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PROCESS OF CHANGE IN ORGANISATIONS THROUGH eHEALTH

Stefan Kirn (Ed.)

Universität Hohenheim | Forschungszentrum Innovation und Dienstleistung

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Process of change in organisations through eHealth

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Proceedings

Foreword

On behalf of the Organizing Committee, it is my pleasure to welcome you to Hohenheim, Stuttgart for the 2nd International eHealth Symposium which is themed “**Process of change in organisations through eHealth**”. Starting with the inaugural event in 2009, which took place in Turku, Finland, we want to implement a tradition of international eHealth symposia. The presentations and associated papers in this proceedings give a current and representative outline of technical options, application potentials, usability, acceptance and potential for optimization in health care by ICT.

We are pleased to present a high-quality program. This year we convey a unique opportunity for academic researchers and industry practitioners to report their state-of-the-art research findings in the domain of eHealth. The symposium aims to foster the international community by gathering experts from various countries such as Australia, Great Britain, Finland and Germany.
A first step is done by this symposium which considers this interaction and delivers an insight into current advances made and open research questions.

The organizers would like to take the opportunity to thank all the people which made the Symposium possible. We are pleased if both attendance to the 2nd International eHealth Symposium 2010 and reading of this proceedings give you answers to urging questions, a basis for critical discussions, references on interesting tasks and stimulations for new approaches.

Hohenheim, June 2010

Stefan Kirn

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OPAL Health –
A Smart Object Network for Hospital Logistics

Martin Sedlmayr, Andreas Becker, Hans-Ulrich Prokosch,
Christian Flügel, Fritz Meier

Abstract
Innovative AutoID technologies such as Radio Frequency Identification RFID have proven to be a key enabler of sustainable process improvements. Hospitals increasingly adopt these technologies to optimize especially logistic processes for cost-effectiveness, quality and safety. Inventory management, temperature monitoring of blood bags and patient identification are typical use cases. This paper describes the development of a smart object network based on a wireless sensor network. It represents an energy efficient, low-radiation communication platform upon which multiple disparate pro-active clinical services can be built. OPAL Health is currently under evaluation at the operating room and intensive care unit of the University Hospital in Erlangen.

1. Introduction

Because of the ever increasing financial pressure, legal obligations of documentation and competition in the healthcare market, hospitals need to optimize their work processes and utilization of resources to increase efficiency and cost-effectiveness while maintaining high quality care. Innovative information technologies can enable and support further optimization of processes. In particular, automated identification technologies (AutoID), such as barcodes and radio frequency identification (RFID), can improve the readiness, workflow, and safety in patient treatment and medication (Egan & Sandberg, 2007). In addition, AutoID technologies aim at synchronizing material and information flows, avoiding manual notation or keyboard data entry.
As of today, various Auto-ID and localisation technologies are available already proving their value in application domains like consumer logistics or production control. They do so by identifying and tracking objects which supports the monitoring and optimization of processes (Want, 2006). In this respect smart object technologies like radio frequency identification (RFID) and real time locating systems (RTLS) are established technologies in these domains. Wireless sensor networks (WSN) (Akyildiz, Su, Sankarasubramaniam, & Cayirci, 2002) merge these technologies and take them even a step further creating ubiquitous, self-organizing networks of intelligent objects actively monitoring their environment.
But most smart object products of today are specially designed for or focus on one application. In addition, many technologies require pulling the information from a label or tag. A generic, pro-active solution which can be easily adapted to new services is missing. To develop and deploy an active, generic and flexible solution for clinical logistical services based on a wireless sensor

network is the aim of the OPAL Health project (optimized and safe processes by mobile and intelligent monitoring and localization of assets and inventory in hospitals). The benefits of a generic technology platform based on a wireless sensor network will be shown in two disparate scenarios: asset management of mobile medical devices (real-time location) and transfusion safety (temperature surveillance, patient identification).
There are medical and business benefits to motivate especially these scenarios. The Scenario "asset management" was chosen, because searching for (mobile) medical devices may require up to 30 minutes of each working shift and up to 10% of the inventory – disappears – annually (Glabman, 2004). The scenario "transfusion safety" was chosen, because cooling chains must be unbroken to prevent deterioration of the blood (Kim, et al., 2006), and the recipient must clearly be identified to give the right blood to the right patient, which is number one failure in adverse events (W. H. Dzik, 2007).
The project entered its last phase, the deployment in the clinical environment, which covers tracking, identification and monitoring of more than 500 objects. Until the end of the year, sufficient data will be gathered to evaluate the readiness of the sensor network technology in real life and to estimate the economical and safety benefits.
The paper is outlined as follows: After a short view on the technological background, the approach taken in OPAL Health is explained in terms of the underlying hardware and the overall system including its integration into the hospital IT. The discussion formulates open issues. We conclude by demanding further research in integrating various AutoID technologies and organisational aspects into an integrated vision.

2. Background

For many years, barcodes have been used on wristbands, packages and documents to identify patients, drugs, lab samples and charts. Radio Frequency Identification (RFID) – prevalent in retail logistics – uses radio waves to identify objects and to communicate data with so called tags or transponders (Egan & Sandberg, 2007). In contrast to barcodes, RFID does not need a line of sight working even through tissues.
RFID technology is categorized in two main types: active and passive. Passive RFID tags need an external source of energy (reader) to be activated and transmit data (Wessel, 2006), limiting them in their communication range. Furthermore, the energy required to activate and read a tag may interfere with medical equipment (van der Togt, et al., 2008). In contrast, active RFID tags have a built-in battery and can actively send data, but still have to be activated by an external reader.
Sensor networks (Akyildiz, et al., 2002) use active transponders for the unsolicited exchange information through a network of tags to reach a destination (multi-hop), thus using much less sending power than even active RFID (Sedlmayr, et al., 2009). They can be combined with different types of sensors to allow monitoring of environmental conditions. By combining a tag with sensors and actors thus enabling it to participate in its surrounding we call it a smart tag. And by pairing smart tags with real life objects such as mobile medical devices, blood bags and patients, the objects become "smart", i.e. a smart object.
The number of reports on using smart object technologies in clinical settings clearly demonstrate the broad applicability of the technology (Vilamovska, et al., 2008). Four enabling functions have been identified as beneficial in healthcare applications: tracking, identification and authentication, automatic data collection and transfer, and sensing. They are applied in four key healthcare applications: patient safety and quality of care, management of devices and supplies, pharmaceutical application, and management and support of patients and healthcare providers.
For example, the cooling chain of blood bags can be proven by active sensors continuously monitoring the temperature and even pro-actively alarm in case of exceedance (W. H. Dzik, 2007).

