Contract No. IST 2005-034891

Hydra

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

D2.1 Scenarios for usage of Hydra in Healthcare

Integrated Project
SO 2.5.3 Embedded systems

Project start date: 1st July 2006 **Duration: 48 months**

Published by the Hydra Consortium
Coordinating Partner: C International Ltd.

25 January 2007 - version 1.41

Project co-funded by the European Commission within the Sixth Framework Programme (2002 -2006)

Dissemination Level: Public

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1. Introduction

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

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

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

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

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

2. Executive summary

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

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

2.1 Scenario Thinking – The IDON method

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

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

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

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

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

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

2.2 The 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.

3. The Healthcare domain

3.1 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.

3.1.1 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.

3.1.2 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

3.1.3 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.

3.2 Organization of workshops

The planning of the workshop took place at a meeting on 10 August 2006 at C-LAB in Paderborn, Germany. At the meeting, the major features of the workshop were decided, the roles were distributed and the participants in the workshop identified. It was decided to conduct the workshops under the label of "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.

3.3 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.

3.4 Trigger question

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

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

3.5 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

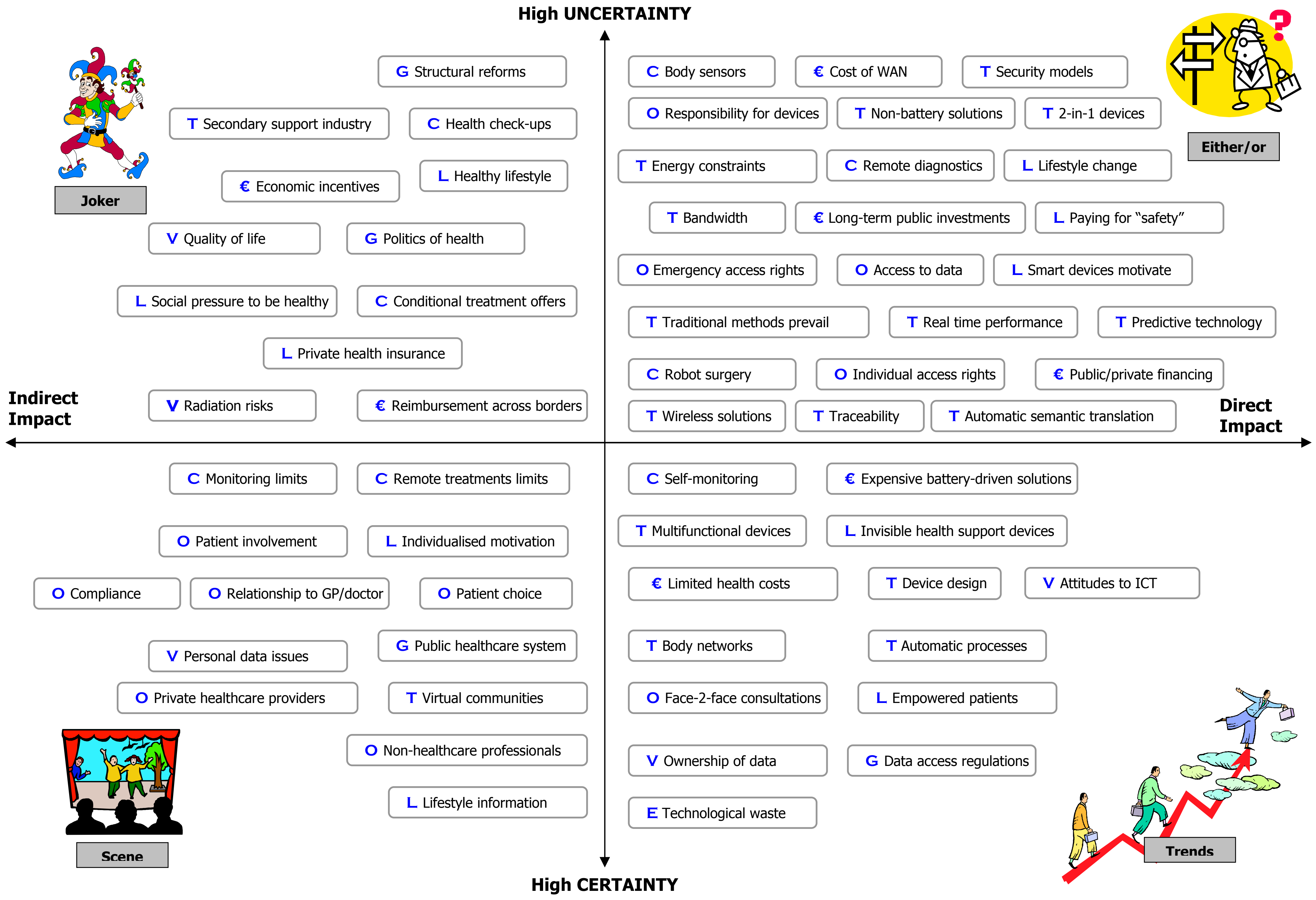
Organisation and logistic systems (O)
Responsibility for devices
Access to data
Emergency access rights
Individual access rights
Patient involvement
Patient choice
Private healthcare providers
Non-healthcare professionals
Relationship to GP/doctor
Compliance
Face-2-face consultations

