in recent years. It is also instrumental for cost containment and in the fight against case overload in both primary and secondary healthcare systems. ICT platforms are extensively used in fully automated processes to support self-management and remote monitoring using minimally-invasive, multi-parametric devices. Automatic process means that devices are self configuring, self discovering and easy to use so that self-management requires minimal intervention from patients. Remote monitoring is seen as an important supplement to other case management methods; it does not replace direct, face-to-face interaction between doctor and patient. Most patients, and doctors, prefer it this way.

A third trend [3] focuses on the increase in assistive medical devices (smart devices) and how these will become an integral part of healthcare, particularly in relation to improved self-management of chronic diseases. Wearable devices interconnected in a wireless body network, are easy to wear, and often multifunctional, when patients need different devices for monitoring different parameters. They are also ergonometric, invisible or easy to hide for convenience. And they are designed to help people live normally and to take the focus off the disease itself rather than act as a constant reminder of their condition. An example is the integration of entertainment functions into medical devices. The only major problem with healthcare devices is that many of them still need expensive, bulky battery power for operation. This increases costs, limits usability and contributes to more electronic waste.

A final trend [4] is the continued issue of securing privacy, secure access, non-repudiation and rights of ownership of health data. Personal health data are extremely sensitive and privacy has been an increasing concern with citizens. National legislation is in place across Europe to restrict access to health data and protect the right of the patient, but in some countries the regulations can be a hindrance for efficient and effective healthcare, because the rules are not sufficiently adapted to the procedures in the real world. The balance between privacy and protection of health data and efficient and informed healthcare is difficult and is still an unresolved issue in Europe as a whole. The question of ownership of health data is closely related to this issue. Patients have full ownership of their own health data and thus full control of access rights which in some cases restrict the efficiency of e.g. emergency care, shared care or even highly popular and otherwise effective multidisciplinary, multifaceted constructs such as chronic disease liaison groups and palliative support schemes.

7.9.3 Defining the script

In the final step, the four scenarios come to life as imaginative plays defined by scripts. In writing the scripts, the environmental factors enter according to a simple grouping: What is happening, how is it happening and why is it happening?

<u>What is happening?</u>

The scene shows a typical user situation around 2015. The developer user is being presented with a series of requirements for new medical equipment and health care systems. Developing infrastructure for this domain has a series of unique requirements, such as safety, accuracy, 24/7 operation, data security and privacy, adaptability to legacy systems, configurability, usability for users and administrators, scalability, cost benefit, etc., etc. The complexity and the stringent extra-functional requirements often drive both development and manufacturing cost through the roof. The developers will therefore increasingly be met with the need to reuse existing devices or systems, use off-the-shelf components where possible.

<u>How is it happening?</u>

The main thrust for the developer users script are extra-functional features such as the regulatory requirements, medical equipment standards, safety and security aspects, and the commercial benefits to be derived from the under laying business cases. It is essential for the successful adoption of new technology in the healthcare sector that cost/benefit analyses shows sufficient clinical and economic benefit to the healthcare professionals and decisions makers

The developer user tends to favour integration of systems and devices using standardised middleware, which adheres to medical standards. By using a Hydra middleware, the developer users are able to develop integrated solutions, compliant with medical standards and regulations, secure and trustworthy, with high degree of functionality and precisely targeted the medical end-user in question.

Why is it happening?

The complexity of the overall healthcare system including its tortuous business models and multiple value chains makes system conceptualisation a major challenge to developers. Focus is on making every part of the system adaptive using methods of end-to-end reconfigurability. The key objective of such end-to-end reconfigurability methods is to develop architectural design of reconfigurable devices and supporting system functions so as to offer an expanded set of operational choices to the different actors of the value chain, e.g. doctors, patients, administrators, manufacturers, etc.

One primary target group is the GP's or doctors in the primary healthcare system. They are the frontline users facing the patients and they need the most support in dealing with new technology. They require extreme ease of use, high efficiency in the day-to-day operation of the system in order to relieve the high caseload, and security and privacy on behalf of the patients. Most important, though, is that the system comes with an agreed and supported fee structure and business model.

Writing the scenarios

The four scenarios have been written on the basis of the scenario thinking process with the group of experts in healthcare, health information, pervasive healthcare and embedded software technologies in medical equipment. The scenarios have been illustrated with pictures and drawings to stimulate the reader's imagination.

7.9.4 Writing up the scenarios

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

1. Technology convergence + Clinical evolution
2. Technology convergence + Clinical revolution
3. Technology divergence + Clinical revolution
4. Technology divergence + Clinical evolution

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

1. Overload

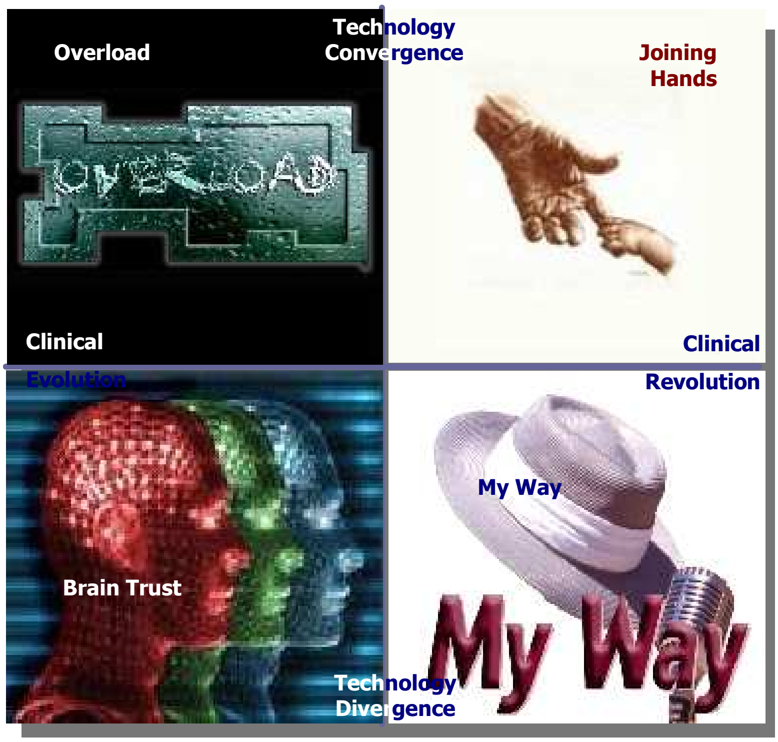
This scenario addresses the constant drive to cope with an increased number of patients, as a result of demographic factors and the rising number of patients with chronic diseases. Healthcare services continue to be publicly funded and politicians must constantly contain costs through various initiatives, so it is difficult to make investments in ICT solutions, unless they have a very short pay-back. However, citizens demand timely, high quality care increasing the load on the already overloaded system. Even if ICT solutions exist, many clinical procedures are still manual. Developers have a range of new technologies which can trace people's health in real time, anywhere, anytime. However, even though healthcare professionals have a positive attitude to ICT, they tend to use it mainly in patient administration and to meet demands for cost control and efficiency. Jokers are the emergence of private health insurance and economic incentives e.g. tax levels depending on health.

2. Joining Hands

This scenario addresses the proliferation of self-management schemes for long term diseases and as prevention tools for life style changes. Clinicians and developer users work together to bring about a wealth of smart devices and low power sensors in wireless, self configuring body networks which semantically interfaces to legacy health care systems. The systems are reliable and safe and doctors increasingly rely on the remote information to also perform diagnosis and long term risk assessment. Since citizens are serious about their health, partly because of social pressure, self management has become a major tool in matching the rising need for high quality health care in addition to frequent health checkups. Politicians have realised the need for making long term investments in ICT infrastructure but many patients spend additional money for top class care. The challenge for developer users of Hydra middleware is to make the applications sufficiently intelligent even with power and resource constrained embedded devices. The demand for both functionality and extra-functional features is very high.

3. My way

Medical researchers and practitioners are using range of new and highly advanced markers for early detection of diseases to counter the increasing impact from lifestyle and unhealthy living. The rising number of private insurances encourages the healthcare professionals to invent unconventional smart sensor systems for remote diagnostics, monitoring and early warning if groups of high-risk patients. But developer users have pursued their own objectives, which not always supports the progress in clinical methods. One problem is that communication networks specifically for health care applications has not materialised in Europe like in the US. Another challenge for developer users is the integration of a large number of heterogeneous, multifunctional, ergonometric, and invisible devices imported from other applications and to turn them into a coherent medical application.



3. Brain Trust

The thrust in this scenario is the slow, but steady progress of synergetic cooperation between technology developers and medical researchers and clinical practitioners. The majority of health care services are publicly financed, putting a great pressure on government spending. Most people are not making any real efforts to change unhealthy lifestyles, and development of ICT infrastructures are mostly concerned with administrative efficiency and cost savings. One area where real progress has been made is in terms of security and privacy for patient data. National legislation is in place across Europe to restrict access to health data and protect the right of the patient and all developer users must comply with these rules. Patients have full ownership of their own health data and thus full control of access rights, which in some cases restrict the efficiency of e.g. emergency care, or shared care.