RFID is also a viable alternative in the bedside matching process for bar codes, which are susceptible to dirt and wrinkles (Sandler, Langeberg, Carty, & Dohnalek, 2006). Stationary RFID readers may even be built into OR tables to match the RFID-wristband of a patient with a blood bag tag (S. Dzik, 2007).

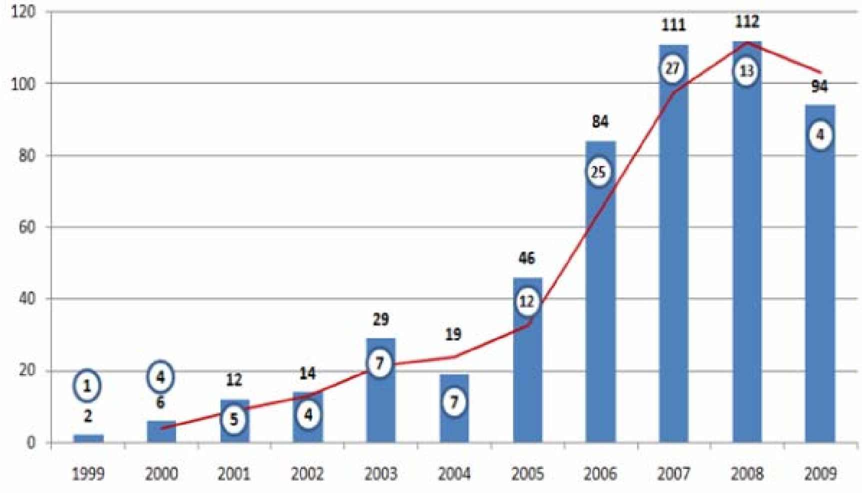

Illustration 1: Development of RFID and healthcare related patent in the triad (US, EU, JP).

The increasing number of RFID related patents in the healthcare domain is an indicator for the interest and development of smart object technologies and applications (Illustration 1, data for 2009 not complete). Assuming a temporal offset of the patent and the actual product, many new applications can be expected in the next years.

3. OPAL Health Approach

3.1. Wireless Sensor Network Technology

The OPAL smart tag consists of a small embedded microcontroller, a wireless transceiver, an antenna and different sensors and actuators equipment. The layout is based on the S3 hardware reference design by Fraunhofer IIS (Fraunhofer-Institute for Integrated Circuits IIS, 2009a), but has been extended towards a flexible clinical communication platform. The microcontroller executes the wireless MAC- and networking protocol, the drivers for the sensors and actuators including signal processing and all local services (such as matching algorithms). The wireless transceiver is used to transmit user and signalling information between nodes.

While the sensors and actuators are different for each target application scenario and sensor tag, the basic hardware remains the same among all types of tags, i.e. in OPAL: a device tag submitting its position, a blood bag tag to measure the temperature and to match it with a patient tag identifying a patient. Each of these mobile tags mainly varies in software configuration and the surrounding cases (square-cut for devices, soft edges and a wrist band for patients). Additionally so-called anchor nodes are installed at fixed positions as basic infrastructure to support the positioning of nodes and routing of messages. Gateway nodes allow access to the smart object network on an IP-level and IP-WSN crossover.

The software on each sensor node is based on the s-net protocol (Fraunhofer-Institute for Integrated Circuits IIS, 2009b), which offers a platform for the implementation of application specific smart object network solutions. The main areas of application of S3 are advanced distributed metering systems, tracking of assets and persons, condition monitoring and wirelessly connected smart processing systems. The main reasons for using a dedicated sensor network protocol instead of other solutions such as WiFi or ZigBee (Baronti, et al., 2007) are:

- Ultra low power operation for a long operation time of nodes: The nodes need to operate at least two years without maintenance (battery) to follow the existing duty cycles of medical devices.
- Robust ad hoc networking to reduce maintenance and support mobility: Especially in an OR setting where huge amounts of metal affect radio signal dispersion (see also multi hop).
- Multi hop communication allows for large scale installations in an energy efficient manner. The low power transmission required by using multi-hop instead to bridge larger distances also reduces the potential interference with medical equipment.
- Support for customization and different parameter sets to adapt the protocol to different application requirements.

Illustration 2: Mobile tags (blood bag and patient wristband on the left) and a stationary anchor tag

One problem arises when tagging mobile medical devices is caused by the sheer size of the tag. While larger ventilators offer ample space to glue a tag on the back, modern and very small infusion pumps within a rack offer no free space at all. Therefore on the one hand, a compromise between using a generic – and thus cheap – case design versus a device-specific – and thus expensive one- has to be found. On the other hand, it is already clear, that without support from vendors a solution for tagging will be impossible.

3.2. System Architecture and Hospital Integration

Any new communication technology will only come to its full potential when being seamlessly integrated into clinical legacy systems. On the one hand, data about devices and other material (e.g. inventory numbers patient case identifiers, maintenance intervals) are required to initialize the object tags used for monitoring and identifying patients and objects. On the other hand, the network generates a wealth of important information on e.g. locations (tracking), usage (identification) and sensor readings (monitoring) which should be fed back into clinical systems. OPAL uses a service-oriented approach for flexible integration into the clinical IT-landscape.

