Report from Dagstuhl Seminar 12231

Future Internet for eHealth

Edited by

Katarzyna Wac[1], David Hausheer[2], Markus Fiedler[3], and Paolo Bonato[4]

1 **University of Geneva – Geneva, CH,** katarzyna.wac@unige.ch
2 **TU Darmstadt – Darmstadt, DE,** hausheer@ps.tu-darmstadt.de
3 **Blekinge Institute of Technology – Karlskrona, SE,** markus.fiedler@bth.se
4 **Harvard Medical School – Boston, US,** pbonato@partners.org

Abstract

From June 3-6, 2012, the Dagstuhl Seminar "Future Internet for eHealth" was held in Schloss Dagstuhl – Leibniz Center for Informatics. During this seminar, participants presented their current research, and ongoing work and open problems were discussed. The executive summary and abstracts of the talks given during the seminar are put together in this paper.

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1 Executive Summary

Katarzyna Wac
David Hausheer
Markus Fiedler
and Paolo Bonato

The paradox of life in the 21st century is that while advancements in technology and medicine enable us to live longer, our lifestyle choices increase the probability of becoming chronically ill earlier in our life and experience long-term limitations, requiring long-term social support. In 2005, 78% of European medical care spending was on chronic disease management, while 86% of deaths were due to such a disease. Yet, current health systems are designed for an acute cure rather than for a chronic care, leading to a continuous increase in healthcare costs. To achieve economically sustainable and affordable healthcare system, efficient and effective solutions are needed integrating technological advancements, and empowering the patients for better self-management, as well as healthcare teams for better decisions.

Recently, multiple initiatives have been established to shape the Internet of the future, supporting key application sectors such as healthcare, transportation, and energy, amongst others. At the same time, the emergence of next generation high bandwidth public wireless networks and miniaturized personal mobile devices have given rise to new mobile healthcare (mHealth) services. For example, highly customizable vital sign tele-monitoring of chronically ill patients can be provided based on body area networks (BAN) and mHealth applications. Such applications enable live-transmission of the data to healthcare providers, and real-time feedback to the patient, enabling her to self-manage her disease and health, respectively. Additionally, elderly people can benefit from applications that help them to stay in contact with their care teams, which are provided with valuable hints on the state of the elderly, thus in the long run facilitating economically sustainable care combined with an improved quality of life.

However, such applications do not emerge by themselves, but need to be carefully designed to support in an evolutionary way the existing healthcare workflows, fulfilling their duties at the given quality level and cost. Such a task can only be tackled in a multi-disciplinary way as it was a goal of this seminar; experts from healthcare, elderly care, insurance experts, together with experts from domains such as human-computer interaction, interactive application design, telecommunications, networking and economy teamed up to understand and support each other in designing and deploying future-proof eHealth services and applications based on Future Internet technology.

At large, the seminar addressed the following questions:

1. Which will be the key eHealth applications and services in the Future Internet?
2. Which are current and future quality requirements of eHealth applications and services?
3. Which business models are viable for future eHealth applications?
4. Which methodological support is required to design economically sustainable network-supported eHealth services?

Question 1 teamed up the participants around relevant use cases and facilitated discussions on the technical question 2 and the economical question 3, respectively. Question 4 addressed research needs from different domains and fertilized corresponding activities for advancing the topic of Future Internet for eHealth.

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3 Overview of Talks

3.1 Do We Have Smart Answers to Mary's Conundrum?

Albert Alonso (Hospital Clinic de Barcelona – Barcelona, ES)

Mary is a 79 years old woman that lives alone in her family home. She suffers from arthritis (legs and hands), has a long-standing digestive problem, a mitral valve leakage, and small mental lapses. She also suffers from technophobe ((*e.g.*, she hates ATM and care alarms). She is independent but sociable. Mary needs nutrition and mobility support, some help with shopping, bathing support and, above all, socialisation opportunities. She has no children, only a stepson and a niece – each 90 minutes away, being busy working. She's got 2 sisters, equally dependent, that do not drive. Her neighbours are elderly couples 70+, each husband with history of cancer.

The healthcare system approaches her as follows: her general practitioner seems to be uninterested, he just repeat medications and sees nothing curable; her cardiologist is only concerned with her medication compliance; her orthopedist seems to be undecided about how to help her; her neurologist is similarly unsure; her geriatrician – considers a possibility of a peace maker; her home nurse just visits her monthly and finally, her respite care is just checked annually.

So the question arises on who manages her health. Mary's health is seriously compromised if not helped holistically. The goal shall be to harmonize health care and social care and take into consideration the family and carers' own needs as factors.

After two decades of efforts in revising care provision, and piloting new modalities of care services, the number of Marys is on the rise. In spite the solutions that information and communication technologies have proposed, there are many that still see them as a doubtful joker in the pack. Does anyone have an answer to Mary? A smart one?

3.2 Adiposity, Obese Children and Adolescents and New Technology of Electronic Support

Gerald Bieber (Fraunhofer IGD – Rostock, DE)

Currently there is a trend in our society of changing behaviors, influenced by ubiquitous availability of computer workstations, television, computer games and Internet, as well as convenience of 'fast food' diet and high carbohydrate foods. Additionally, the physical activity of the humans is not sufficient, and as a result, the human weigh is too high on average. Today, only 1/3 of the population has normal weight. These all factors increase the risk of suffering from a disease; in the future a high increase of type 2 diabetes is expected. In Germany alone, already over 6 million of people are diabetic. In comparison, in 1960 only 0.6% of the population got the diabetes disease, yet currently, almost 10% of the Germans diabetic. The disease rate is expected to double again for the next 10 years. Diabetes is associated with dialysis, blindness or amputations; it is one of the most expensive and cruel diseases. The trend of the increasing disease rate can be reversed only by a change of lifestyle. Overweight children and adolescents usually retain their high weight when they become adults, but children can be educated to change their unhealthy behaviour.

In order to achieve a sustained motivation for lifestyle change, it is necessary to promote and practice health physical activity. Therefore, it is useful to assess the physical activity objectively and unobtrusively and use it in an individual treatment plan. For the treatment, it is necessary not only to detect whether the patient is active or passive, but what activity was performed over a period of time in chronological order. The set of identified activities allows an estimation of the energy expenditure and needed therapeutic support. Moreover, a motion-dependent treatments can be performed. The use of accelerometers to monitor physical activity by new algorithms for pattern recognition allows the identification of various physical activities. Jumping, running, walking, cycling or driving a car can be detected, additionally to sitting and resting. This can be done simply by wearing a standard smart phone, or a smart watch in combination with a special application deployed on it.