8. Healthcare scenarios

8.1 Overload

Health care professionals are coping with an increased number of patients, as a result of demographic factors and the rising number of patients with chronic diseases. Since healthcare services mostly are publicly funded, politicians must constantly contain costs through various initiatives, so it is difficult to make investments in ICT solutions for disease control, unless they have a very short pay-back. However, citizens demand timely, high quality care increasing the load on the already overloaded system. Even where ICT solutions exist for care and workflow improvements, many clinical procedures are still manual.

Equipment developers have a range of new technologies which can trace people's health status in real time, anywhere, anytime. However, even though healthcare professionals have a positive attitude to ICT, they tend to use ICT mainly in the form of diagnostic equipment and in patient administration to meet demands for cost control and efficiency.

Michael Johnson is 29 years old and is severely obese with a BMI[8] of 31. Overweight increases the risk of many diseases and health conditions, including hypertension, diabetes II, stroke and others. Michael lives in Southampton, UK, and works as a long-distance truck driver. He spends most of his time on the road which has become a second home for him. He drives all over Europe but rarely get a chance to see much other than motorways, the restaurants and rest areas along the motorway. He doesn't mind so much; he just loves driving his truck and being independent.

About 6 months ago, he fell very ill with strong chest pains. After several tries he finally managed to set up consultation with his family GP, Dr. Ross. After extensive examining and blood tests, Dr. Ross called him in to tell him his diagnosis: *"I am afraid that due to your overweight, you have developed diabetes type II, Michael. Your blood pressure and your cholesterol figures are also too high".* Dr. Ross went on to give Michael a thorough introduction to diabetes, its occurrence and the potential risks he was facing. Dr. Ross also told him that he must loose weight, start to eat a healthier diet and do more exercise, if he wanted to steer clear of a heart attack, which could potentially kill him.

Dr. Ross wanted to put Michael on a strict clinical treatment programme with close monitoring. He wanted to track Michael's glucose level and blood pressure to avoid potentially life threatening situations and keep an eye out for any deterioration of Michael's general health status as to alleviate occurrence of related conditions. For longer term health improvement, he instructed Michael to loose at least 4 stones (25 kg). The treatment plan was a combination of dietary changes to a fat-free, high nutrition diet, and daily exercise. Dr. Ross told him that weight loss would lower his blood pressure and improve cholesterol level. Since he had diabetes II, it could also reduce his blood glucose and haemoglobin A levels. *"Weight loss and exercise is thus a key factor to your wellbeing. You must learn to manage your disease"*, Dr. Ross told him.

At first, Michael was very dismissive about Dr. Ross' instructions and showed no interest in following the self-management scheme. Being constantly on the road makes it hugely inconvenient for him to monitor health status, change his diet and exercise. On the other hand he is slightly worried about his future life, so when Dr. Ross tells him about the liaison communities that exist for patients like him, he becomes interested. A self-management group, OurHealth, has recently been created in Southampton. It is formed around a virtual community in which members use internet and wireless technologies to stay in contact with each other anywhere, anytime, posing new ways of interacting socially. It uses peer pressure to help members stay on track with their diet and weight loosing programmes. The virtual community also includes doctors, other healthcare professionals, such as dieticians and fitness instructors, and ICT experts maintaining the community infrastructure.

[8] Body Mass Index (BMI) is basically the relationship between a person's height and weight

It all fitted quite well with Michael's work and lifestyle and he decides to give it a try. On Dr. Ross' recommendation, Michael buys electronic home care devices that can measure his weight, blood pressure and glucose level. The devices are battery operated and he can easily carry them with him. Tim Jones, an ICT specialist in OurHealth suggest to Dr. Rah, one of doctors at OurHealth, that Michael should be more closely monitored when he is on the road. Tim suggests that data from Michael's medical devices can be automatically uploaded to his patient record (EPR) using the NHS Connecting for Health backbone[9]. In this way, Michael can be professionally monitored without really realising it. Since all devices are BlueTooth enabled, Tim suggests equipping Michael with a mobile phone with BlueTooth and java processor. Tim will then turn it into a multiple-parametric smart device that automatically can upload data to the NHS system, for doctors to monitor his progress.

Michael is extremely happy with his new smart device, which he uses for entertainment (music and movies), information (news, traffic and weather), communication (voice and text) and now medical monitoring and feedback. The smart device collects and sends off the readings to his EPR in NHS using the 3G broadband network in Michael's truck. This network is used for fleet management and technical monitoring of truck performance by his company, but the company has allowed its drivers to use it also for private communication. The truck's GPS system also provides location information.

Today is a typical day for Michael. It is his second day on the road on the way from Southampton to Lisbon. Michael has performed his usual measurements and the data are encrypted and stored on his smart device, where they are filtered and compared to previous readings. As long as the data remains on the smart device, they are completely private and Michael needs to authorise each secure transmission to the NHS databases. When the data have been analysed, Michael receives an audio message via his car stereo, which the smart device has automatically interfaced to. This way he can keep his eyes on the road. It informs him that the measurements are good. His cholesterol level is down, his weight is down and the glucose level is stable. It asks him if he wants to upload the data to the NHS system. Michael confirms in natural language and the data are uploaded. Five minutes later Dr. Rah from OurHealth calls him on the mobile phone to congratulate him. The data filter has flagged Michael and both Dr. Rah and Dr. Ross have been notified.

The next hour, Michael chat with friends from OurHealth until it's time for him to stop for lunch. As Michael drives into the parking lot, his smart device registers the different food the restaurant offers translated into English. The information contains dietary information, which is compared to his health data collected earlier that day and his dietary plan. The smart device analyse the restaurant's lunch menu and displays a list (in English and French) of the food that Michael can have. Michael chooses a salad and the kitchen automatically receives his order, when he enters the restaurant.

The biggest challenge however, has been to get Michael to exercise. Michael practically lives in his truck and he never sets foot near a fitness centre. But Michael has got a new pair of Nike running shoes. Build into the shoes are wireless sensors that collects information on the number of steps taken and calories burnt. Data are sent to his smart device and when he gets back to the truck, the smart device uploads the data to OurHealth database; geocoded with location information. There is fierce competition among the virtual community members for running the longest distance. A winner is drawn every week and featured on the community's web site. A special price is also given to the two members, who have been furthest away from Southampton. Michael thinks this is great fun.

As a consequence of joining the OurHealth community, Michael is on his way to a better life. He is now very much in line with the increased public focus across Europe on healthy food and exercise; his BMI is reduced to 28 and he is slowly moving into a lower risk group. Once he reaches his weight goal, he can also look forward to a decrease in his tax payments, in an attempt to encourage healthy lifestyles.

[9] NHS: The UK National Health Service's National Programme for IT connects over 30,000 GPs in England to almost 300 hospitals.

8.2 Joining Hands

Proliferation of self-management schemes for long term diseases and as prevention tools for life style changes is widespread. Clinicians and developers work together to bring about smart devices and low power sensors in wireless, self configuring body networks which semantically interfaces to legacy health care systems. Systems are reliable and doctors increasingly rely on them to perform diagnosis.

Citizens are serious about their health, partly because of social pressure. Self management has become a major tool in matching the need for high quality health care. Politicians have realised the need for making long term investments in ICT infrastructure but many patients spend additional money for top class care.

The challenges for developers are to make applications sufficiently intelligent even with resource constrained devices and a high demand for extra-functional features.

Jean-Claude, a 31-year old male having recently being diagnosed with diabetes I (Insulin-Dependent Diabetes Mellitus - IDDM). Jean-Claude is employed as an account executive in a manufacturing company in Louvain, south of Bruxelles. His work is demanding and Jean-Claude usually works long hours and commutes frequently between the company's headquarters in Louvain and the manufacturing plant in Antwerp. A large part of his job is about meeting with key clients. He travels app. 80 days a year, mostly in Europe but occasionally to the Far East. He also entertains clients visiting the company in Louvain or Antwerp.

Jean-Claude gets a lot of satisfaction from his job but he is very strict on taking time off frequently, to recharge and find new inspiration. He tries twice a year to take two full weeks vacation and makes sure that nothing disturbs him. He and his girlfriend Sandra often go on a week-long canoeing trip in Sweden or they go hiking in the Alps. Jean-Claude wishes that his disease should interfere minimally on his private and professional life and it should not be limiting his ability to carry out his present work and not adversely affect his overall career plans and future job opportunities.

When Jean-Claude's diabetes is controlled, it will help prevent serious complications such as infections, kidney damage, eye damage, nerve damage to feet and heart disease. Controlling diabetes is thus very important and is normally supervised by a medical doctor. However, the Wallonia region's new self-management programme gives Jean-Claude the possibility to take much greater control of his own disease and yet still be under strict supervision by medical professionals using the automatic supervision facilities in the new mobile quality healthcare system (SMSQ - Système Mobilier de la Sante Qualité). After consulting with his family doctor, he decides to enrol in the self-management programme. At the first meeting with the regional diabetes centre, Jean-Claude is given a detailed explanation of his disease, its cause, its symptoms and how he can control it through monitoring, medication, exercise and a proper diet. The doctor then creates a personal self-management profile in the SMSQ system to allow it to interact with Jean-Claude's Electronic Patient Record (EPR) and to set up learning, monitoring and feedback schemes for him.