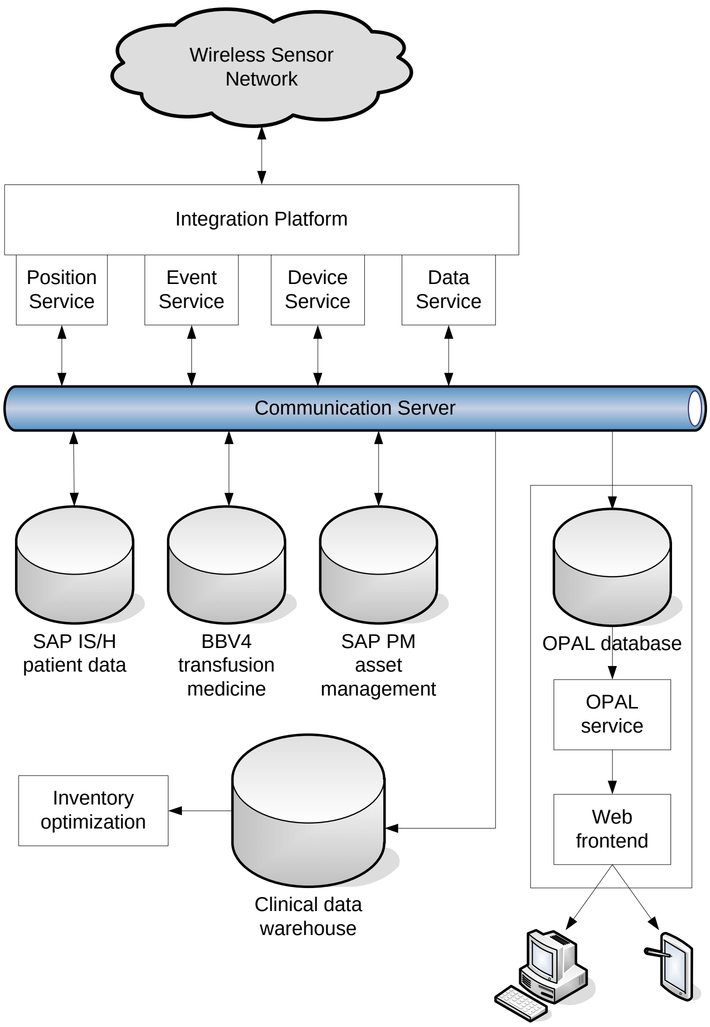

Illustration 3: OPAL system architecture

Figure 1 shows the overall architecture and modules of the OPAL system. Each of the components will be described briefly in the following:

- The wireless sensor network: The sensor nodes package an antenna, a battery, a microprocessor, sensors (temperature, movement) and actors (LED, buzzer) in a small case to be attached to devices, blood bags and patients. Wall mounted beacon nodes serve as gateways to the clinical network.
- The integration platform is used to manage the wireless sensor network. It collects data from the sensors and communicates the information such as position or matching data with the clinical communication server.
- The communication server in the hospital is the central hub in clinical data communications. The university hospital is using JavaCAPS/eGate (Wentz, Kraska, Knispel, & Prokosch, 2005) as enterprise information bus for reliable message routing and delivery. OPAL uses the server for binding the modules as well as for interacting with other clinical applications.
- Clinical information sources (legacy systems, departmental systems from various vendors) are already used to manage patient data, assets and blood bags. Each of the systems has to be interfaced to exchange the data required to initialize the sensor tags.

- The OPAL database logs all events of the sensor network such as position, temperature, matching and pairing. It also caches object data from clinical sources such as inventory numbers. Services around the database interpret the events and trigger functions, e.g. alerting staff in case of the exceedance of a threshold.
- The frontend is a set of web pages usable on stationary and mobile devices by end users to interact with the OPAL system. It is possible to search for devices, look for the most current location, request information about blood bags and assign tags to each of these objects.
- Inventory optimization is an optional module to calculate the optimum number and distribution of medical devices according to supplies, stocks and needs. The module can generate transport requests early to balance stocks preventing local overstocks and ultimately reduction of overall investments.
- Retracement of blood bags refers to an external module which contributes to the audit of the transfusion practice. At distinct steps in the process, a documentation set is sent to a central server which will hold a gapless documentation of blood bags from the donor to the recipient.

The OPAL database services need to exchange information such as inventory numbers, patient case numbers and blood bag data with various legacy and departmental systems. Hence, interfaces to the corresponding applications have been built using SAP-BAPI connections (device data), HL7 messages (patient data) and direct database access (blood bag data).

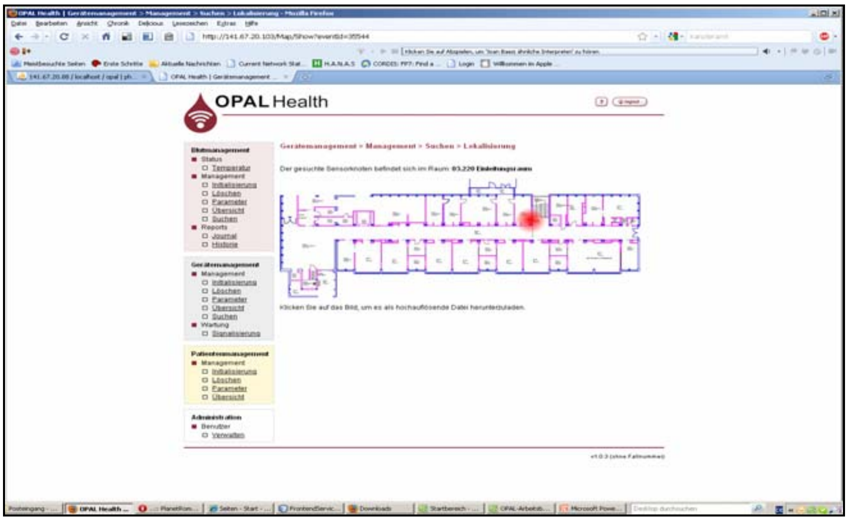

Illustration 4: Frontend showing the current location of a certain medical device

The system is implemented using a service oriented architecture based on public standards. Each module provides its functions as a web-service (Newcomer, 2002) defined in the web-service description language (WSDL). The data has been specified in an XML schema and is sent via the communication server using SOAP messages. Using standards for communication will facilitate the scalability and transferability of the OPAL system. The mediation and caching of object data in a central OPAL database will compensate for different or missing legacy systems.
The data scheme used stores all sensor network generated events such as position events, temperature events and matching events. The logic to detect broken cold chains or unexpected movement of devices is calculated based on the event data. Information about alarming events such as missing tags, false matching events and the like is escalated through email and via DECT-based SMS (specific to the University Hospital Erlangen).