In our research we have developed the DiaTrace-technology, which transforms a smart phone to a mobile assistant for physical activity and food assessment. The mobile assistant rewards the user with electronic medals when he/she performs sufficient physical activity. Together with MEDIGREIF-Inselklinik, the DiaTrace technology was used for the treatment of obese children and adolescents and provides new insights in term of objective and subjective perception of food intake and physical activity. Furthermore, this technology can be used to design new treatment concepts, *e.g.*, for physical activity dependent medication.

3.3 Applied Health Technology and Old Age (in a Global Context)

Doris M. Bohman (Blekinge Institute of Technology – Karlskrona, SE)

My main interest is grounded in my ethnographic research in South Africa focusing on older people, where the use of mobile phones to a large extent is a natural part of their daily life. From this perspective, my interest focuses on mobile technology and health (*i.e.*, applied health technology) and on strategies how to increase the involvement of the potential users in design innovative solutions – the quadruple helix model. The main question arise – what can we learn from Africa when introducing and developing mobile technology based solutions in health care for older individuals in an European context.

The first objective to understand is what are the direct and indirect health benefits for older individuals and their families of using mobile technology/mobile phones in a context as Sweden/Europe and in a context as South Africa/Africa. Secondly, how does mobile technology/ mobile phones influence the intergenerational relations, mainly the relations between the older and the younger generations in relation to health services. Furthermore, which are the patterns of older individuals' use of mobile phones in health service and health promotion in Europe versus Africa and finally, which are the potential factors for formal health sector integration of mobile technology/mobile phones.

3.4 A Simplified Approach to the Design of Wearable Systems

Paolo Bonato (Harvard Medical School – Boston, US)

The development of wearable systems for mobile health (i.e. monitoring patients in the home and community settings) has mostly occurred in a vacuum, namely in engineering schools and companies without proper interaction between engineers and clinical personnel. Consequently, the field has witnessed a great deal of emphasis on the development of new technologies rather than on the design of solutions to well-defined clinical problems. This bias toward the development of new technologies has led to the incorrect assumption that all wearable systems for mobile health should allow clinicians to monitor patients continuously and ubiquitously. This is not correct. In fact, the majority of the clinical applications that fall within the umbrella of mobile health do not require continuous and ubiquitous patient monitoring, but rather often they 'only' require monitoring individuals for a few days at certain points in time (e.g. every few months) while they undergo a clinical intervention. To achieve the goal of delivering wearable systems that address real-world problems, it is essential that further developments in the field of wearable technology be put in the context of the specific clinical problems that one intends to address. Herein, we propose an 'oversimplified' approach to the design of wearable systems for mobile health that is based on focusing on three questions. (1) What would clinicians do with the data gathered using the wearable system? (2) How quickly would clinicians have to take action if wearable sensor data indicate that a clinical intervention is needed? (3) How long would clinicians need to monitor each individual to gather the clinical information of interest? Although these questions might come across as trivial, we argue that they capture fundamental aspects of the design of wearable systems that are critical to assess what technological solutions would be ideal on a case-by-case basis. For instance, proper understanding of the objectives of the data analysis procedures to be set in place would indicate whether real-time processing is required with significant implications from an engineering standpoint. If one intends to monitor patients at risk for severe arrhythmias, then the system to be developed would need to provide the ability of processing electrocardiographic data in real time and of relaying an alarm message to a caregiver when needed. If instead one intends to monitor patients with Parkinson's disease to titrate their medications, the data could be stored in data logging unit potentially worn by the patient and the data could be analyzed off line. It is clear that applications with such different requirements would lead to very different hardware and software implementations.

3.5 User Driven Service Design and the Future Internet for eHealth

Sara Eriksen (Blekinge Institute of Technology – Karlskrona, SE)

With an interdisciplinary background in Informatics and Human Work Science, I have been inspired by the Scandinavian tradition of Participatory Design (PD) as well as a near-sighted focus on everyday work practice.

The questions arise on how do people actually go about getting their work done, how does technology support everyday work, and when it does not, and furthermore, how can users' complaints be fed back in to the further design and development of technology to reduce frustration and constant work around.

Participatory design, I would claim, is more radical than User Centred Design. It lets the users have a say and I think this would be especially relevant in eHealth, where many of the users may be sick, elderly or have functional disabilities. However, I have found that PD is not all that radical anymore. In the most unexpected situations, I keep finding myself eye to eye with innovative users with great ideas. Not only do users have great ideas, they have attitudes. They expect to be able to do something useful with technology, and keep up with their friends and families on Facebook while they are at it. The question arises why not helping them to do so.

Maybe a large part of the problem when approaching eHealth is that we are not expecting this kind of initiative from what we perceive as marginalized user groups such as elderly, sick people and people with functional disabilities, who seem helpless. The question arises how can we more deliberately cultivate multiple methodological perspectives in technology design and development, and allow for a wider range of different user roles in our R&D projects with the aim of co-designing the Future Internet for eHealth.

3.6 FIT for eHealth – Show-maker or Show-stopper?

Markus Fiedler (Blekinge Institute of Technology – Karlskrona, SE)

Emerging Future Internet Technology (FIT) appears to be enabler and orchestrator, *i.e.*, some kind of show-maker, for a plethora of new apps and services in the eHealth domain. For instance, virtualisation/clouds and cooperative communications are believed to support the deployment of eye-catching eHealth apps and services in cost- and energy-efficient ways. However, user adoption is at stake if newly introduced apps and services do not (over-)fulfil requirements and expectations put by their (typically rather picky) users. Thus, it is time to identify potential show-stoppers that might hamper the successful dissemination of new eHealth apps and services to be built on top of FIT. Following up on this inventory, potential consequences for the design choices for FIT have to be addressed in order to yield an optimal user experience of eHealth services and thus success in the market.

3.7 eHealth to Fit

Geraldine Fitzpatrick (TU Wien – Vienna, AT)

Designing effective health IT has always been challenging as our own and others' experiences with electronic health records and related technologies show. New healthcare models around self-care, aged care and chronic disease management make this even more challenging as care moves out of clinical settings into patients' hands and people's homes. eHealth technology is seen as the critical enabler for this move. However the challenges of moving care into the home however should not be under-estimated. It is not just a case of moving technology from one setting to another, or creating more mobile apps. Rather, health and care embedded into everyday life (rather than in a discrete clinical encounter) presents a radically different space for health IT and for health practice. It fundamentally challenges our conceptualisations of patient, clinician, care and home and sets up new challenges for design and evaluation.

In previous research we have used mobile, wireless and sensor-based technologies, also tangible devices, to design for self-motivated care at home; we have also conducted various studies with older people and around AAL-home monitoring. From these experiences, plus the work others, we can identify a number of design challenges driven by the following issues: (1) whose voices are heard; (2) what implicit values or norms are we inscribing by design; (3) how do we design technologies to fit into lives and homes in a way that can both meet the needs of the health care system while also delivering value to the people who need to use the technologies; (4) how do we design for integration into the diverse spaces, routines and social contexts of everyday life; and (5) how do we design for the consequences of patient empowerment, shifting to a model of collaborative control and interpretation.