The doctor then creates a dedicated e-learning environment for Jean-Claude. The SMSQ system reads the diagnosis and pertinent data about Jean-Claude from the EPR. The SMSQ Content Compiler assembles a complete e-learning package for Jean-Claude including descriptive literature, multimedia presentations and interactive learning programme. The learning package also includes additional customised information from internet resources using semantic search capabilities. The learning package is available both for PC and PDA viewing thus allowing Jean-Claude to access the learning material at any time. Further, the doctor creates a specific clinical pathway for Jean-Claude in the EPR. It contains information about which in-vivo parameters should be monitored at regular intervals, their threshold values and measurable milestones to be reached at specific dates. For Jean-Claude, the doctor decides to monitor the following parameters: weight, blood glucose level, blood pressure, and urine ketones.

Jean-Claude now needs the instrumentation to perform the monitoring. First he gets an electronic scale so he can measure his weight twice weekly. He is also supplied with wearable miniature sensors for automatic monitoring of blood pressure and blood glucose 4 times a day. To supplement the SMBG, Jean-Claude is also instructed to test his urine for ketones with a testing pen when his blood sugar level is above 200 mg. Ketones in the urine is a warning sign of a low insulin level that requires quick action. The connection and pairing of medical devices is automatic and the result is send to the SMSQ system, which controls the total number of devices. Each device is uniquely linked to the patient by the combination of device ID and the gateway ID. All the sensors communicate securely via a wireless body network with an available gateway in range. It could be his mobile phone, car radio or just a service gateway that he passes on his way.

The diabetes centre then creates a role for Jean-Claude's family doctor as the supervisor of Jean-Claude's self-management program and simultaneously enables the electronic billing system that collects information about the supervisor's transactions, which in turn is used for automatically calculating his provider fee.

During a subsequent consultation with his own GP, the doctor logs in to the SMSQ website and accesses Jean-Claude's monitoring scheme. He asks for a default monitoring scheme for blood glucose level and adjusts the maximum thresholds to 150 mg before a meal and 200 mg after a meal. The minimum threshold is kept at 50 mg. He asks to be informed by email if measured levels are within 10% of the threshold and by voicemail if they are over the threshold. In addition, he sets up a feedback alarm scheme that instructs Jean-Claude with a beeper if he needs to do a urine ketones test. If Jean-Claude does not respond with a new measurement within 40 minutes, an emergency is declared. The doctor also sets up a scheme for reading Jean-Claude's weight every Monday and Thursday and his latest blood pressure every Tuesday and Saturday. Especially the weight is interesting to follow at the moment, because Jean-Claude needs to loose 8 kg over the coming 8 months. Finally, the doctor sets up a PDA based feedback dialog session to be used in case of abnormal measurements or measurements outside the pre-set limits.

When Jean-Claude returns to home, he first attends to the e-learning programme setup by the diabetes centre. He decides to download two training animations for blood pressure and glucose measurements (including tips and tricks) to his PDA, so he can carry it with him when he travels. He then performs some test measurement. The data are uploaded to the EPR system via the SMSQ system and Jean-Claude's doctor is notified to log-in to the EPR to check the data for consistency and calibration. When he has approved the data, all subsequent data are automatically transferred to the EPR. The SMSQ system monitors all data traffic and performs the alert services according to the monitoring schemes created by the doctor.

Measuring the various parameters on a daily and weekly basis quickly becomes routine for Jean-Claude. He is still subscribing to "pre-alert by SMS" scheme to let him know when and how he should perform the measurements, but he is considering moving over to a pure monitoring scheme, which only warns him in case the expected measurements are not being received by the SMSQ. Based on his normal weekly routine measurements, the SMSQ system monitors the progress according to the thresholds and limits set up by his family doctor. Data are stored in his EPR and the SMSQ constantly monitors for deviations from the clinical pathway. Any deviation exceeding the allowable bands will trigger the system to send a request for further explanation from Jean-Claude, either via SMSQ or via PC. At the same time, the SMSQ system assembles a revised learning package for Jean-Claude with emphasis in the consequences of changes in his disease control.

Tuesday morning at 11:30, the SMSQ sends an SMS to Jean-Claude that the last blood glucose measurement measured his glucose level to 215 mg. The message instructs him to test his ketones level as soon as possible. Jean-Claude is in an important client meeting that is running longer than planned and he cannot leave the room. At 11:45, a new he receives a new SMS warning him that he must perform his ketones test within 5 minutes. At 11:48 Jean-Claude leaves the meeting and quickly goes to the toilet. Using his pen ketones meter he measures the level and the data are instantaneously uploaded to the SMSQ system. Within 2 seconds he receives an SMS informing him that his ketones level was only slightly elevated and he is instructed to take a normal dose of insulin.

8.3 My way

Medical researchers and practitioners are using range of new and highly advanced markers for early detection of diseases to counter the increasing impact from lifestyle and unhealthy living. The rising number of private insurances encourages the healthcare professionals to invent unconventional smart sensor systems for remote diagnostics, monitoring and early warning if groups of high-risk patients.

But developer users have pursued their own objectives, which not always supports the progress in clinical methods. One problem is that communication networks specifically for health care applications has not materialised in Europe like in the US. Another challenge for developer users is the integration a large number of heterogeneous, multifunctional, ergonometric, and invisible devices imported from other applications and to turn them into a coherent medical application.

The mayor of the German city of Tübingen, south of Stuttgart, Hans Dietrech Grün was to give the opening speech at the 6th International Conference on the use of ICT in Medicine. He wanted to present the best possible case from his city to impress the international audience of international health professionals and decisions makers. He therefore summoned Ralf Knoblauch to give a presentation at the city hall about recent advances in the internationally renowned Tübingen Hospital Medical Network (THOMNET) project. Ralf was head of the University Hospital's ICT department and was as such responsible implementing all ICT systems in the hospital. Some systems were based on large mainframe computers crunching numbers in digital imagery, some were storing and retrieving massive amount of data in huge administrative databases, and some we simply small devices with embedded control systems such as screening flow meters for urology.

It never ceased to astonish Ralf, how relatively little synergy there had been over the years of, on the one hand, new applications resulting from advances in information technology and ICT systems, and on the other hand, rapidly advancing medical and clinical methodologies. Even though ICT had been employed in medicine and healthcare for many years with success, it was as if developers to some extend have neglected the real needs of patients and physicians and failed so far to fully respond to requirements, particularly related to integration. Although significant progress has been made with respect to the creation of new medical instruments, the same effort has not been devoted to the integration of these instruments in operational information systems with all devices working in a single framework of health-care resources. Not until the birth of the THOMNET project.

To his great satisfaction, Ralf had been appointed THOMNET project manager. The hospital management had convinced the state government that integration of systems, subsystems, apparatuses and devices were particularly critical for the effective and high quality operation of the hospital since different medical devices and hospital data bases using different protocols and data representations was unable to interact automatically, thus failing to deliver efficient healthcare. The financial committee had then approved the construction of a new intra-hospital network at a cost of €12.5 million. The aim was to create a new paradigm for integration and cooperation between data, devices and systems which should make it possible to access and integrate all available health care resources and offering a continuous, widespread, cooperative health care system.

Ralf and his group worked on the project in cooperation with external system integrators and software consultants. They organised the work in a four workpackages, each targeting a part of the very complex hospital system. One was looking at the integration of data from different medical apparatuses and devices, one looked at sensors capable of collecting environmental data about the patient or location of devices, one worked with query of patient data from the electronic patient records stored in the hospitals computer systems, while another created references to hospital administrative information, and management of financial data and health care resource planning.

In the original network plans, the medical network would be organized into layers with the patient at the centre. The inner layer, with sensors attached to the patient, would provide monitoring support and would be organized as a body area sensor network. They would constitute dynamically arriving and leaving mobile nodes in the THOMNET network. The next layer would include environmental sensor networks such as indoor climate controls, access control, etc. surrounding the patient.

A third layer would include powerful nodes consisting of therapeutic or diagnostic and medical instruments such as EMG machines (electromyograph) offering neurological diagnostic information or a PC receiving data and managing a monitoring and alert detection service. The devices enter as nodes in the THOMNET network providing results and customized data processing. The various data repositories, interactive computer models, etc. would also belong to this layer.

The layers would interact with the outermost layer to exchange physiological and medical data, alerts and patient-related data for case management or administrative purposes, audio and video communication processes for collaborative working or media distribution and secure and trusted external communication. Wireless connections will be used where possible to support mobility and adaptability at the various levels of the network. For security reasons, all communication uses strong encryption.

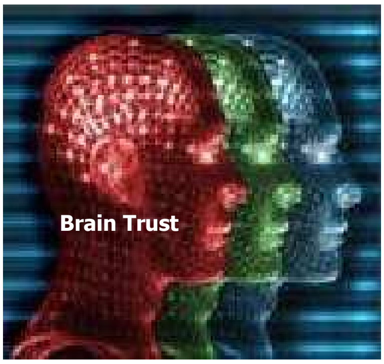
To meet the goals of the integration, Ralf is planning to develop a new network architecture and appropriate middleware for the various nodes. The network must support execution of commands from existing hospitals systems or from a wide variety of locally or externally connected actors such as health care professionals, administrators and patients and their relatives.