4. Discussion

RFID technology has started its way into the hospital market due to its superiority to barcodes; wireless sensor networks even go beyond this by enabling pro-active services. But both are still in their infancy in clinical use with little empirical research (Tzeng, Chen, & Pai, 2008). Hence, there is hardly any experience which could guide developers yet alone managers in developing and introducing it in the clinical daily routine besides promising case studies (Vilamovska, et al., 2008). Among the barriers is the direct cost of the technology which can sum up to half a million dollars per site (Page, 2007) while the return of investment is unclear; case reports of specific projects however indicate a three year breakeven point (Nagy, et al., 2006; Vilamovska, et al., 2008). This is why OPAL smart tags have been designed to be used without modification in various clinical scenarios, thus lowering the per-unit cost due to mass-production while distributing cost among more benefits as more services can be built upon the same platform.
The advantages of having recent and complete data may even lead to new services and business opportunities: sharing of devices between wards will be facilitated and in future companies might manage the stocks on behalf of wards. In addition, the pairing of devices with patients and documenting operating times enables use-oriented billing. OPAL Health has developed simulators to calculate indicators for alternative asset management strategies indicating a 15% benefit (reduction of number of devices = cost). However, these promises still have to be validated.
The number of stakeholders involved in the processes might arise as a problem when balancing interests, especially in not centrally managed hospitals. For example, if the blood bank is tagging blood bags to increase patient safety, the receiving wards have to invest personnel time on handling the tags without having immediate benefits. Disposal of the tags might be performed by an independent service company which also has no direct benefit in removing (un-pairing) and returning the tags. Illustration 5 shows the involved parties during blood transfusion, the blood bank (BB), the anesthesiology (AN) and the transport service (KSG) which is a commercial building management and service company.

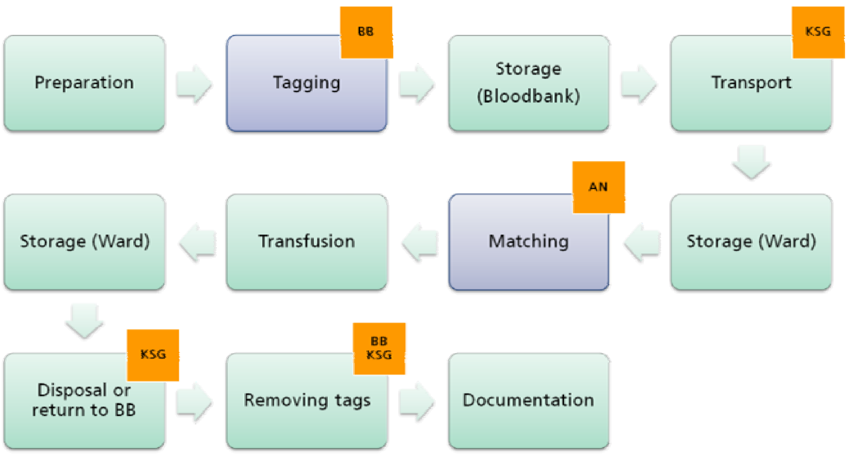

Illustration 5: Actors involved in the process of blood bag management (simplified)

Privacy and security problems as well as resentments of staff and patients against wireless sensors transmitting sensitive data have to be solved (the perception however is country-specific). OPAL has been designed from ground up taking possible risks into account. A thorough security analysis has been conducted to ensure that the most important and effective countermeasures are met. For example only the minimum of information avoiding any patient identifying data is being stored or communicated between tags. The involvement of end users during the design process has further helped to assure the acceptance of the system.

A major problem is the rapid development of the technology. New generations of better, cheaper and more powerful sensor chips become available. Within the first year of the project, the price calculated for one tag dropped by almost 30% while the processor capacity increased by 400%. A new chip integrating microprocessor and transceiver will be introduced by Texas Instruments this year. Unfortunately, security features such as strong communication encryption still have to be developed "on the chip" as they are too expensive in computing power and battery life today hampering the processing and storing of sensitive data on the tag. Battery life is still a limiting factor, challenging the design of the hardware itself as well as the communication protocol to balance between duty and rest cycles. Therefore it is necessary to effectively minimize the amount of sensitive and identifying data within the sensor network. Only the case number of a patient or the inventory number of a device has to be transferred on a tag to identify the attached object. Even that can be circumvented by using pseudonyms. However, a wireless sensor network offers decentralized processing power which lies idle as for now due to security and power consumption reasons.

An open issue is the case design of the tags. Tagging dozens of different devices from different vendors revealed as a challenge. It conflicts with using large quantities of generic case designs (cost). It is already clear however, that without support from vendors a solution for tagging will be impossible (e.g. tagging small syringe pumps without free space in a tight rack).

The service oriented approach based on web standards has helped to easily integrate the OPAL system into the clinical IT landscape and to adapt it to various data sources. It further scales well towards customized and new kinds of services in other scenarios.

5. Conclusion

OPAL Health has developed a generic communication platform for clinical use. Based on the same hardware, completely different scenarios have been built and are currently under evaluation at the University Hospital Erlangen. Operating 300 tags for asset management and 230 for transfusion safety make OPAL one of the largest sensor network installations in the world. From a technology point of view, wireless sensor networks are ready to be used in clinical applications. A thorough business evaluation based on a stakeholder analysis and other means such as balanced scorecard are on the way.

But as more and more AutoID technologies become vital elements of everyday processes, new questions arise from a user's perspective requiring further investigation beyond economic interests:

- The broad variety makes it hard to integrate solutions of different technologies and different vendors. The struggle for interoperability is important so that the solutions add up to a synergetic melting pot rather than a fragile agglomeration. This includes cross-topics such as security and safety as well es usability (how do all these technologies fit together?).
- The novelty of the technologies, often still being under development, hinders their adoption. While some positive case reports indicate success in the related trialed examples, the transferability on other houses or even countries cannot yet be proven. In addition, cross-organizational topics such as blood bag management requires the commitment of many stakeholder of which only some have an immediate benefit while others only have to invest efforts.

There is a need for standardization and proven interoperability, not only for one product, but among all AutoID technologies within the health sector. We strongly believe that technology enables better and more (cost-) effective processes. However, to realize the full potential, innovative processes and organization will be required.

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6. Literature

Akyildiz, I. F., Su, W., Sankarasubramaniam, Y., & Cayirci, E. (2002). Wireless sensor networks: a survey. *Computer Networks, 38*(4), 393-422.

Baronti, P., Pillai, P., Chook, V. W. C., Chessa, S., Gotta, A., & Hu, Y. F. (2007). Wireless sensor networks: A survey on the state of the art and the 802.15.4 and ZigBee standards. *Computer Communications, 30*(7), 1655-1695.

Dzik, S. (2007). Radio frequency identification for prevention of bedside errors. *Transfusion, 47*(2 Suppl), 125S-129S; discussion 130S-131S.

Dzik, W. H. (2007). New technology for transfusion safety. *Br J Haematol, 136*(2), 181-190.

Egan, M. T., & Sandberg, W. S. (2007). Auto identification technology and its impact on patient safety in the Operating Room of the Future. *Surg Innov, 14*(1), 41-50; discussion 51.