There are also complex evaluation challenges. In the health domain, clinical, randomized control trials are the standard for 'evidence' and they rely on relatively stable and controllable environments. Yet the implementations of many eHealth technologies are being appropriated in continually on-going ways and often specific to situated contexts that make it difficult to run such trials. Yet 'evidence' is still needed for large-scale systemic changes in healthcare delivery. We are still researching, for example, what new evaluation methods will allow us to orient to both process and outcomes equally, and how do we understand dynamic situated appropriation that will enable us to more systematically evolve new models of care and care processes. We need to understand and have a consent on what are measuring, what constitutes 'evidence' and for whom.

Who we think eHealth technologies are for, how we design for them, and what we evaluate, matters if we are to design technologies that really fit into people's lives and deliver value to both patients, their care providers and the healthcare system.

3.8 eHealth will Revolutionize Health Systems in Africa!

Caroline Franck (Hôpitaux Universitaires – Geneva, CH)

In 2000, Member States of the United Nations committed to the attainment of a set of quantifiable Millennium Development Goals for redressing poverty and improving lives by the year 2015. Even though the situation has improved, it is very unlikely in sub-Saharan Africa that the health – related goals will be achieved. Factors contributing to the failure of these goals are a shortage of trained health care professionals, especially in rural areas, and a lack of education. Both of these aspects are correlated with the following factors: limited resources, inequity and inefficiency.

The Internet and multimedia technologies are reshaping the way knowledge and services are delivered, due to the fact that it can be offered at relatively low cost and provide real-time distribution. Additionally e-learning creates a learner-centred, self-paced learning environment, which makes e-learning a real alternative to traditional classroom learning. Information Technology enables us to provide access to education, knowledge and research to the poor and remote villages on a large scale. Decreases in technology and infrastructure costs facilitate the use of these applications in low-resource settings like sub-Saharan Africa. For example, mini-VSAT connections and portable ultrasonography devices permit tele-medical applications in rural sub-Saharan regions. Centres of excellence and tele-consultations may decrease shortage of expertise in rural areas through providing remote access to specialists and empowering health care professionals, like for example midwives, to perform obstetrical evaluations.

Further on, the introduction of Health Information Systems will facilitate transparency and evidence base, which will largely contribute to enhancing accountability at all levels. They will also empower lower levels in the care or management pyramids, whose contribution will become increasingly visible. Such major developments in a national health policy constitute per se a major reform for health sectors that would take this direction.

3.9 Serious Games for Health

Stefan Goebel (TU Darmstadt – Darmstadt, DE)

"We do not stop playing when we get old, we just get old when we stop playing" (George Bernard Shaw)

In the health(care) application domain, a shift to prevention should take place. This covers both primary prevention – in the responsibility of individuals/private (and healthy) person – and secondary prevention in charge of the healthcare system (practically: healthcare insurance companies). For the private sector, motivating factors and incentives are necessary to convince individuals to do sports, exercise, change nutrition type or composition and have a healthy lifestyle at large, in order to avoid obesity, cardio problems or other diseases.

Games co-called respectively Serious Games – games being more than pure entertainment, with an additional overall purpose (*e.g.*, to improve the vital status) – provide an excellent opportunity. With respect to secondary prevention, healthcare insurance companies need some 'proof of concept' that game-based approaches do create the proposed (medical) effects. For that, comprehensive evaluation studies are necessary. Our research tackles these issues in a number of 'Games for Health' project in cooperation with technology providers, and stakeholders such as hospitals.

3.10 How To Get Technology, Healthcare & Policy Integrated?

Nick Guldemond (TU Delft – Delft, NL)

Worldwide, healthcare systems are considered unsustainable due an increase demand of care and associated rise of healthcare costs. Aging of societies and the growth of populations with chronic conditions makes a paradigm shift of western healthcare systems necessarily. The Chronic Care Model provides a framework for healthcare change, including a prominent role of the community and patients' self-management. Technology holds the promise to support the premise of the Chronic Care Model. How can technology be linked to the Chronic Care Model and what are the implications for policy, remains a question to be tackled.

3.11 People-centric eHealth

Mattia Gustarini (University of Geneva – Geneva, CH)

I research in the field of ubiquitous computing. So far, along my research I had the opportunity to learn upon the concept of eHealth, however mostly from the point of view of quality of service (QoS). For advanced solutions for QoS in eHealth, I have decided to put the user in the centre of my reasoning. Even before service provision, we as designers need to be clear what should happen around the user, and what are the devices at our disposal to implement eHealth keeping the user truly at the centre of our reasoning. By answering these questions, I have decided to use a smartphone as an eHealth platform, and a lot of research questions popped up. Firstly, we need to understand how to transform the smartphone in a credible, reliable sensor platform for eHealth applications, employing its internal, as well as external sensors. Secondly, how we can reach this goal without interfering with the 'normal' use of smartphone in terms of its efficiency, performance and resources management. Additionally, we need to understand how to involve the user to incentivize the use of eHealth application on smartphone, how to create a collaboration between all users and how to involve them in the collection of data that can be useful and usable for everyone. We shall research issues related to sharing and privacy management, as well as understand what to do with the data collected.

3.12 Promoting Physical Activity with Mobile Devices

Jody Hausmann (University of Geneva – Geneva, CH)

My main research question is how can we deepen our understanding of own physical activity status – understand if we are sedentary or active, and if we are sedentary, what are the ways of getting enough motivation to stay active. Individual factors influence the modality over which the motivation shall be sparkled – being a textual/visual feedback or a meeting with a coach. A user shall have an easy, affordable and convenient way to track every day performance. Is it possible to provide it with a device that is non obtrusive, reliable and does not require many many manipulations – *e.g.*, a smartphone.

Our current research aims to answer these kind of questions. We assess the smartphone's feasibility to unobtrusively, continuously and in real-time track its user's physical activity intensity and quantity per day based on the World Health Organization (WHO) recommendations. Activity Level Estimator (ALE) is an Android OS application, which analyses how much time the user spends on walking and classifies it alone its intensity represented by a level (*i.e.*, low, moderate and vigorous). We conducted a study with 12 participants and we have calibrated and assessed the accuracy of ALE against a Gas Analysis System, a "gold standard". Our results showed an overall average accuracy of 90.06% per minute for walking activity. The next steps in this research will be to help the user to stay motivated.

3.13 eHealth Means Disruption and Change!