A special concern that Ralf is dealing with is that sensor devices produce large streams of data which must be collected and assessed. But sensors must also to be light and portable to reduce the impact on the patient's well-being and thus must be constrained in terms of power. Consequently, the amount of information transmitted outside the network should be minimized in order to prolong its lifetime. Ralf decided that the sensors should manage the data streams via a middleware layer, which provides support for the management of local and remote data streams and for stream buffering, and exploit the services of the outermost network layer for routing.

The University Hospital has acquired a system that allows storage and consultation of radiological files and shared them among departments using standard Quicktime applications. The radiology department wanted this system to be available to other departments on the THOMNET. The department imports all new digitized files, or other externally obtained images, in an image library. The programme allows juxtaposition of digitalised radiological files and can be combined with other computer-assisted teaching or computer-assisted presentation applications. Non-radiologists should also be able to perform multi-criteria search and visualisation of selected radiological files and view the results in a consultation mode over broad band wired and wireless connections.

The University Hospital's Urology Department has recently entered into a project with the URobotics Lab at Johns Hopkins in the USA. The project is about performing robotic telesurgical procedures on urological patients at the Tübingen University Hospital. The procedures include cases such as, renal biopsies, kidney repair, and nephrectomies for non-functioning kidneys. The procedures will be using a robotic endoscope positioner for the orientation of the laparoscope. It requires a PC to manage the robotic communication and remote control, as well as audio and video connection. The department asked Ralf to provide the necessary network connectivity on the THOMNET network so that network latency could be held below 1 second for this particular application.

Ralf's future work will focus on how to provide dependable and secure communication protocols to connect all nodes in THOMNET. The protocols should ensure confidentiality and protection against malicious attacks, ensure secure and safe integration of the network with the medical devices and with the administrative and patient data available in the hospital networks and be configurable to existing and new regulations on patient data protection and other relevant regulations.



8.4 Brain Trust

There is a slow, but steady progress of synergetic cooperation between technology developers and medical researchers and clinical practitioners. The majority of health care services are publicly financed, putting a great pressure on government spending. Most people are not making any real efforts to change unhealthy lifestyles and development of ICT infrastructures are mostly concerned with administrative efficiency and cost savings.

One area where real progress has been made is in terms of security and privacy for patient data. National legislation is in place across Europe to restrict access to health data and protect the right of the patient and all developer users must comply with these rules.

Patients have full ownership of their own health data and thus full control of access rights, which in some cases restrict the efficiency of e.g. emergency care, or shared care.

Ella Jensen is Danish, 64 years old and suffers from osteoarthritis in both her knees. She used to work as a cleaning lady, a physically demanding job, but had to retire when she was 58 because of health problems. She has had problems with her knees for many years but she has never sought any medical advice. She didn't like going to her family doctor to simply complain about the pain; it was just a pain and she didn't think it was a disease so why bother the already very busy doctor. Her husband, Jens, was getting more and more concerned about her. The last 4 months, the pain has increased and Ella has started to take the maximum recommended dose of Paracetamol every day to relieve the pain. Yet, this isn't enough and she is often lying awake at night unable to sleep because of the pain in her knees. She is finding it increasingly difficult to climb the stairs in their house and they have therefore moved the bedroom downstairs. Her condition is also affecting her physiologically and she often feels very depressed. After having listened to her complaints for more than a year, her husband, Jens, made an appointment with her family doctor.

When Ella and Jens arrived at the clinic, the nurse asks Ella to fill out an online form allowing Dr. Nielsen and selected health care providers to access her central health data. Also Jens is included in this list. Due to recent EU legislation, health records are now defined as private property of patients. Patients therefore have to grant healthcare professionals formal permission to access their health data on a case by case basis. Moreover, patients can choose to restrict access to include only relevant information on a case by case situation. This has caused some problems limiting proper and efficient care to patients because access to important information wasn't granted simply because the patient didn't think it was relevant. Work is therefore currently done on securing an automatic filtering of healthcare data to ensure that healthcare professionals can access all relevant data. However, it is a costly affair to develop and implementing such a system into the public healthcare system and administrators are reluctant to invest despite the obvious benefits.

At the clinic, her family doctor, Dr. Nielsen, immediately suspects that Ella has osteoarthritis based Ella's history of pain in the knees and her overall physical condition. Ella is mildly overweight which could explain the rapid deterioration of her condition. When enquiring about her medical history, Dr. Nielsen also learns that she has had a knee operation as a young girl due to a skiing accident. When Dr. Nielsen does a full examination of her joints, he can clearly feel the bony swelling and creaking of the joint, which is typical of osteoarthritis. The movements of the knees are also clearly restricted and the exam shows tenderness over the joint and excess fluid and instability in the joints. There is no doubt that Ella is indeed suffering from osteoarthritis.

Before leaving the doctor's office, Ella asks Dr. Nielsen for some stronger painkillers than Paracetamol. He offers her a week's prescription for Cocodamol. The prescription is electronically sent to Ella's pharmacy. Cocodamol contains Paracetamol and a second codeine-like drug. They may therefore be stronger than Paracetamol but are more likely to cause side-effects, such as constipation or dizziness, which he explains to her. She is instructed to follow exactly the dose prescribed for her.

On their way home, Ella and Jens stop at their local pharmacy to pick up the medicine. Recently, several news articles have appeared about the resurrection of counterfeit Cocodamol in Denmark. This was a real big problem 10 years ago, where up to 20 per cent of all finished drug products closely resembled legitimate drugs but contained only inactive ingredients, incorrect ingredients, improper dosages, sub-potent or super-potent ingredients, or be contaminated. The widespread use of RFID tags to authenticate drugs have almost eliminated this problem in Europe and drug counterfeiting poses no real public health and safety concerns today. However, in some countries more than half of the drug supply may consist of counterfeit drugs. The most pressing issue today is that the RFID tags were also used to register the medicine used by patients.

Ella's husband makes sure that the pharmacy checks the RFID tag on the package and provides him with proof that this drug is authentic and comes directly from the manufacturer. The RFID reader is connected to the pharmacy's WiFi network and Jens can see the entire history of the particular drug on his PDA: Where it was manufactured, when it was shipped and when it arrived in the pharmacy. He stores the information as a document on his PDA.

The pharmacy does not register which drugs have been delivered to which patients. Only the prescription is registered, so no one knows for sure if the patients indeed have collected the drugs and are taking them.

After many years of discussion, the Danish government recently voted to principally approve the creation of a central register for medicine use, not just prescriptions. The main supporters of the central register claim that it will give pharmacies a better overview of what other drugs the patient have been prescribed. It will also give the social workers insight into the patient's total drug use or abuse. The opponents calls it over-registration and wants to abolish the central register and store this information in a distributed system, where the patient has full control over when, how and to whom the information is released. Pharmaceutical companies, device manufacturers and patient associations now have 3 months to propose a system where the anonymity and privacy of the patients is preserved.

Cocodamol are delivered in blister packages that carry a tiny RFID transmitter. Since it is so important adhere to the prescribed dose for this drug, the manufacturer must keep track of when the patients actually take the medicine. Ella places the blister package in an electronic device that register every time she takes out a pill of the package. The data are collected in the electronic device, and every time she passes the RFID reader in her mobile phone, the data are uploaded to her EPR. With intelligent filtering mechanisms provides continues monitoring of her compliance. If for some reason she does not adhere to the prescribed dose, or if the data are missing, Dr. Nielsen is informed.

Ella is not very happy with this monitoring. She feels that the technology has taken control over her life and she cannot understand why she cannot be trusted to take the pills as she always does. However, Jens is quite satisfied. Very often, he has experienced that Ella has forgotten to take her pills. Some times she forgets about it, because she is watching TV. Sometimes she takes them twice, because she has forgotten that she already had taken them. He is really worried about her compliance with this strong drug, so he subscribes to the same information that Dr. Nielsen is having, just to make sure.

The fact that he is authorised to do this is controlled by the electronic consent form that Ella filled in when she saw Dr. Nielsen the first time.

9. The Agriculture domain

9.1 Background of the Agriculture domain

The advent of the PC in the late '70s led to a proliferation of systems with promises of simplified accounting, paperless offices, automated process control and even systems that could think. Much of this promise has not been delivered. Developments in the UK for example typify these ICT expectations - where in 1984 there were sixty three companies claiming to provide specialist agricultural software to farmers and growers. Even IBM decided to move into the apparently huge market of 100,000 British farmers. Most of those companies soon realised that there were no fast bucks to be made and numbers fell back quite quickly to four or five specialist operators. However, the UK was different than the rest of Europe in that much of our development was through commercial software houses whereas most other countries relied more heavily on the education and research sector to provide software and systems. Farmers in mainland Europe seem thus to be more willing to try new systems and embrace new technologies like decision support tools[10].