Fraunhofer-Institute for Integrated Circuits IIS. (2009a). S3TAG radio module for wireless data transmission Available from http://www.iis.fraunhofer.de/fhg/Images/KOM_SSNW_MHW-1000548_0202_0812_tcm278-137075.pdf

Fraunhofer-Institute for Integrated Circuits IIS. (2009b). Slotted Mac Protocol Stack. 2010, from http://www.iis.fraunhofer.de/EN/bf/ec/dk/sn/lsg/index.jsp

Glabman, M. (2004). Room for tracking. RFID technology finds the way. *Mater Manag Health Care, 13*(5), 26-28, 31-24, 36 passim.

Kim, S.-J., Yoo, S., Kim, H.-O., Bae, H.-S., Park, J.-J., Seo, K.-J., et al. (2006). Smart Blood Bag Management System in a Hospital Environment *Personal Wireless Communications* (pp. 506-517).

Nagy, P., George, I., Bernstein, W., Caban, J., Klein, R., Mezrich, R., et al. (2006). Radio frequency identification systems technology in the surgical setting. *Surg Innov, 13*(1), 61-67.

Newcomer, E. (2002). *Understanding Web Services: XML, WSDL, SOAP, and UDDI*. Boston: Addison-Wesley.

Page, L. (2007). Hospitals tune in to RFID. *Mater Manag Health Care, 16*(5), 18-20.

Sandler, S. G., Langeberg, A., Carty, K., & Dohnalek, L. J. (2006). Bar code and radio-frequency technologies can increase safety and efficiency of blood transfusions. *Labmedicine, 37*(7), 436-439.

Sedlmayr, M., Becker, A., Münch, U., Meier, F., Prokosch, H.-U., & Ganslandt, T. (2009). Towards a Smart Object Network for Clinical Services. *AMIA Annu Symp Proc*(accepted, to appear).

Tzeng, S.-F., Chen, W.-H., & Pai, F.-Y. (2008). Evaluating the business value of RFID: Evidence from five case studies. *International Journal of Production Economics, 112*(2), 601-613.

van der Togt, R., van Lieshout, E. J., Hensbroek, R., Beinat, E., Binnekade, J. M., & Bakker, P. J. (2008). Electromagnetic interference from radio frequency identification inducing potentially hazardous incidents in critical care medical equipment. *JAMA, 299*(24), 2884-2890.

Vilamovska, A.-M., Hatziandreu, E., Schindler, R., Oranje, C. v., Vries, H. d., & Krapels, J. (2008). Deliverable 1: Scoping and identifying areas for RFID deployment in healthcare delivery *Study on the requirements and options for RFID application in healthcare* (Vol. TR-608-EC). Brussels: RAND Europe.

Want, R. (2006). An introduction to RFID technology. *Pervasive Computing, IEEE, 5*(1), 25-33.

Wentz, B., Kraska, D., Knispel, S., & Prokosch, H.-U. (2005). 10 Jahre Erlanger Kommunikationsdrehscheibe-der Weg zu einer zukunftssicheren Integrationsplattform *50. Jahrestagung der Deutschen Gesellschaft für Medizinische Informatik, Biometrie und Epidemiologie (gmds), 12. Jahrestagung der Deutschen Arbeitsgemeinschaft für Epidemiologie*. Freiburg im Breisgau: Deutsche Gesellschaft für Medizinische Informatik, Biometrie und Epidemiologie.

Wessel, R. (2006). German Clinic Uses RFID to Track Blood. *RFID Journal*. Retrieved from http://www.rfidjournal.com/article/articleview/2169/1/1

Perspectives on E-Health: the human touch

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1. E-Health

The multidisciplinary nature of E-Health has resulted in a plethora of definitions focussing on one or more of the following themes: information and technology technologies (ICTs), process-driven activities and people-focussed dimensions. These three aspects are also the essential components of contemporary Knowledge Management (KM) which results from the intersection of people, process and technology [1,2]. As with KM, when discussing people-centric issues, there is inevitable cross-over with process and technology issues as all three of these concepts are inextricably linked.

In essence, E-Health has at its core the intent to effectively share health information by way of technology. The term E-Health "…characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology" [3]. Due to the potentially wide definitions of the term, the NHS Service Delivery and Organisation (SDO) Programme has funded mapping projects to understand the field. Literature review articles have identified the range of E-Health definitions used worldwide [4,5]. Even though these definitions address a wide array of areas within healthcare, the benefits of E-Health are universally accepted and include:

- supporting the delivery of care tailored to individual patients
- improving transparency and accountability of care processes
- facilitating shared care across boundaries
- patient-centric care delivery
- aiding evidence-based practice and error reduction
- improving diagnostic accuracy and treatment appropriateness
- improving access to effective healthcare by reducing barriers created (physical location or disability)
- facilitating patient empowerment for self-care and health decision making
- improving cost-efficiency by streamlining processes, reducing waiting times and waste [6].

Much of the current E-Health literature focusses on the role of technology. Whilst technology is integral to the success of E-Health initiatives, we must also understand the importance of process and people. This paper will focus on the people issue and will provide an overview of key concepts. Brief case studies will be presented which illustrate how people-centric activities are central to E-Health success.

1.1. Examples of people-based issues in E-Health

1.1.1. Social Networks

In its simplest form, a social network is a structure comprised of several nodes (entities which could be companies, institutions or people) which are interconnected according to varying dependencies and interdependencies. These could include common interest, value, linkages and so forth. Given the myriad of different possibilities, the resulting visualization can often be very complex. Social Network Analysis (SNA) examines these relationships as linkages (ties) between nodes (the actors within the network). The social networks (and contacts) combine to form social capital, considered to be of vital importance for communities and individuals [7].

The fact that relationships matter is a key concept within social capital theory [8]. As interactions allow people to create communities and a sense of belonging, the rich experience of a trustworthy social network can produce great advantages to the individuals within the social network. The "trustworthiness" of the network is essential as trust between individuals (known persons within the network) has broader implications for people outside the network (strangers) with whom interactions (face-to-face) would eventually take place [9]. Without this essential interaction, trust breaks down causing major social problems. The NHS Faculty of Health Informatics has conducted special training sessions for its staff on social networking tools [10]. These training sessions were aimed at educating their staff on the various facets of social networking and to apply them for effective collaboration within NHS. Such networking tools increase the efficacy of delivering healthcare and also ensure that the people delivering them can actually enjoy doing their jobs [10].