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 A.

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



High UNCERTAINTY
High CERTAINTY
Indirect Impact
Direct Impact
Joker
Either/or
Scene
Trends
G 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

3.6 Flip-flopping the pivotal uncertainties

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

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

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

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.

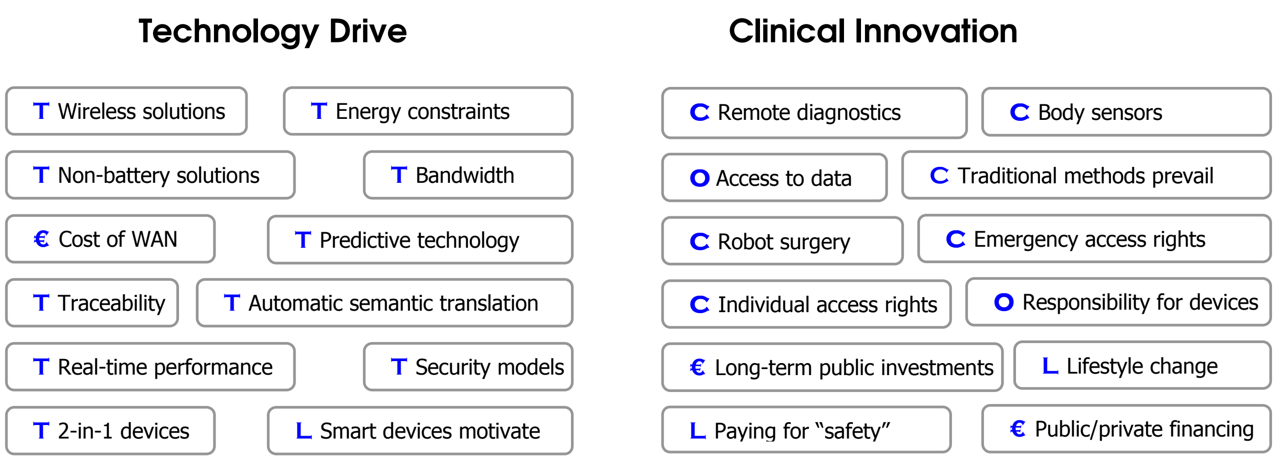
predict changes in health?	-	Insufficient research and development in the field of predictive technologies have meant that these are not available on the market.
Smart devices motivate Are there any extra benefits of smart devices besides the technological possibilities they offer?	+	Smart devices motivate 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.

3.7 Clustering the uncertainties

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

When inspecting all 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"**.