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

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

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

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

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

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

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

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

9.1.1 European Union policies on safe food

The concern of the European Union is to make sure that the food we eat is of the same high standard for all its citizens, whether the food is home-grown or comes from another country, inside or outside the EU[11].

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

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

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

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

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

9.1.2 Farm Management Information Systems

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

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

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

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

information in electronic format can accelerate the process of farmer involvement in terms of building relationships to benefit both the farmer and the outside actors[12].

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

9.1.3 Traceability

Traceability along the food supply chain is basically the combination of two processes: intra-enterprise traceability and inter-enterprise traceability[13]. If enterprises working in the same sector adopt different ways to describe the input, the production processes, and the output, it will not be possible to communicate information either to providers or to consumers.

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

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

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

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

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

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

9.1.4 Dairy farming

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

9.1.5 Precision Farming and Mapping

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

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

A study shows[14] that the practitioners of Precision Agriculture tend to belong to a younger generation and they cultivate larger areas than the average farmer. The average age of the Danish respondents was 43 years old and 46 for the American respondents (Fountas, et al, 2004). In Denmark, the average age of farmers in 2000 was 52 years old (Danish Agricultural Council, 2000) and in the USA in 2002 was 55.3 (USDA, 2002). Another particular aspect is that farmers are very reluctant in entrusting the data storage and data protection to entities outside the farm. 81 % of the Danish and 78% of the US Corn Belt farmers indicated that they would prefer to store the data themselves, while 88% of the American respondents would prefer not to store the data in a shared Internet-based database (Fountas et al., 2004).

9.2 Organization of workshops

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

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

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

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

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

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

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

Participants from pesticide manufacturers and cooperatives were not available.

9.3 Selection of application area and time horizon

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

9.4 Trigger question

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

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

9.5 Identification of environmental factors

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

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

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

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

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

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

Economic futures (€)
Sustainability
Increased buying power

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

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

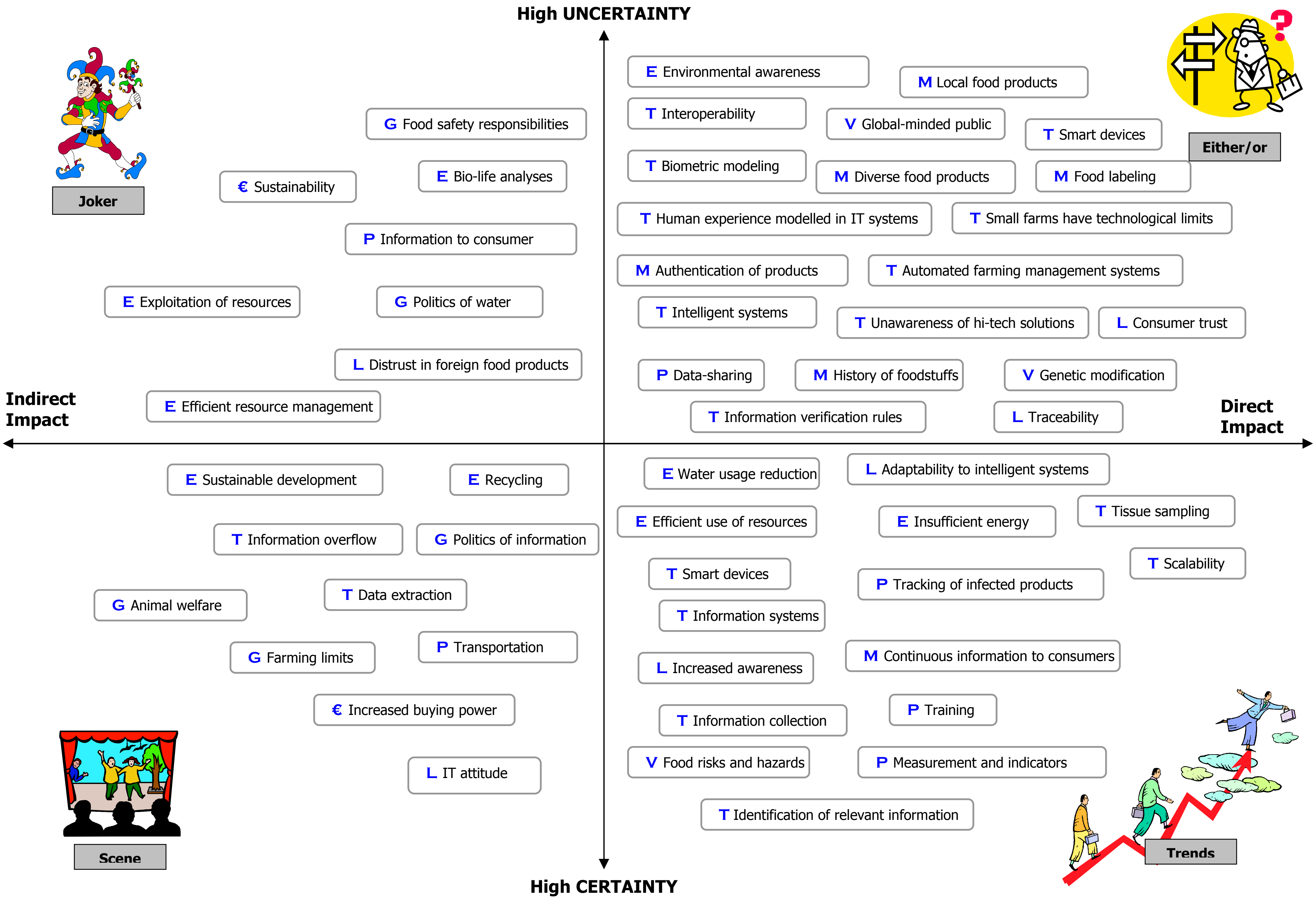
Products, production and logistic systems (P)
Information to consumer
Data-sharing
Training
Tracking of infected products
Measurements and indicators
Transportation

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

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

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

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



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

9.6 Flip-flopping the pivotal uncertainties

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

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

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

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

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

9.7 Clustering the uncertainties

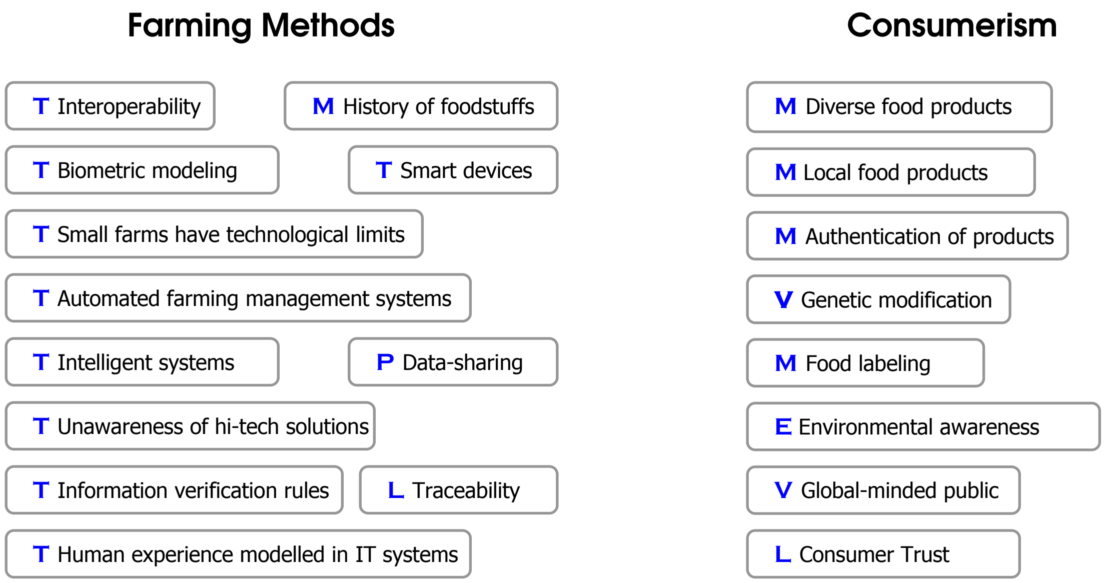
We will now group the pivotal uncertainties in two groups by searching for connections and associations between the various uncertainties.

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

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

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

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



9.8 Naming the sub plots

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

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

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

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

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

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

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

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

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

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

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

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

9.9.1 Developing the scene

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

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

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

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

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

9.9.2 Building the sets

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

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

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

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

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

9.9.3 Defining the script

What is happening?

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

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

How is it happening?

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

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

Why is it happening?

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

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

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

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

Writing the scenarios

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

9.10 Writing up the scenarios

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

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

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

1. The Piggy Bank

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

2. From Farm to Fork

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

3. Ye Ole Barn!

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

4. There is no hurry!

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

10. Agriculture scenarios

The Piggy Bank

10.1 The Piggy Bank

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

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

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

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

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

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

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

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

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

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

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

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

10.2 From Farm to Fork

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

10.3 Ye Ole Barn

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

10.4 There is no hurry!

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

Only safety and low prices are of some importance.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

11. Scenario interpretation – planning the requirements

In this chapter we summaries the future developments that are foreseen by the experts and the impact it will have on development of networked embedded systems in 2015. Since many of the future scenarios are involving end-user activities and application functionalities, we will try to bridge the gap to the formulation of technical user requirements, which will be reported in D2.5 Initial requirements report and which forms the basis for the Architecture Design Specification in WP3. In other words, we will try to dress the scenarios with additional comments on aspects of functionality and implementation as seen from a developer user's point of view.