Rainer Herzog (Siemens Enterprise Communications – München, DE)

This talk addresses the disruption and change needed to be embraced to support eHealth in the Future Internet. The actors driving the disruption and change are healthcare providers, payers and patients. The issues to be considered are (1) mobility of patients and practitioners; (2) scarcity of care resources and competences; (3) need for intuitive user interfaces; (4) need for a team-based future care; (5) need for connected service platforms for healthcare provision, as well as (6) resources needed to educate an informed and empowered patient.

3.14 Applications of Virtual and Augmented Reality in Healthcare

Hannes Kaufmann (TU Wien – Vienna, AT)

Augmented Reality (AR) combines the real and the virtual and is interactive in real-time. In addition, virtual and real objects are registered in 3D space to pinpoint their positions for precise overlays. AR has been in the news a lot in recent years, mainly because of AR Apps on smartphones. Augmented Reality has a lot more to offer though. Hardware setups are versatile and range from mobile devices to immersive lab installations. Just as versatile are the application areas ranging from industrial uses (*e.g.*, automotive, manufacturing), training and education, modelling (architectural planning), design, visualization (*e.g.*, scientific, medical, and information), entertainment and more recently, the widening spectrum of possibilities in the medical domain, rehabilitation and therapy. An example of the latter is an EU FP7 ICT project on virtual rehabilitation – PLAYMANCER. It focused on developing serious games for cognitive behavioural therapy – specifically for patients with eating disorders and pathological gambling, and on serious games for the rehabilitation of chronic back pain patients. Rehabilitation for chronic pain follows a multidisciplinary approach, which despite the effort, often lacks long term success. Patients fail to translate skills learned in therapy to everyday life. In order to encourage continuous training and ensure impact at a wider scale when it comes to "Active Ageing", technology can and should be used to motivate people to exercise at home.

Movement data can provide medical experts with useful information regarding patients' home training, *e.g.*, duration, intensity and correctness. As an alternative home motion capture system, the low cost Microsoft Kinect was compared to an 8-camera precise optical motion capture system that we research. The results show that overall, the Kinect performs surprisingly well. It correctly captured some of the exercises used within the serious game. It cannot measure all required parameters (*e.g.*, head rotations cannot be detected) and lacks accuracy required for others (*e.g.*, velocities of hand/arm movement). For clinical evaluation such a device cannot be recommended due to large errors. However, for health related home use, a Kinect like depth camera can be used as a full body input device for serious games and other rehab or health programs that do not need supervision.

To reach the general public, using mobile technologies for health care purposes, seems to have the broadest impact. MIT's CATRA and EyeNETRA projects are suitable examples of these. Augmented Reality is predestined to contribute in these areas as well. Qualcomm recently announced the Tricorder X challenge to develop a mobile diagnostic tool based on a smartphone, making reliable health diagnoses available directly to "health consumers" in their homes.

My main interest is to find and develop applications of VR and AR that benefit people. What I have to offer is an extensive experience in tracking technologies, sensor fusion, mobile AR, immersive VR, motion capture, 3D displays and more. Currently, health related research proposals are under review for patients with mild dementia and Alzheimer, Parkinson patients and precise localization of blind people outdoors.

Regarding mobile and upcoming technologies for elderly people, excellent usability must be of uttermost importance. We will see a variety of new approaches and health technologies emerging until the end of this decade. With extensive funding opportunities on the horizon (*e.g.*, EU's HORIZON 2020), we should take our chances to develop and spread successful medical applications based on virtual, augmented and mixed reality.

3.15 Paradigm Shift in Patient Care Approach Could be Promoted by mHealth Usage

Zviad Kirtava (Tbilisi State Medical University – Tibilisi, GE)

In this talk we firstly discuss if eHealth will be a unifying tool between developed and developing countries or new frontier of digital divide. Secondly, we discuss if the mobile telemedicine and mobile tele-monitoring will be providing new path from inpatient-oriented care-centred model to outpatient-oriented prevention-centred one. Additionally, we address the issue of mobile learning, driven by cost of module developments and potentially propelled by an inter-academia to business cooperation, which would enable international students access high-quality training materials. Furthermore, we consider the possible roles of physicians and healthcare institutions, being supporters, observers or opponents of eHealth. One of the important questions is, if the business of healthcare would be threatened by universal access to patient data and competition.

3.16 eHealth Bike Solution for Cardiovascular and Pulmonary Rehabilitation

Willy Kostucki (Clinique Antoine Depage – Brussels, BE)

Physical inactivity is an independent risk factor for cardiovascular diseases, and sport is among the few non-controversial treatments to reduce the incidence of cardiovascular diseases. Improving the physical condition is as effective as the control of other risk factors like smoking, hypertension, diabetes, obesity, stress, and it competes with invasive treatment (stent) in several subgroups and this regardless to sex or age of the patient.

The opportunity resides on a paradox, *i.e.*, the more patients are at risk, the more intensive and well managed must be cardiac rehabilitation processes. Nevertheless, this rehabilitation is difficult to achieve, especially for patients that are physically limited due to their illness and eventual co-morbidities, as well as psychologically weakened, and for whose who are naturally afraid of physical exercise, which they tend to find boring. The other major hurdle to a "winning" rehabilitation is the "compliance" by the patient to the prescribed exercises.

The uniqueness of the proposed eHealth Bike Solution is the loop between the patient and the cardiologist that will continuously improve the acuity of the prescription and the efficiency of the training and thus the patient's health. Loop after loop. The eHealth Bike has also so many features never to be found on any even top market available fitness bikes today: Pad-driven application, blood-pressure monitoring, heart rate monitoring, unique ergonomic design, seat motorization (for the elderly), weight sensor, and so on. It tends to be more a health station rather than a simple bike. As for an accessibility, everything is web-based.

Searching investors is a bottleneck for those kinds of projects. Thus the question remains which business models are viable for future eHealth applications. Since cardiology is also a highly technical medical specialization with already many applications available, additional issue relates to the key eHealth applications and services in the Future Internet. I personally believe in the integration of the specializations instead of the present splitting in today's techno-medicine.

3.17 Assisted Living in a Smart City

Ernoe Kovacs (NEC Laboratories Europe – Heidelberg, DE)

The current Internet is a very successful world-wide infrastructure which enables different parties to communicate and offer and consume services. The success of the Internet is largely based on the adoption of two "hourglass patterns".

The first hourglass pattern is around the TCP/IP protocol stack in which the many applications are using the TCP/IP network layer (the waist of the hourglass) and in which that layer also hides the complexity and evolution on the lower networking layer. The big advantage of this is that the networking and application layer could evolve independently resulting in very dynamic progress in both areas. The second hourglass pattern is around Web technologies. Web technologies are enabling an explosion in services. They are (again) forming a commonly used waist enabling the technologies below it (*e.g.*, database, OS, scripting languages, middleware system, network) to evolve independently of the applications that are using it. The results are a worldwide market for services such as eCommerce, social networks, search, video services, information access, and many more.