3.8 Naming the sub plots

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

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

In the **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 *which leads to the name:* **TECHNOLOGY CONVERGENCE**	• 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 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 • Body sensors are used to predict and prevent development of diseases • Medical companies have free access to personal health data • ICT solutions and methods of treatment will be an important supplement to traditional non-ICT healthcare treatments, improving healthcare overall • Robot surgery is a widely used practice within secondary healthcare • Access to a person's health data is based on the particular 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 • Healthcare providers have assumed responsible from manufactures for the 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 • 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 • Overall, people will be serious about changing their lifestyle to live healthier in order to avoid or managed lifestyle diseases • The costs of healthcare services are split equally between public and private funding to secure sufficient resources for improved healthcare	• All patients must be seen by a GP in person before they receive a diagnosis • Body sensors have not been developed sufficiently and cannot be used for medical purposes • Medical companies may not access personal health data • ICT is still limited within healthcare and its advantages for improving healthcare and self-management have not been realised • There has not been sufficient developments within robot surgery to be able to offer it to patients • It is not possible to base access rights to a person's health data on context and situation • It is not possible to ensure that healthcare professional's individual data access rights are automatically granted • It is unclear if the healthcare provider or the manufacturer is responsible for ensuring that proper functioning of medical devices • It is difficult to convince politicians to make long-term investments in ICT for improvement of the public healthcare system • The elderly will rather live without the added security monitoring and medical devices provided than paying for these services and devices themselves • Despite health problems most people are not making any real efforts to change their unhealthy lifestyles • 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: **CLINICAL REVOLUTION**	*which leads to the name:* **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.

3.9 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.

3.9.1 Developing the scene

In this process, we start with the scene, which is common for all scenarios. The elements for defining the scenes are found in the lower left "Scene" quadrant of the original grid of environmental factors. These factors are deemed 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.

3.9.2 Building the sets

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

3.9.3 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.

3.9.4 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

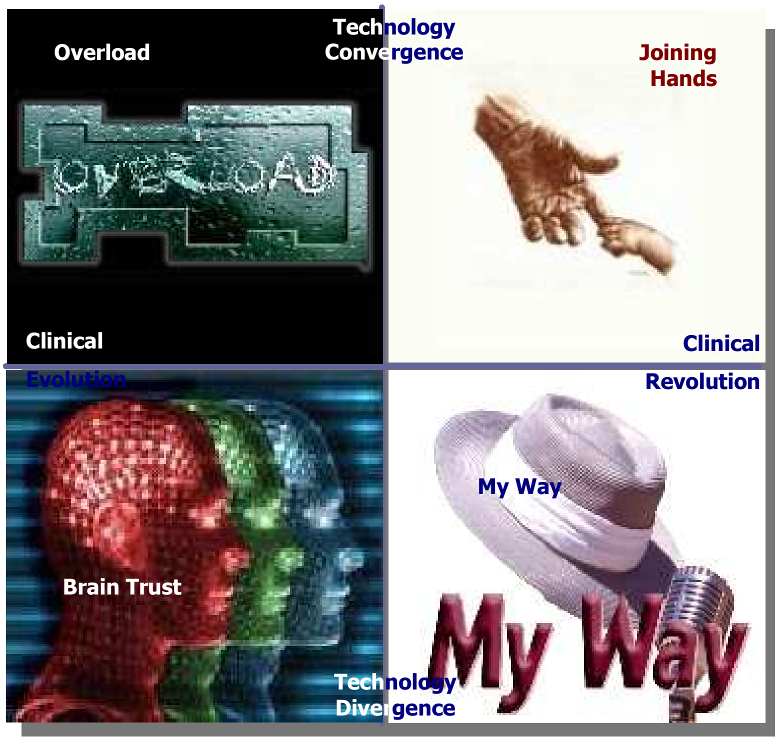
This scenario addresses the constant drive to cope with an increased number of patients, as a result of demographic factors and the rising number of patients with chronic diseases. Healthcare services continue to be publicly funded and politicians must constantly contain costs through various initiatives, 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.

4. Healthcare scenarios

4.1 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.

4.2 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.

4.3 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.

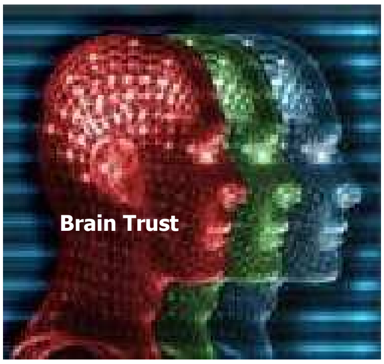
To meet the goals of the integration, Ralf is planning to develop a new network architecture and appropriate middleware for the various nodes. The network must support execution of commands from existing hospitals systems or from a wide variety of locally or externally connected actors such as health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



4.4 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.

5. Appendix A: 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