The objective is not to derive requirements but to facilitate the understanding of which thoughts and ideas went into the future scenarios during the three days of intense discussions among experts.

11.1 Building Automation clusters

Building Automation experts agreed that the use of ICT in Building Automation, Smart Homes, Facility Management, Industrial Services, etc. was already today well integrated in numerous applications and had provided substantial improvements in efficiency and new business opportunities. An entire industry of system integrators, system developers and application service providers has emerged over the years and grown into a multi million euro business. This development clearly shows that ICT technology does provide value to customers and that sustainable business models can be developed, although there are presently problems with the consumer acceptance because of high prices. On the other hand, the market for smart facility management solutions in the building sector is rising.

The experts also found that the future was likely to see further roll-out of increasingly intelligent solutions in Building Automation. The use of the internet to provide connectivity, whether for control, monitoring or simple telemetry, will surely increase strongly, while at the same time, the technology would continue to put downward pressure on prices making the technology increasingly affordable for private consumers.

There was an agreement that advanced ICT technology will continue to support the world of embedded devices with more and more functionality. There is, however, a need to increase system development productivity without compromising overall characteristics. The systems should also be versatility in terms of performance, power and coping with the requirements of entire classes of applications and markets, ranging from low-end smart home electronics to high-end Facility Management or Plant Management systems. Systems must also be reliable and available, which requires having several modes of interconnection, dynamic memory hierarchies, distributed security, low-resource operating systems and semantic, dynamic run-time tools for context awareness and proactive ambient intelligence.

Key issues of future networked systems encompass heterogeneity, extra-functional properties such as performance, robustness, safety, security, timing and resources, and ability to cope with uncertainty and incomplete and unstructured information.

The experts were not certain, or disagreed, on the future outlook for a range of other topics. Broadly, the topics of uncertainty can be grouped in two clusters. The first cluster refers to issues relating to interconnectivity of heterogeneous devices and systems; the other cluster to how different user perspectives influence the future development of networked systems.

In the first cluster of factors, uncertain prevails as to how myriads of commercial and proprietary systems will interconnect and be able to cooperate and work together to achieve a common task? Which mechanisms of interfacing will provide the interconnectivity and also hide the complexity of the underlying network? What kind of network architecture will prevail to support interconnectivity? Who will be responsible for developing the applications? And what will be the business model that attracts developers and users to engage in these activities?

Two divergent instances of this cluster were termed: "Interconnectivity" and "Interoperability". Interconnectivity" is understood as networks of devices and systems operating in a hierarchical architecture with a central node or command post. All subsystems are connected and communication between systems is channelled through the central node. Sensors, devices and components in subsystems will only be reachable through said subsystem's pre-arranged interfaces and system functionality is either provided in the subsystem itself or in a dedicated application on the control node (functionality involving several subsystems).

The other instance of this cluster is "Interoperability", by which is understood full access for all applications to all sensors, devices and components across subsystems, regardless of the host platform. Whenever a subsystem or application would require an external sensor or device, it would simply search the network for the appropriate resource, connect to it and use it for its own purpose. Building automation infrastructures would thus be truly pervasive, ubiquitous and highly dynamic. They can offer almost unlimited functionality to end-users, and support a wide variety of stationary and nomadic devices and services, in a variety of formats and a multiplicity of delivery modes.

The other cluster of factors influencing the future is related to the user and how different user perspectives influence the future development of networked systems. The cluster is called "Universal Focus".

In one extreme instance of the cluster, the development is very end-user centric. End-users want to have a considerable freedom to configure the systems to their own needs, which points in the direction of scenarios with very strong end-user participation. The end-user centric framework require highly integrated systems with extremely simple user terminals and interfaces, designed according to ergonomic principles, and a high degree of system reliability. The domestic environment must be trusted and secure.

The opposite situation is dominated by developer-user orientation and the view of manufactures of systems, components, devices and services. The system view often takes over from the end-user view. Systems have to have capabilities to interact with other systems and with users. A special challenge is that additional functionalities will lead to higher manufacturing cost, which today cannot be compensated by higher prices on the market.

A table of main architectural and technological challenges derived from the Building Automation scenarios is shown in section 11.4.

11.2 Healthcare clusters

Healthcare experts agreed that life style diseases are *the* most eminent challenges facing European welfare in the near future. It was also agreed, that the tremendous advances obtained in health informatics, from telemedicine over administrative systems such as Electronic Patient Records and technology assisted learning to interactive professional knowledge sharing systems, have created a history of highly advanced and highly successful ICT applications, which can be used as a guideline for ICT system innovation and development to alleviate the socio-economic impact of lifestyle diseases.

The experts agreed that the Europeans, by a large majority, will continue to favour national health care systems financed by public tax revenues, but that more and more patients will seek private treatment so that the traditional national health monopoly will increasingly be under attack. Patients will be much more involved in their own health not the least due to increased access to on-line information on health and lifestyle diseases, participation in virtual communities and availability of smart devices which is a significant tool for helping and motivating people to live healthier and manage their chronic conditions.

The experts agreed that self-management, personalised monitoring and intelligent feed back are some of the most promising potential uses of ICT in healthcare. These solutions will require new, innovative systems and services based on wearable or mobile devices, which empower patients to participate in self-management case programs and facilitate remote monitoring and care in nomadic persons or at home. Emphasis will be on non-invasive or minimally-invasive, multi-parametric monitoring, integrated with legacy health systems and combined with expert feedback in a user environment that motivates citizens to take greater interest in their own health status. Great attention must be given to the diverse need for data protection and privacy legislation in the different countries in Europe. Personal health data are extremely sensitive and privacy is a concern of citizens that must be taken seriously, including issues of privacy, secure access, non-repudiation and rights of ownership of health data.

The experts were not certain, or disagreed, on the future outlook for a range of other topics. Again, the topics of uncertainty can be grouped in two clusters. The two clusters refer to factors relating to whether technology research and clinical research provide the thrust to health care innovation in a concerted, synergistic action or independently of each other.

The first cluster is called "Technology Drive". The experts argued that technology had been seen to be a driver for innovations in preventive medical treatments and in many aspects of clinical processes. On the other hand, clinical demands and patient concerns have been the driver for many ICT innovations, e.g. in security and traceability.

The two divergent instances of this cluster were termed "Technology Convergence" and "Technology Divergence". The first case points to synergistic co-existence of technology and clinical innovation. Development and implementation of new ICT technologies in healthcare have enabled better preventative health measures to be put in place and healthcare services have generally been improved due to technological innovations. On the other hand, ICT innovations have been spurred by new clinical practice and medical discoveries (the virtuous circle).

This future trend requires a new generation of personal, wearable, minimally-invasive medical sensors, wireless body networks with multiple sensors acting together to provide a full picture of the persons health condition as well as new capabilities of modelling of markers for early disease prediction. Interconnectivity and secure and trusted communication infrastructure is essential to support the clinical innovations.

The other instance of this cluster is "Technology Divergence" in which the two research and development areas are progressing in different or same direction, but without real integration and without a common goal. ICT developments and implementations in healthcare are out of synchronisation and take-up of new ICT technologies in medical practice is slow, so the full potential of ICT in healthcare cannot be realised. Developers of networked systems pursue other applications and tailor innovations to serve needs in other domains. When new ICT technology eventually finds it way to healthcare, it needs modifications and becomes costly. An example of this is BlueTooth communication, which was developed to suite the need of office workers connecting peripherals to their PC, but is now becoming a building block in many healthcare operations. However, BlueTooth communication is in many aspects, i.e. power consumption and security, not the most suitable technology for body networks of medical sensors.

The other cluster of factors influencing the future in healthcare is related to clinical innovation and how regulatory activities, public opinion and citizens preferences influence the future of healthcare systems. The cluster is called "Clinical Innovation".

The two instances of "Clinical Innovation" are "Clinical Revolution" and "Clinical Evolution". In the first instance, high public investments and successful use of ICT technologies have resulted in high innovation in disease prevention and treatment and resulted in improved productivity of healthcare systems. Developers of medical systems work closely with medical experts and develop innovative solutions based on their needs. Examples are non-invasive or minimally-invasive sensors for various vital signs such as blood pressure, blood glucose levels and a whole range of other disruptive products and solutions, which cause radical improvements in health care services.

The other instance is called "Clinical Evolution". It represents a future where medical and clinical practise still is much more evolutionary than revolutionary. New clinical methods and processes are mostly developed in response to eminent demographic or financial threats rather than proactively in anticipation of future needs. In this future, the requirements for completely new ICT solutions will be limited and developers will need to think in terms of incremental improvements rather than large shifts.

A table of main architectural and technological challenges derived from the Healthcare scenarios is shown in section 11.4.

11.3 Agriculture clusters

Healthcare experts agreed that ICT technologies for agriculture is still in its infancy (compared to e.g. building automation) but that it is rapidly becoming more and more important and more and more innovative.