Research in the Future Internet is driven by two aspects. Firstly, we are experiencing that the current Internet is reaching its limits. This is very obvious and observed with respect to the availability of addresses, but it can be also easily seen in many other areas, being it network management, content distribution, mobility management, and so on. Secondly, drive arises from the demand for better features in the network itself. With advanced features, better services can be build. For example, network virtualization and isolation will enable the creation of world-wide services which do not have to be aware, hardened and adapted to the fluctuating and harsh network conditions of today's Internet. Problems can be managed and solved in the virtualization layer, while the services can focus on providing their services. Clouds are promising endless computing resources, but need to be able to provide their data processing for each user as needed. The Internet-of-Things promises to deliver real-world information in aggregated and well-prepared forms to users and services – from around the world and ultimately in an open system. The search service is on for a new hour glass pattern that will enable to create the promising services of the future and shield them from the complexity of network, virtualisation, cloud, service orchestration, Internet-of-Things, and other technology evolution.

Evolution and progress in the eHealth sector is mirroring these developments and is also driving some advancement. First successes in eHealth were in the management of the overall medical and non-medical processes in medical facilities or across organisations. This goes hand-in-hand with the early phases of the Internet enabling world-wide and easy communication. Nowadays access to medical information, as well as to eHealth services is common practice. Serious work is now conducted with a goal of embedding sensor information into eHealth. The need for security and protection of privacy is driving respective research and would benefit from, *e.g.*, virtualization of networks.

The example of Ambient Assisted Living (AAL) in Smart Cities is illustrating this. Initially, AAL was applied in the area of smart homes or as a mobile services. These are isolated systems, usually under the control of a single authority. Technology is now equipping buildings, streets or places to become smart environments, and very soon complete cities will become a platform of a Smart Cities. In such environments, many providers of data, computing resources, knowledge processes, and useful services need to jointly work together for providing a open AAL environment.

This clearly calls for a Future Internet in which many players can be free and open, but also controlled and if needed, secured and isolated work together. Research has started here. The FI PPP project FI-Ware is searching for a configurable service platform for the Future Internet. It can serve as an example for first steps towards the new hourglass patter for the Future Internet, also benefiting advanced eHealth systems.

3.18 Data and Process Interoperability in eHealth

Lenka Lhotska (Czech Technical University – Prague, CZ)

Health records have been usually kept in the paper form. Doctors are still used to use it and consider it a good practice, as they are versatile and complete. Usual practice is to make human operators (usually nurses) enter the selected information from paper documentation into a Hospital Information System (HIS) during a night shift, which also raises the error ratio of the operator. The paper documentation usually contains free text, printed documents, filled forms and paper reports (*e.g.*, signals, results of diagnostics, analyses). Usually there is no backup of the paper documentation and the task of digitalization into Electronic Health Record (EHR) is inconceivable in such extent. Legislative defines the extent of a health record, therefore it is rather clear what belongs to the documentation. Patient has the right to look in the documentation and request a copy.

However, there is no usable standard for fully compliant EHR, although the health information is often saved in some form of a HIS (that are usually mutually incompatible).

There is no standard for signal data (*e.g.*, ECG, EEG) and the data are often stored in proprietary formats. The HL7 has been adopted in several countries as standard. However, the standard content of EHR is not yet well defined.

Although the legislation defines a mandatory back-up period for health records, there is no defined need on the readability of the medium. It is not clear whether a CD/DVD (or even diskette) is readable after 50 years, or whether devices for reading the media would be available. The question is also whether we are able to read 20 years old data/compression format. It is undefined whether the data should be archived as-is or stored with a transaction log (describing who/when/how changed any information, who approved the change) that cannot be modified (electronically signed). Another question is whether the data are stored securely (no stealth alternation can be made, consistency checks are performed). An important question is whether there exists an easy way to make the data anonymous for medical research, statistical purposes, business decisions, and so on. The answer for the latter question is that obviously no, as even the electronic documentation contains copied/-pasted text documents containing unstructured sensitive data. It is also important to ensure availability of data codebooks (such as ICD) that were up-to-date for each data in data-life timeline as the recent codebooks might not contain information referenced by archived data.

Actually there are insufficient legislative regulations on the health documentation with subsequent electronic health documentation legislative. Doctors are obliged to let the concerned party consult the documentation and must provide a copy on any data media. The problem is that the doctor usually inserts internal notes in the documentation which he does not want to reveal to public for multiple reasons – they entered subjective notes, the documentation contains information from a 3rd party as the patient was lying, due to the fear of prosecution, and so on. A question is whether the data from, *i.e.*, patient monitors (signals, trends, curves, etc.) belong to the hospital or to the patient, *i.e.*, whether the medical facility has the right to use data for any form of research. It is unclear whether the medical facility has even the right to obtain the raw data (without any pre-processing) from the appliance. It is not always easy to get the data in any readable format from the device manufacturer. And even there is a possibility to retrieve the data, it is a question whether it can be used in a clinical trial together with data from another appliance, as usually a filtering and pre-processing of data is performed that might not be comparable. It is crucial to have (also) access to the raw data.

There exits an unordered list of usual reasons that block the adoption and implementation of interoperable EHR. These reasons are not generally applicable to all the doctors nor IT professionals and should not be taken literally: (1) Doctors have been healing patients without any PC. They do not need any PC to perform medicine; (2) IT professionals ask the PC (EHR) to do things that are not present in the paper form (mainly the strutcuralization). Doctors often claim that about 40% of physicians do not have a PC. This is however questionable due to need of sending electronic reports to the health insurance companies; (3) Doctors do not want to be restricted by any structuralization or ontology when taking quick notes. They prefer to use free text. They also need to enter subjective and personal notes into the documentation that should not be seen by anybody outside the medical professionals; (4) People are in general unwillingly accept changes – the changes usually bring higher administrative load and the outcome is unclear; (5) Doctors are afraid of that with complete documentation it will be tougher to defend against liability claims; (6) In the discussions of IT professionals vs. doctors there is usually nobody accepted as a respected moderator (person) so the discussion goes deep into unimportant details and gets usually stuck for long time. It is extremely complicated to find any consensus in a reasonable time.

There is currently no fully implemented interoperable EHR standard. The E-prescription is running in a pilot stage now. Integration of the medical information is a problem: many standards, medical facilities are forced to buy cheap appliances with limited support. Medical facilities do not demand data in readable format for further processing. We are losing important data for long-term studies; also the sharing of chronically ill patient information is limited. There is no successful intent to adopt any working solutions available. Usually, there are attempts to find single (incompatible) solution (and reinvent a wheel). Integration is possible, however no one is forcing the medical facilities, HW/SW manufacturers to use interoperable standards. There must exist joint coordinated effort to unify the standards and to use the interoperable standards.