The proliferation of web-based social networking includes recent phenomena such as wikis, blogging, chat, instant messaging, file sharing, file exchange, video and contact management. The "social" aspect (the ability for individual users within the trustworthy environment to "tag" important documents and items - thus saving valuable time for other interested users) has key advantages for contemporary organizations. When this is combined with opinion and fact-finding from individuals, these comment-based contributions can combine to provide the basis for a useful Community of Practice (CoP).

1.1.2. Community of Practice

The term "Communities of Practice" (CoP) refers to a network of people, working on the same or similar areas, coming together (either physically or virtually) to share and develop their collective knowledge [11]. The intention is that this would benefit themselves as individuals as well as the organization. Engagement in CoPs may be viewed as a way in which the individual helps establish his or her own identity and this identity relates to processes of change. CoPs may be within a subject discipline, or they may be within an application area that involves people from a variety of subject disciplines. Wenger explains practice as meaning - an experience which is of interest located in a process referred to as the negotiation of meaning. This negotiation requires active participation defined as "...the social experience of living in the world in terms of membership in social communities and active involvement in social enterprises ... it can involve all kinds of relations, conflictual as well as harmonious, intimate as well as political, competitive as well as cooperative" [11].

A schematic may help to explain the concepts. Figure 1 below depicts the "KARMAH Starwheel", a representation of a Community of Practice created and facilitated by the Knowledge Management for Healthcare (KARMAH) research subgroup (working under BIOCORE) at Coventry University, UK. Essentially, as the group's interests match those of KM within the healthcare environ, the span of knowledge is widespread, depicted by five distinct avenues: OB (Organizational Behaviour, including change management, strategy, ICTs, clinical governance), CI (Clinical Informatics and Engineering, including AI, cybernetics, expert systems), ET (Education and Training, including HRM, work study, industry-academic interfaces), PS (Privacy and Security, including technical, legal, ethical and organizational aspects), DM (Data Mining, including algorithms, knowledge discovery, genomic mining).

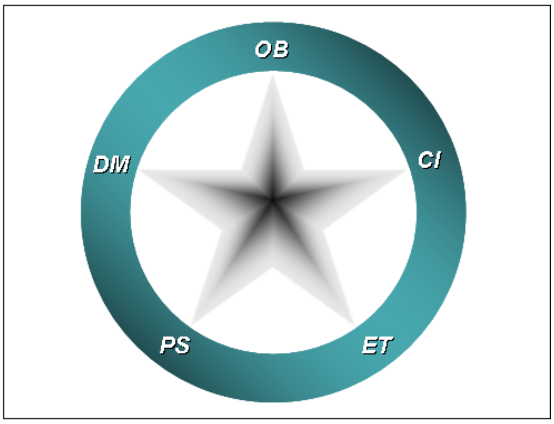

Figure 1: Example of a Community of Practice

Having recognized that the nature of Healthcare KM is such that a blend of key skills is required to achieve true progress in this rapidly evolving area, the "Starwheel" depicts the group's strategy for efficient sharing and debate of current knowledge in the field. The schematic shows how participants, with expertise and competencies in the given areas (e.g.. OB, CI etc) can bring key ideas to a central repository (the centre of the star) from which other members can draw/amend/add before returning back to the centre for final refinement. At the same time, members are free to interact by moving directly across the wheel. In this manner, it is envisaged that this will lead to an increased and rapid level of publication and/or collaborative projects for all active participants. This is a useful example of a multidisciplinary Community of Practice.

1.1.3. Organisational Development and Mess Management

Organisation Development (OD) refers to long term programme, led and supported by top management, to improve an organisation's visioning, empowerment, learning, and problem-solving processes, through an ongoing, collaborative management of the organisation's culture. There is special emphasis on the culture of intact work teams and other team configurations, particularly on the consultant-facilitator role and the theory and technology of applied behavioural science, including action research [12]. The approach: (1) emphasises goals and processes with emphasis on processes, (2) deals with change over medium and long-term, (3) is about people and recognises their worth, (4) involves the organisation as a whole as well as its parts and (5) emphasises the concept of a change agent/facilitator.

Some organisational scenarios, by the nature of their complexity and particular characteristics – such as E-Health, require a soft rather than a hard systems approach to change. The philosophy, value orientation and theoretical underpinnings of Organisation Development (OD) as a generalised example of soft systems models for change are ideally suited to E-Health initiatives. Factors such as power bases, organisational culture, leadership styles and changes in the organisation's environment can make organisational change a lot more complex and emotionally charged (or "messy") than traditional models of change can adequately deal with.

The traditional (hard systems) model of change is not likely to be effective for E-Health scenarios as the nature of the presented (and multidisciplinary) problems are defined differently by different stakeholders. E-Health systems are therefore inherently complex and quantitative criteria cannot always readily be agreed upon. Work by Ackoff [13] on "Mess Management" concludes that the issues involved with such complex scenarios should be "dissolved" (or "idealised"). This would involve three broad stages: (1) changing the nature of the problem context (or system) so as to remove the problem, (2) development-orientation (and therefore keen to improve the quality of organisational life for self and others), (3) redesign of the systems at various levels of the organisation in order to dissolve the problem.

2. Populomics

The healthcare domain not only provides challenging opportunities for managing knowledge but also is one of the areas where it is often most poorly understood and deployed. This predicament is slowly being addressed as more and more KM-focussed projects are initiated and healthcare professionals (and other stakeholders) with better understanding of KM are being involved. More family and community residents are becoming "caregivers" and "care providers". This shift is enhancing the impact of social, behavioural, community and economic realities on their therapeutic regimens and provider relationships. In short, the social and behavioural sciences, which traditionally had not been considered within the domain of healthcare, are increasingly recognized as fundamentally linked to illness, health and healthcare outcomes [14] while the need for an integrated approach to health research and healthcare is gaining appreciation, thinking across disciplinary lines can be challenging.

The growing realization of healthcare disparities is forcing clinical researchers to think about disease causation not only among individual patients, but also across entire groups or populations of people. Among patients who have vastly differing cultural beliefs and practices, diets, educational or literacy levels and socioeconomic resources, clinical practitioners and researchers developing interventions that ignore these sociocultural realities may struggle to demonstrate or maintain therapeutic efficacy across increasingly multicultural populations of patients. Focussing on electronic health care records, a growing number of patients want both access and control of their own information, large employers are exploring new methods to improve employee (and beneficiary) health while reducing healthcare costs and leading technology companies are anxious to offer an effective technology solution.