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. A most imminent problem is to have systems reflect 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. On the other hand, farmers are inclined to ask for proof of real cost benefit, before they invest in new ICT solutions.

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.

The experts were not certain, or disagreed, on the future outlook for a range of other 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".

One instance of the "Consumerism" cluster describes a situation where innovative ICT developments enable producers to produce high quality products that meet the high demands of the market. Producers see clear advantages of using ICT to improve cooperation with other producers, as well as a mean to optimise the quality of their products. This 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.

A table of main architectural and technological challenges derived from the Agriculture scenarios is shown at the end of this chapter.

11.4 Summary of architectural and technological challenges

Each scenario represents a unique set of technical, security and socio-economic requirements. To cover the broadest possible spectrum with the Hydra architecture, all requirements should be reflected in the requirements specification.

The following table displays the main topical requirements that can be derived from the twelve scenarios.

Doman	Building Automation				Healthcare				Agriculture			
Scenario number	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Resource constrained devices	√		√					√		√		
RFID tags								√	√	√	√	√
Real time operation	√		√			√						
Heterogeneous networks	√				√				√			
Interoperability		√	√							√		
Self configuration			√	√	√						√	
Interface standards	√	√							√			
Data persistence	√											
Multimodal interfaces			√	√								
External SoA			√	√	√	√		√				√
Cognition			√		√			√				
Semantics			√				√					
Learning		√										
External modelling services	√					√			√		√	
Location awareness		√		√						√	√	
Multilinguality					√							
System intelligence		√	√			√						
Embedded Intelligence	√	√				√			√			
Remote monitoring	√	√			√			√	√		√	
Data logging		√				√				√		
Broadband networks							√					
Ad hoc network architecture												
Sensor networks	√								√		√	
Fault tolerant networks	√											
Automatic service discovery	√				√							
Interconnectivity			√		√		√		√			
Credentials	√	√								√		
Authorisation	√					√						
Authentication		√										
Distributed security model		√						√				
Distributed trust model		√	√							√		
Third party authentication		√							√			
Secure transmission							√	√				
Biometric devices				√								
SDK	√								√	√		
Business innovation and models	√											√

12. Appendix A: Environmental factors in Building Automation

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

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

Topic, statement or question	Explanation and comments	Environmental factor
High uncertain – indirect impact		
Security responsibility defined and assigned	The responsibility for system security is clearly defined and assigned to specific actors.	Clearly defined security responsibilities
Complexity requires structured access to information	The complexity of networked system requires a logical/structured access to the devices and information sources in the network.	Structured access required
Application programming	Will end-users be required or allowed to perform programming of applications?	End-user programming
Changing in thinking about systems	A systemic approach will prevail for concepts of systems, including logical and ad-hoc connected components.	Systemic concepts
Just one interface	All devices share one common interface.	One common interface
Customers will produce power themselves (solar)	The systems will be extendable with energy producing devices like solar panels.	Energy costs neutrality
Can information overflow be avoided?	Methods exists to avoid information overflow	Information overflow avoided
High uncertain – direct impact – technology push		
Costs of making devices compatible	The additional costs for producers in order to make their devices interoperable are low.	Interoperability costs
Warranty period decrease	The warranty period for products and services will decrease in the future	Warranty period
Warranty issues are purely political	The warranty coverage for interconnected products is a regulatory issue and as such not related to the product or service in question.	Warranty coverage
Human body as connectivity device	New technologies introduced for interconnecting devices	New connectivity methods
PDA's available to most/all	All end-users will have and be able to use PDA's	PDAs available to all
Which standards and programming language	Which standards will be introduced and dominating? Which programming languages will be introduced and dominating?	Technical standards Programming languages
Certification of drivers and applications	Device drivers, interfaces and applications will need a third party certification to be acceptable for interoperable systems.	Certification
Third party authorization	Authorization will be handled by third party authorization bodies	Third party authorization
Proper functioning in operating environment	Systems will function properly in their operating environments	Proper functioning
Customer pays to use devices-does not own it	The manufacturers will introduce new business models	Business models
Security system –centralized or decentralized	The security model generally be centralised across the network.	Centralized security
Will there be a killer application?	The manufacturers will introduce new products and services which have sound value propositions.	Business value creation
End-user accepts responsibility for correct use	There is a common understanding that the end-user is responsible for using the devices/products correctly according the defined guidelines and instructions	End-user acting responsibly
High uncertain – direct impact – market pull		
Can we agree with manufacturers on trust models?	The manufacturers will be able to impose trusts models based on e.g. their reputation and market visibility.	Trust models
More energy is needed to run smart homes	Smart homes will provide more efficient use of energy resources compared to traditional homes.	Energy efficiency
Efforts to save energy are widespread	End-users will focus on systems to save energy	Energy savings
Biometric devices needs freedom	End-users want to have freedom to select the most suited	Choice of biometrics

of choice	biometric device	
Users attitude to configure own system	End-users want to be able to configure their system	End-user configurability
Customer trust in application manufacturer	Manufacturers' reputation will dominate the end-users' trust model.	Reputation of manufacturers
Self learning must be build into system	The systems will have provisions for self-learning	Self-learning capabilities
Houses, hotels used as personalised computer platforms	Houses, hotel rooms etc. are able to adjust to each individual's computing and ambience preferences automatically.	Transferable personalised settings
Consumers wants full transparency	The end-users want to have full insight into the functionality provided by the system	Transparency
Do we need user interfaces?	System intelligence will assume responsibility for large parts of the system's actions.	Intelligence used proactively
Added value must be clear if smart homes is to appeal to customers	The value propositions in smart home systems are generally clear and accepted by the end-user.	Accepted value propositions
Customer confidence	End-users are confident that products work properly	End-user confidence
You can talk to systems	The systems will be based on speech recognition and natural language interfaces	Speech control
Systems can be moved to new home	The system follows the end-user when moving to new premises or homes	Transferability of systems
Laws to protect customers	There are strong laws and regulations to protect consumer interests	Consumer protections
Laws to prevent misuse of data	There are strong laws and regulations to protect private data	Data protection
Procedures for approving updates must be in place	Automatic updating requires approval from end-users and procedures for this are build into the system	Automatic updates
High certainty – direct impact		
Government force public to use ICT	Increasing number of public services will only be available in electronic form	eInclusion
Wearable computers	Wearable computers will be widely available	Wearable computers
Need of flexibility	All systems must be flexible, adaptable, configurable, scalable and modifiable	Flexibility
System reliability	System reliability is crucial	System reliability
Additional functionalities mean additional costs	Additional functionalities in appliances and device will lead to higher cost to purchase and use.	Increased costs for new functions
Trouble-free interaction between many different devices	It will be possible for many different devices to interact and communicate	Device interaction
Need to network (manage) hundreds of devices	The complexity of networks increase rapidly with increasing number of devices.	Network complexity
Need interoperability and standards	Increased demand for networked devices. Increased demand for interoperability standards.	Device networking required Interoperability standards
Simple touch pads	Devices and appliances will be equipped with simple touch pads	Simple touch pads
Easy to use systems	The systems must be easy and simple to use for the end-user	Simplicity
Malfunctions can be predicted	Preventative measures are in place which can predict and thus prevent malfunctions of devices	Predictability
Automatic upgrading	Devices will be upgraded automatically	Automatic upgrades
Manufacturer has remote access to product	Manufacturers will have remote access to any product anywhere, e.g. for maintenance service purposes	Remote access for manufacturers
Multimodal interfaces necessary	User interaction will increasingly take place using multimodal interfaces.	Multimodal interfaces
Devices able to handle abuse	Devices will have preventative measures installed so to prevent misuse by end-user	Prevention of misuse
Customer wants energy-saving products	End-users are demanding products that use less energy	Energy savings
Affordable devices	Devices will be affordable to all	Affordable devices
Graphical displays, especially for older people	Socially and physically disadvantaged end-users will require graphical displays on devices.	Graphical interfaces for the disadvantaged
Interacting systems	Systems will increasingly have capabilities to interact	Interacting systems
Ergonomic	Devices and interfaces must be designed according to ergonomic principles.	Ergonomics
Domestic environment provides a trusted a environment	The domestic environment is trusted and secure for the use of devices and applications.	Trusted domestic environments
Access rules established	Access rules to devices and applications will be commonly understood and accepted among end-users.	Agreed access rules
High certainty – indirect impact		
Access control/	The manufacturers will be able to impose access control models	Imposed access control

authentication	and authentication schemes on end-users.	
Access control system is open to manufacturers	Manufacturers have open access to their systems on end-users' premises	Open access for manufacturers
Smart home accessible for everyone	Smart home technologies are widespread and affordable to everyone	Smart home affordability
Firewalls in systems	All systems have built-in firewalls	Firewalls
Easy for consumers to configure and manage security	Consumers are able to configure and manage security issues themselves	Security configurability
Devices can live off ambient light in the room	Smart home devices will use new types of renewable energy sources thereby decreasing the need for traditional energy.	Renewable energy sources
High value appliances in homes to attract renters	Smart home appliances have high value propositions and therefore make the homes more attractive to tenants.	Attractiveness of homes
Governments will have a back-door access to data	There will be special legislation to allow the government to access personal data information.	Government access to personal data
Maintenance services contact the customer when needed	Preventative maintenance will be used to increase customer loyalty and create new services.	Preventative maintenance
Mobile phones are available to all	All end-users will have and be able to use mobile phones.	Mobile phones available to all
Using mobile phones and PDAs is not suitable for all of population	The use of mobile phones and PDAs is not suitable for all end-users or all needs.	Suitability of terminals
Constraints in keypads	Traditional user interfaces like keypads are too limited for serious interaction	Interface constraints
Products and services are bundled together	Manufacturers will offer both products and services in bundles	Bundling of services
People live only a short time in each home	People move house frequently	High moving rate