3.19 Wireless Multimedia Support for eHealth: The Status and the Way Forward

Maria Martini (Kingston University – Kingston upon Thames, GB)

Recent pervasive multimedia healthcare applications include hospital tele-consultation, health monitoring, intelligent emergency management systems, pervasive healthcare data access, ubiquitous mobile telemedicine, assisted living and remote surgery. Research projects are addressing such applications and the suitability of the current Internet to support these. An example at European level is the CONCERTO EU FP7 project, addressing content and context aware delivery for interactive multimedia healthcare applications. From a more strategic and interdisciplinary point of view, the eMobility European Technology Platform recently delivered a Strategic Applications Agenda, discussing the future key applications and challenges in three main domains, including Health and eInclusion. Recent challenges and future research directions of comprehensive wireless multimedia health monitoring and management will be discussed, including the concepts of context awareness, context quality issues, security and reliability, and autonomous and adaptable operation.

3.20 eHealth System for Diabetes Prevention, Monitoring and Treatment

Goran Martinovic (University of Osijek – Osijek, HR)

Diabetes, a chronic, incurable systemic metabolic disorder characterized by hyperglycemia, interferes with the exchange of carbohydrates, fats, and proteins in the body, which results in typical symptoms, and after a long period of time, it affects the structure of most organs and organ systems – the cardiovascular and the nervous systems. The number of people with diabetes is increasing steadily, even the number of people in their adolescence. This is a consequence of modern lifestyle, *i.e.*, an increase in the number of etiological factors of diabetes among which obesity is emphasized in particular. In the last thirty years, the number of diabetes sufferers has risen from about 160 to about 350 million people. Every year, about 3 million people die from diabetes-related causes worldwide. In Croatia, type 2 diabetes affects about 320,000 people (about 7% of the total population). The actual situation is probably much worse, since many do not feel sick and they do not have symptoms, hence get undiagnosed. The disease has a long asymptomatic phase, and at the time of clinical diagnosis, the disease is usually present for 7-12 years. About 30% of microvascular complications (mostly retinopathy, nephropathy and neuropathy) have already been developed by then. A patient with diabetes has also developed other risks for the development of microvascular complications, *i.e.*, obesity, hyperlipidemia, hypertension, smoking, sedentary lifestyle and the like. According to this, early disease detection by determining the blood glucose level is difficult, and early diagnosis through symptoms can significantly aid healing and reduce its complications. Also, early detection, monitoring and prevention of behavioural patterns that can cause a disease or accelerate the development of the disease, can alleviate or even prevent the disease itself.

Pervasive and ubiquitous information and communication technologies have been offering considerable support in the process of detection, treatment as well as monitoring and facilitation of diseases in general, including diabetes. However, in the ICT sector, patients and physicians long for an integrated and unified cooperative eHealth environment that would provide a lot more options to everyone. Wired and wireless networking at a relatively high speed, wireless sensor networks, body networks, web, mobile technologies and service-oriented computing environment, can increase support to measurement, collection, storage and analysis of numerous data. Some of these data are collected and stored off-line during medical check-ups in patients, by means of various questionnaires and from databases (*e.g.*, clinical data, symptomatic information, information about patient's lifestyles, certain laboratory parameters), while some are directly or indirectly measured, assessed, stored and analysed in real time (*e.g.*, glucose level, level of ketoacidosis, blood fat level, blood pressure values). Typically, on the basis of available data values, computer systems enable symptomatic and individual reaction often neglecting their mutual connection and interdependence. This connection and integration of knowledge is possible either off-line by using a PC, or it is done by a physician, which is not possible for many patients/data. In contrast to this, intelligent computer analysis of a large number of data collected for a great number of people/potential patients who live in different living conditions and behave differently, can provide the following: (1) multi-criteria risk assessment of developing diabetes based upon off-line (archived) data and data collected in real time; (2) learning from data and decision making, as well as forming and pinpointing habits and patterns of risky behaviour (*e.g.*, on the basis of glucose value, start an insulin pump or remind of the therapy; on the basis of the step counter, remind the patient (or a potential patient) of a physical activity, and related regular energy intake via an adequate composition of meals); (3) making a decision how to respond in case of life-threatening conditions of the patient, *e.g.*, a decreased blood glucose levels below permissible levels, a high level of ketons in the blood, deterioration of the condition due to diabetes-related deterioration and vice versa.

Data storage (preferably in the context of events, *i.e.*, respecting the domain, semantic and ontological principles), analysis, learning and decision making (based upon multi-criteria intelligent procedures, pattern recognition, self-study) require significant computing power and storage capacities (mostly on demand), inclusion of various sensor, mobile and wireless components, user interfaces and applications available and affordable to a wide range of average users, support at the level of social networks, support to cooperation, availability to a patient, a physician, but also as part of the public health and emergency and rescue system. With all these technologies, cloud computing seems to be the best integration and service-oriented solution. It assumes a high level of access security and data confidentiality at the level of transactions, a high level of environment availability, application of the principles of autonomic computing, as well as an acceptable business and financial model that will not jeopardize the operation and accessibility of such future eHealth systems.

3.21 Context is Everything: Using Sensors to Support Self and Collective Understanding

Dave Marvit (Fujitsu Labs of America Inc. – Sunnyvale, US)

Technology, and specifically sensing technology, is often viewed as supportive of reductionist thinking, after the statement "if we have all of the details at the lowest level then we will understand everything." While the reductionist fallacy is well understood, it is not as widely recognized that sensing technology may be the key to enabling systems thinking. Because all data is ultimately health data (since everything effects our mental and physical states), the use of sensing technology in the name of health offers a great opportunity to build systems that support contextual understanding. Work born of this philosophy has begun and will be (briefly) described in the examples including a generalized platform for mobile, continuous, multi-sensor monitoring, analysis, and service delivery – and some initial services based upon this platform.

3.22 Integrated Systems for Measuring and Intervening on the Exposome

Kevin Patrick (University of California – San Diego, US)

Advances in science and engineering have produced a world with increasingly ubiquitous information and communication technologies. Mobile, sensing, networking and computing technologies support the collection, analysis and use of increasing amounts of health-related data at every level: the genome, microbiome, biological and physiological parameters, and the exposome, the sum total of life-course health behaviours, environmental exposures (both healthy and unhealthy), stress, and social and economic influences on health. Traditional methods of addressing environmental causes of disease usually focus on a single element (*e.g.*, asbestos and mesothelioma) or risk factor (*e.g.*, alcohol and esophageal cancer; tobacco and lung cancer). The exposome is much more complex, multi-layered and multidimensional than this but we have been limited in our ability to measure it because we have not had sufficient technical infrastructure to do so. Mobile sensing, networking and computing technologies allow us to better understand the multi-layered and interconnected systems important to human health. Importantly, the same mobile and computer technologies that support the collection and analysis of these data also support increasingly "intelligent" systems-based interventions to improve both individual and population health.