Increasingly, scientific evidence suggests that disease causation results from complex interactions of social, environmental, behavioural and biologic factors which simultaneously and often cooperatively act across more than one level of existence over time [15]. Thus a comprehensive understanding of health and disease requires the integration of knowledge derived from the bench, sociobehavioral and population sciences. Most historic and contemporary conceptual models of health though, have often been derived either from the socio-behavioural sciences *or* the biomolecular sciences. With the exception of those pathways based on stress (neuro-immunological) mechanisms, the published frameworks in the behavioural sciences and epidemiological literature largely lack clearly stated, causal biologic connections to observed health outcomes [16-20]. On the other hand, most biologically oriented formulations poorly account for socio-environmental and behavioural effect modifiers that may profoundly influence the pathogenesis of disease and the development of health disparities [21-24].

Populomics represents a new comprehensive way of studying health problems and crafting health solutions. It is being advocated by some officials at the National Institutes of Health as a new science that should be supported as the population level equivalent of genomics, which may lead to quantum leaps forward in understanding health challenges and developing new effective therapies and treatments [25]. The three case studies illustrate how KM and knowledge-based initiatives such as Populomics can be used to create powerful health outcomes.

Both Populomics and the people-centric theories described earlier can be applied to E-Health cases as they embody organisational processes that seek a synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings. We now present three case studies which illustrate the importance of human expertise as part of their E-Health focus.

2.1. Case exemplar #1: Breast Screening

Breast cancer is the most common cancer in women with over forty thousand women being diagnosed with the disease each year in the UK [26]. Any information related to the breast can largely affect a women's consciousness and a threat of breast cancer will have varying impacts on women psychology. Typically breast cancerous cells originate in the mammary glands (lobules) or in the ducts connected to these glands or in other tissues around these glands [27]. When in close proximity to the lymphatic system, these cells can result in being carried to other organs of the body. This subsequently results in cancerous growth in that organ and is described as metastatic breast cancer [27]. Although many causes had been identified for breast cancer, the knowledge of finding a cure is still not within the reach of modern medicine.

Breast cancer should ideally be diagnosed at the earlier stages of its development. Possible treatments include removing or destroying the cancer cells to avoid the spread of the affected cells. Breast Self Examination (BSE) is an effective and non-intrusive type of self diagnosis exercise for checking any abnormalities/lumps in the breast tissue. Unfortunately this greatly depends on the size of the lump, technique and experience in carrying out a self examination by the woman. An ultrasound test using sound waves can be used to detect lumps but this is usually suited for women aged below thirty-five owing to the higher density of breast tissue [27]. Having a tissue biopsy via a fine needle aspiration or an excision is often used to test the cells for cancer. These tests are mostly employed in treatments or post-treatment examination and as second rung diagnostic confirmation methods. Performing a Computed Tomography (CT) or a Magnetic Resonance Imaging (MRI) scan would result in a thorough examination of the breast tissue but this technique is not favoured due to reasons including that it may not be economical, needs preparation, noisy, time consuming and images may not be clear.

2.1.1. Human dimensions of this case

The objective of this work was to identify the challenges which are being faced by the UK NHS' national breast screening programme and find approaches to alleviate these impediments and eventually reduce mortality due to breast cancer. When the algorithm is executed, the resulting knowledge can be shared with the GPs (with whom the women are registered) can initiate personally interventions. Such interventions can educate the non-attending women and clarify their attitudes and beliefs – this can only occur by way of human interaction (ie. doctor and patient). The expected outcome is that the women commits to a positive informed decision, which would culminate in attending the screening appointment. This work not only confirms that breast screening attendance can be predicted through an automated software solution, but also can be leveraged to increase screening attendance by employing emerging KM tools and techniques. This research work draws its strength from such KM tools and techniques. This work is also one such initiative addressing the NHS' breast screening attendance through efficient KM methodologies. A 25% success in GP interventions will result in saving more than 350 women's lives per year.

2.2. Case exemplar #2: Maternity Services

At its conception in 1948, the UK's National Health Service (NHS) held three core principles: (a) to meet the health care needs of everyone, (b) free at the point of delivery and (c) based on clinical need, and not the ability to pay. The aim was to create an uniform service combining all hospitals under one central system with the ideal that healthcare should be available to all regardless of wealth status. Sixty years on, the NHS is relatively uniform but with significant inequalities in service and quality of care with access to treatment. This case will examine some of the various KM issues induced by the introduction of ICTs into the NHS with a particular focus on Maternity Services.

Maternity Services were not particularly affected by various changes in policy and NHS maternity care is given without charge at the point of delivery. However, in comparison to other European countries, the UK Government has contributed approximately 1-1.5 per cent less to healthcare on an annual basis. This has been a contributory factor in the inadequacies of healthcare provided by the NHS today [34]. The NHS organization consists of multiple layers of health service providers each responsible for the procurement of their own IT systems. This has led to a vast amount of systems that have not been introduced in a coherent approach, therefore integration and sharing of information between providers and across the services has not been efficient or effective. In order to increase efficiency, effectiveness, equity and reduce risk, particularly at the point of care, The National Programme for Information and Technology (NPfIT) was introduced in 2002. Connecting for Health (CfH) is the Government agency responsible for the implementation of NPfIT. It is the largest civil technology program undertaken and is intended to unite separate NHS organizations. This is a centrally driven mandate.

2.2.1. Proposed changes within Maternity Services

Current NHS reforms aim 'to develop a patient led NHS that uses available resources as effectively and fairly as possible to promote health, reduce health inequalities and deliver the best and safest healthcare' [38]. Maternity organizations must therefore supply accessible, efficient, quality care. Services should provide care that is women focused considering individual needs of health status, culture, religion, social needs and disabilities. High quality, efficient Maternity Services are essential in contributing the attainment of the Department of Health's Public Service Agreement (PSA) targets [39]. In relation to Maternity Services, the PSA targets include: (a) reduction by 10% of health inequalities, measurable by infant mortality and life expectancy at birth, (b) a substantial reduction of mortality rates, (c) reduce by 1% per annum women who smoke in pregnancy, (d) reducing the under 18 year old conception rate and (e) increase breastfeeding rates by 2% per annum.