13. Appendix B: Environmental factors in Healthcare

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

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

Topic, statement or question	Explanation and comments	Environmental factor
High uncertain – indirect impact		
Health check-ups will be mandatory	People will be called in for a mandatory health check-up at their GP or local clinic.	Health check-ups
Economic incentives related to health	Economic incentives related to health will be put in place, for example tax level will be determined by BMI.	Economic incentives
The individual will focus more on healthy lifestyle irrespective of social background	Social background will not be a factor influencing how much individuals focus on and prioritise healthy lifestyle.	Healthy lifestyle
Political decisions regarding healthcare are rational	Political decisions regarding healthcare are based on sound, logical and rational reasons i.e. prioritising good health per se.	Politics of health
Increased polarisation puts pressure on unhealthy persons to change their lifestyle	Increased polarisation within our society puts social pressure on unhealthy persons to change their lifestyle.	Social pressure to be healthy
Offers of treatment will only depend on the patient's own engagement and input	Patients own efforts and engagement in their treatment, i.e. live healthy and follow all prescriptions, will be a deciding factor for what kind of treatment they will be offered.	Conditional treatment offers
Danger of radiation limits the implementation of ICT in healthcare	The dangers and risks of radiation from wireless devices put a limit on the willingness to implement ICT in healthcare.	Radiation risks
Political willingness to structural reforms	There will be a more political willingness to do structural reforms in order to make healthcare more effective and efficient.	Structural reforms
Quality of life is not a economical issue	Quality of life issues are not prioritised as a simply economical issue but concerns also increasingly health.	Quality of life
Support become big business	Providing secondary support for ICT in health systems is a major business/industry.	Secondary support industry
Reimbursements across borders	It will be possible to get reimbursements for private healthcare expenditure across national borders.	Reimbursement across borders
Increase in number of private health insurance	More and more people pay for private healthcare insurance.	Private healthcare insurance
High uncertain – direct impact		
The functionality of devices is the responsibility of the healthcare provider	It is the healthcare provider, and not the supplier, who uses a specific device who is responsible for ensuring that it works.	Responsibility for devices
Public investments do not expect return instantly	Public investments in health are not dictated by expectations of an immediate return but accept that it may take at least 4 years before a return of investment is seen.	Long-term public investments
Non-battery solutions will be widespread	Technological solutions that don't run on batteries will be widely available.	Non-battery solutions
High performance level of devices is independent from energy consumption	Devices' performance will not be dependent on how much, or how little, energy they need to function.	Energy constraints
Remote diagnostics is widely available	Remote diagnostics is widely available and used.	Remote diagnosis
Sensors in the body will be used as a preventative method	Placing sensors in bodies will be used as a way to predict and prevent development of diseases.	Body sensors
Wide-area communication is expensive	Wide-area (WAN) telecommunication is expensive and affects the overall costs and thus the use of remote healthcare monitoring.	Cost of WAN
Medical companies will have free access to personal health data	Medical companies will be granted free access to personal health data.	Access to data

Topic, statement or question	**Explanation and comments**	**Environmental factor**
ICT solutions will not replace "traditional" treatment	ICT solutions and methods of treatment, for example remote operation, will not replace "traditional" treatment and clinical methods.	Traditional methods prevail
Guarantee for transfer of data in real time	The transferring of healthcare data in real time or within set time limits will be guaranteed.	Real time performance
Robot-surgery is widespread	The use of robot-surgery is widespread.	Robot surgery
Wireless solutions will only be used in non-critical situations	Wireless ICT solutions will only be used in connection with non-critical healthcare matters.	Wireless solutions
There will always be sufficient bandwidth available	There will always be sufficient bandwidth available for data transfers.	Bandwidth
Access to personal data determined by acute physical factors	The context of a situation determines how access is granted to personal health data, for example, in case of emergency (heart attack) full access will be give.	Emergency access rights
Systems will be able to sort data-access	There is a system in place which automatically sort data access according to individual healthcare professional's access rights.	Individual access rights
Traceability	It will be possible to trace people's health state.	Traceability
The elderly wants to buy "safety" privately	The elderly will want to buy solutions that make them feel safe, such as health monitoring services and devices.	Paying for "safety"
Lifestyle and support devices in one	Lifestyle devices and support/health devices are merged in one.	2-in-1 devices
The security model is individualised and contextualised	The security model is adjusted to each individual and context.	Security models
People are willing to change their lifestyle because of health	People are willing to change their lifestyle to achieve better health.	Lifestyle change
More services will be partly publicly and partly privately financed	More healthcare services will be partly publicly and partly privately financed rather than either/or.	Public/private financing
The technology can predict situations/events, e.g. patients falling down and heart attacks	The technology can predict situations, e.g. heart attacks.	Predictive technology
Smart devices motivate patients	Smart devices motivate patients to live healthy, e.g. exercise.	Smart devices motivate
Automatic semantic translation of journals and data	There will be an automatic semantic translation of patient journals and data in place.	Automatic semantic translation
High certainty – direct impact		
Self-monitoring promotes motivation and prevention	Self-monitoring promotes motivation and prevention among patients.	Self-monitoring
Support device must not signal illness	Healthcare support devices must be made "invisible" so they don't signal illness too directly.	Invisible health support devices
Several functions in one device	Devices will have several different functions related to healthcare but also entertainment functions.	Multifunction devices
Limited access to patient data	National legislation will determine access limits to patient data	Data access regulations
Attitude barriers to ICT in healthcare have been broken down	There are no longer any attitude barriers among healthcare professionals and patients affecting the implementation of ICT in healthcare.	Attitudes to ICT
Near Field Communication	Near Field Communication (body networks with e.g. mobile phones) is widespread as communication platform with body sensors.	Body networks
Doctors will not give up personal contact with patients	Doctors will want to continue to have personal contact with their patients.	Face-2-face consultations
Automatic processes will improve self-management, e.g. automatic medicine control	Automatic processes enabled by ICT will improve self-management, e.g. automatic medicine control.	Automatic processes
Patient wants to own health data	Patients will have ownership of their health data.	Ownership of data
Empowered citizens make high demands	The empowered citizens and patients will make high demand on efficient and effective health care.	Empowered patients
Technological waste is an increasing problem	Technological waste is an increasing problem.	Technological waste
Design of devices improves	The design of healthcare & support devices is improved and made more fashionable and up-to-date.	Device design
Effective battery-driven solutions are too expensive	Effective battery-driven solutions are too expensive.	Battery-driven solutions
Healthcare costs increase	Healthcare costs will increase with the increasing number of ill persons and there will be no loft in place to control costs.	Limited healthcare costs
High certainty – indirect impact		

Topic, statement or question	Explanation and comments	Environmental factor
Monitoring is only acceptable for certain patient groups, e.g. heart patients	Monitoring is only acceptable for certain patient groups, e.g. heart patients.	Monitoring limits
Remote treatment cannot be used by all patient groups	Remote treatment cannot be used by all patient groups.	Remote treatment limits
The patient will be more involved in the treatment model	The patient will be more involved in the treatment model.	Patient involvement
Individualised motivation	The ways of motivating patients to live healthier, use certain devices etc., is highly individualised to meet specific needs.	Individualised motivation
Patients want to decide who treats them	Patients want to be able to decide on who (which doctor) treats them.	Patient choice
The healthcare systems is still primarily publicly financed	The healthcare systems are still primarily publicly financed.	Public healthcare system
Private treatment will become more widespread	Private treatment will become more widespread as people don't want to have to wait for treatment.	Private healthcare providers
Non-healthcare professionals will interfere with healthcare	Other professionals, e.g. teachers, will interfere on issues related to healthcare and healthy living.	Non-healthcare professionals
Information about lifestyle diseases is increased	There will be more and easy accessible information about lifestyle diseases available to the public.	Lifestyle information
Virtual communities motivates better self-management	Virtual communities are a driving force in motivating good self-management among patients.	Virtual communities
Less authoritative relationship to GP/doctor	Patients will have a less authoritative relationship to their GP and to doctors in general.	Relationship to GP/doctor
Compliance is a significant problem	Patient compliance is a significant problem hindering efficient self-management.	Compliance
Citizens are generally not concerned with personal data issues	Citizens are generally not concerned with personal data issues, e.g. in relation to privacy.	Personal data issues

14. Appendix C: Environmental factors in Agriculture

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

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

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

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