The key eHealth applications of the future will leverage near real-time (if not real time) assessment and analysis of the exposome to provide individuals, health professionals (both medical and public health) and policy makers with actionable information to improve health. Quality needs for these applications and services will relate to fault tolerance and self-healing performance at every level: the device/sensor, the mobile phone or other personal computing device, networks, the cloud and other connected systems important to health.

Business models will vary from setting to setting depending on reward structures for health and illness-based care. In the US we have unique problems in this regard with the challenge being to move from a medical-industrial complex based on monetizing illness to a new model of monetizing wellness. Disrupting this process may well come from outside the traditional health care industry.

Methodological support is needed in all aspects of the health supply chain: improved design of sensors, mobile operating systems and networks; improved approaches to power management; human-computer interface issues; persuasive design; newer methods of data-fusion and analysis; and work-flow issues for those involved in health, to name a few.

3.23 Redesigning health in Europe for 2020

Terje Peetso (ICT for Health Unit, DG INFSO, European Commission – Brussels, BE)

This talk addresses the following issues to be addressed to support eHealth in the Future Internet. On one hand these issues include ownership, accessibility, and safety, as well as security related to health related information. On the other hand, health literacy, interoperability, and evidence are to be considered. Finally, the legislative framework and need for common standards need to be taken into account as well.

3.24 Fully Personalized, Content & Context Aware eHealth Services: Present, Future or Fiction?

Pawel Swiatek (Wroclaw University of Technology – Wroclaw, PL)

One of the main motivations for designing new architectures for the Future Internet is to meet challenges imposed on the ICT infrastructure by new applications. One of the most demanding application types are eHealth ones, where quality of the delivered services is often critical to the life of their users. The ICT challenges include among others:

1. Content awareness, meaning the sensitivity of data processing and transmission methods to the content being delivered to the end-user. Content awareness may emerge in: different processing of various data streams (*i.e.*, video encoding or sensor data encryption) and different forwarding methods (*e.g.*, routing) for various streams.

2. Context awareness consisting of different treatment (in terms of forwarding and processing methods) of traffic depending on the particular use-case scenario of application generating this traffic. Context may be connected for example with the type of networking device used by a user or users geographical localization.

3. User awareness understood as personalization of services delivered to end-user. Personalization is achieved by means of proper choice of data processing and transmission

methods according to functional and non-functional requirements stated by the user. Users requirements may be formulated explicitly or be a result of automatic recommendation which is based on the history of the application usage.

4. Sensor networks and applications covering not only eHealth and telemedicine scenarios but also such applications as: smart energy metering, vehicle networks, intelligent building infrastructure, etc. Each particular telemetry application involves specific types of data processing methods and transmission of large number of small portions of data often requiring real-time or near real-time end-to-end performance.

Augmentation of the current Internet architecture with the abovementioned functionalities will fulfil the assumptions of the pervasive computing paradigm where end-to-end delivery of eHealth services on the “anywhere & anytime” basis is facilitated by a cloud of distributed networking devices and loosely coupled application modules. The key feature of such an approach is the user-centricity where the user does not invoke any particular applications or service nor even specifies where the application should be executed.

Here we propose a general idea of delivering to complex eHealth services in a distributed networking environment. The main feature of the proposed idea is that the process of complex services delivery is aware of the content being delivered, the context of the services delivery and that the delivered services are personalized for each separate end-user. In order to achieve the content, context and user awareness, we propose a general scheme for signalling system, which task is to configure distributed application modules and network resources with respect to the requirements imposed by the content being delivered, context of services delivery, and the specific user’s needs.

3.25 Integration of Test eHealth Applications with the Virtualized IPv6 QoS Network

Halina Tarasiuk (Warsaw Univ. of Technology – Warsaw, PL)

For now, International Telecommunication Union – Telecommunications Standardization Sector (ITU-T) is being defining the following service components of service stratum in NGN architecture: IPTV, PSTN/ISDN emulation, IP multimedia (IMS). The aim of these components is mainly to allow a communication for typical home/business users, *e.g.*, for IPTV applications or voice connections. However, nowadays we observe an intensive research on enablers for delivering eHealth services. These services usually would base on typical home users’ services suite – like voice communication or video-conferencing, however, eHealth also requires to define new type of services, which since now have not been considered, *e.g.*, in NGN. Such services should support, *e.g.*, transmission of data from sensors monitoring personal health parameters such as: ECG, heart rate, blood pressure, wheezes detection for asthma patients, and so on. Since the above services are related to the human vital signs parameters, we need to consider, which of them have to be transmitted to a doctor or medical centre using which Quality of Service (QoS) levels of the underlying network, and as a consequence, which of them require utilization of the signalling system of the NGN architecture to establish a new connection.

The IPv6 QoS system is an approach researched in scope of the Future Internet research designed by polish national project “Future Internet Engineering” being a part of the larger

Polish IIP System. In scope of the IIP, we integrated the following test eHealth applications with the virtualized IPv6 QoS network: SmartFit, eDiab and eAsthma. THE IIP is now in the prototyping phase and will be tested in PL-LAB environment, which is established as a Polish national pilot network. We expect that PL-LAB will establish some co-operation with similar pilot networks.

The questions remains (1) what are further requirements posed on Future Internet for handling eHealth; (2) are the existing TCP/IP networks appropriate for Future Internet from the point of view of the eHealth requirements; (3) is a dedicated Service Control Function (SCF) for eHealth in NGN needed; and (4) what signalling protocols are applicable in the dedicated SCF for eHealth, choice being SIP in IMS or XMPP as for now.

3.26 Why is Health still Focused on a Hospital Based Regulated Market: The Concept of the Citizen as Health Coproducer

Vicente Traver Salcedo (Universidad Politécnica – Valencia, ES)

Most of the ICT investments in the field of eHealth are oriented to health care practices instead of being focused on primary prevention, especially taking into account how chronic conditions treatments are consuming most of the health care budget. As every decision in our life is affecting our health state and not only the decisions we take when we are in the health care service provision loop (which is less than 1% of our life), I am proposing to “break the wall”.

The question how to do that remains unresolved. The focus of putting individuals in charge of managing their health and lifestyle and the fact that health is co-produced in their everyday life, gives rise to the question of what should be the new Rules of the Game (ROG) that need to be followed. There exists a traditional regulated healthcare system, where the ROG’s have been defined and refined over the years with doubtful success. Based on PREVE EU project results, what we propose is the co-production of health from a citizen-based perspective, where so far no ROG’s have been defined and new stakeholders and business opportunities are emerging.

Therefore, the future of a sustainable health system implies to extend the healthcare system. To achieve that, there there are a lot of questions about behaviour modelling, value creation, value networks and business models that need to be answered as technology is already available, yet technology itself has no value. Instead of that, value is created by the individual by using technology enabled services. This also reinforces the concept that the support provided from the outside to individuals to manage their lifestyle must be personalized and based on their free will. Therefore, ICT must fill the existing communication gap among all the stakeholders involved and the new ROG still needed to be defined, in a more complex scenario, involving a wide range of opportunities to improve our health and lifestyle.

3.27 QoE and QoS as Ingredients for eHealth Service Acceptability

Muhammad Ullah (Blekinge Institute of Technology – Karlskrona, SE)

The provision of eHealth services that have clinical efficacy, diagnostic accuracy and hold capabilities to fulfil end user expectations is still challenging, especially when service acceptance is the criterion for success. The contributing factors that may affect user acceptance include, on one side, the uncertainty about the capabilities of the deployed technologies for the desired eHealth service, and, on the other side, the resulting end-user perception or experiences of the delivered service quality. For user experiences (in turn, depending on their expectations and previous experiences), "quality of the delivered service" is considered as a criterion having a significant influence on service acceptability in most of the circumstances. To deal with acceptance of service quality by their end users, a notion of Quality of Experience (QoE) has emerged. QoE as by definition represents user experiences of the delivered service, stands for the user perception and level of satisfaction, motivates user inclination toward service acceptance or rejection. In other words, the higher is the QoE of the eHealth service the higher will be the acceptance ratio and vice versa. One of the major contributors to QoE is the Quality of Service (QoS) level of the end-to-end communication channel between the service provider and the service user. To avoid the mismatch between the capabilities of deployed technologies and end-user expectation, the QoE metrics of the highest importance in healthcare practices needs to be identified, especially those influencing the eHealth service efficacy, efficiency and effectivenss. The deployed technologies must assure at least the required levels of QoE.

3.28 Future Internet for eHealth: From QoS via QoE to QoL (and Back)

Katarzyna Wac (University of Geneva – Geneva, CH)

The key aim of the Future Internet for eHealth shall be to establish quality research on computing and communications systems deployed in the healthcare domain and delivering clinically validated eHealth services to patients, their professional and voluntary caregivers "anywhere-anytime-anyhow". The general approach shall be necessarily a transdisciplinary one, as many of the challenges in development and deployment phases of these systems need to be addressed considering not only the system, its services and their Quality of Service (QoS) in an operational environment, but, as sometimes missing in the current research – the actual system end-users, approaching eHealth not from the perspective of new hype technology, but from the perspective of new innovate ways to achieve their pre-defined goal in the healthcare domain. These end-users have thus different eHealth services' requirements, expectations and perceptions of the Quality of Experience (QoE), including system's usability, efficacy, efficiency and effectiveness. In transdisciplinary research projects, we shall aim to establish innovative methodologies to demonstrate the value of Future Internet for eHealth improving the QoS, the QoE and ultimately the health outcomes and QoL of its end-users, and thus the social welfare.

3.29 Free Access to All Medical Data, Why Not?

Marc van Anderlecht (Uni-Com Medical – Brussels, BE)

In my talk I present an idea of having a free access to all medical data. I do not expect positive responses based on the fact that people will decrease their expectations for medical data privacy. Even if the sharing of personal data is in increasing, some "cultural" or legal heritage will impeach this. The question is driven by the fact, that is that it is now possible to use dictionary for pathologies, use ISO norms for other data, and use "open source" or recognized files format (HL7, Dicom, etc.) for data. The interest for medical research should be more important than particular interest of some states, so the standardization coordination will be boosted in that direction and states will have an excellent incentive thanks to reimbursement policy. Standardization has already proven in many cases being very important for market competition, as well as for the community, that has a direct advantage in terms of decrease of costs for the use of medical devices.

By addressing those necessary points with respect to data format and its standardization, we can put forward the architecture of a global medical records' database. The idea is that instead of protecting all and each patient medical data, which is very difficult and expensive; we put all the medical records with a free access and protect only the identity of the patient. A patient key code, a physician key code (or any other protection used for example for banks) is enough to protect the identification of the patient related to his/her personal record. We suggest to increase the sharing of medical records and decrease the IT security costs.

Participants

- Albert Alonso
Hospital Clinic de Barcelona – Barcelona, ES
- Gerald Bieber
Fraunhofer IGD – Rostock, DE
- Doris M. Bohman
Blekinge Institute of Technology – Karlskrona, SE
- Paolo Bonato
Harvard Medical School – Boston, US
- Sara Eriksén
Blekinge Institute of Technology – Karlskrona, SE
- Markus Fiedler
Blekinge Institute of Technology – Karlskrona, SE
- Geraldine Fitzpatrick
TU Wien – Vienna, AT
- Caroline Franck
Hôpitaux Universitaires – Geneva, CH
- Stefan Göbel
TU Darmstadt – Darmstadt, DE
- Nick Guldemond
TU Delft – Delft, NL
- Mattia Gustarini
Univ. of Geneva – Geneva, CH
- Jody Hausmann
Univ. of Geneva – Geneva, CH
- Rainer Herzog
Siemens Enterprise Communications – München, DE
- Hannes Kaufmann
TU Wien – Vienna, AT
- Zviad Kirtava
Tbilisi State Medical Univ. – Tbilisi, GE
- Willy Kostucki
Clinique Antoine Depage – Brussels, BE
- Ernoe Kovacs
NEC Laboratories Europe – Heidelberg, DE
- Lenka Lhotská
Czech Technical University – Prague, CZ
- Maria Martini
Kingston University – Kingston upon Thames, GB
- Goran Martinovic
Univ. of Osijek – Osijek, HR
- Dave Marvit
Fujitsu Labs of America Inc. – Sunnyvale, US
- Kevin Patrick
University of California – San Diego, US
- Terje Peetso
European Coomission – Brussels, BE
- Pawel Swiatek
Wroclaw University of Technology – Wroclaw, PL
- Halina Tarasiuk
Warsaw University of Technology – Warsaw, PL
- Vicente Traver Salcedo
Universidad Politécnica – Valencia, ES
- Muhammad Ullah
Blekinge Institute of Technology – Karlskrona, SE
- Marc van Anderlecht
Uni-Com Medical – Brussels, BE
- Katarzyna Wac
Univ. of Geneva – Geneva, CH