In addition, the Department of Health produced the *Maternity Standard, National Service Framework (NSF) for Children Young People and Maternity Services* (2004) identified as best practice guidance. The NSF is based on a care pathway approach which place value on women-focused care rather than meeting the needs of the service. In doing so, an emphasis is placed on evidenced-based procedures and guidelines representing a method for continuous quality improvement. Maternity care pathways will provide a system through which services will be integrated between primary, secondary and social services to provide comparable high quality effective clinical care.

The large scale and constituents of the work force will have a major impact of change within the NHS. In comparison to other countries the UK has a lower number of health care professional per population [35]. Recruitment and retention of staff in some services, particularly midwifery, create significant difficulties and can seriously effect patient care. The NHS Plan proposes new ways of working to reduce professional barriers resulting in a more flexible workforce between staff groups. In addition, it aims to increase the amount of skilled workforce. Nurse Practitioners/Midwives could assume 20 per cent of doctor's work, whilst Health Care Assistants (HCAs) could perform duties of the Nurse/Midwife workload. This skill mix change would increase the workforce capacity. However significant investment in IT would reduce administration time allowing increased time providing patient care.

The aim is to electronically connect all 50 million plus patient records, allowing access by patients and health professionals in over 30,000 General Practitioners (GP) Practices and 300 hospitals. It was envisaged that during an incremental period of ten years, NPfIT will bring modern computer systems into the NHS changing the way the NHS works to improve patient care and services. However, the formation of a single demographic database gives rise to many concerns. In particular, how this information will be used, by whom and how patient confidentiality and security will be maintained are common themes amongst those resistant to a national database. Many patients and clinicians are concerned that the system is not secure [36]. A number of clinicians are sceptical of the need for integrated records via a national database, as systems already exist for locality data sharing between relevant GP's and hospitals 'without the need to leave a copy of the information on the nationally accessible database' [37]. In order to satisfy patient concerns and control access, the consequence of illegal misuse of data from the databases may require greater legal penalties than the current financial ones.

2.2.2. Human dimensions of this case: patient expectations

Patients today are better informed with access to better information regarding treatment, management and prevention of illness and diseases. Patients have rights to informed consent but also demand informed choice of type and place of their care. Healthcare does not meet patient expectations particularly regarding access of care and waiting times for treatment. In addition, the health service is not yet sufficiently patient-centred; the Wanless Report included survey evidence showing that patients commonly feel that they have insufficient involvement in decisions, there is not one to talk to about anxieties and concerns, tests and treatment are not clearly explained with insufficient written information provided. A survey by the Department of Health in 2005 observed that women using NHS Maternity Services would have preferred more choice in type of care and place of delivery. Certain geographical locations have experienced an increase in European migrants which has had an impact on Maternity Services, particularly with language difficulties. For local Trusts there are cost implications involving translators and written forms of communications that are not met centrally. With widening access to current maternity health care information, for example via the internet, the general public are more assertive and better informed to demand change within Maternity Services.

2.3. Case exemplar #3: Effective Humanitarian Aid

Several countries within the EU have become robust in the area of E-Health, combining challenging research and educational activities with active development work involving industry and healthcare professionals. State-of-the art E-Health applications, electronic patient records and secure broadband networks will improve the quality of delivered healthcare services equally regardless of distance between the healthcare provider and the patient.

Ongoing work, led by a consortium of EU-based partners (the UK, Finland and Germany), has the ability to generate new, innovative, and user-friendly E-Health applications, monitoring and diagnostic devices to support the distribution of healthcare in a new holistic way. One of the specific regional characteristics of the Finnish partners in this consortium is the sparsely population in a large geographical area. This aspect, in conjunction with increasing healthcare costs and the growing problem of healthcare professionals emigrating, creates a conflict between the legislation which defines equal healthcare services to all citizens. It has led to a situation, where healthcare policy makers, researchers and healthcare professionals have been compelled to deliver healthcare services in new, even radical, methods.

This case examines the efficacy of a secure, usable and effective clinical information network for the advancement development of a suitable grid methodology to support humanitarian aid work. The hypothesis of the work is based on the conception that special healthcare services can be provided equally to developing countries alike in industrial countries. By utilizing new information and communication technology it is possible to distribute and deliver the best knowledge available provided by different specialists acting in the healthcare sector. This proposed approach can be seen as a generic model for the existing phenomena to provide humanitarian aid. Medical imaging has been chosen as a specific special healthcare sector in order to validate the new service model. The work aims to provide proven evidence of the best ways for humanitarian aid organizations to utilize grid methods to support the operative work. This research aims to generate well defined and theoretically proven methods and guidelines to utilize GRID method in supporting humanitarian aid work. The objectives are to coordinate and support research activities in order to establish a secure infrastructure-based service. This service would ultimately aim to:

- overcome the lack of qualified healthcare specialists
- establish trustworthy cross-border data transmission
- improve patient treatment and optimize existing healthcare resources
- use existing healthcare resources for humanitarian aid purposes
- provide a powerful tool for the development of expert databases relating to specific disease areas particularly for rare disorders, where clinical data sharing will expand and enhance knowledge relating to diagnosis and treatment

The chief outcome from research will be an increase in the quality and efficiency of humanitarian healthcare delivery through the secure outsourcing (and resource balancing) of clinical data. Other outcomes include the definition and dissemination of the necessary organizational and technological changes required to deliver these improvements, with a view to continually extending the technology to include an increasing range of clinical applications. These outcomes are envisaged in order to provide a high profile focus that can bring together the various multidisciplinary aspects of work.

2.3.1. Human dimensions of this case

The results would also raise the profile of new ways of working for people and organisations in the field of humanitarian aid and inform the end users of issues concerning secure, cross-border and cross-cultural, transfer of clinical knowledge. This would bring interdisciplinary expertise to bear upon key and fundamental issues as well as developing a deeper understanding of human decision-making for effective humanitarian aid

3. Conclusion

Our current work includes additional research continuing to investigate the human dimensions of the three cases. For all of the given case studies, the knowledge created is useful for contemporary E-Health. The outcomes leverage the health knowledge created in order to share it with the health-care deliverers to alleviate the particular predicaments faced, be they increasing uptake of breast screening, fostering better access to maternity services or fostering better humanitarian aid. Such work has direct synergies with the central component of Populomics, one of the key aims of which is to reduce disparities and inequalities. Although the role and importance of E-Health for the three provided case scenarios are central to their success, their focus on large patient communities empowers Populomics to add its inherent value to the case studies. Socio-behavioural factors and community-wide risk profiles can be integrated into the existing knowledge-based initiatives as, in combination, Populomics and E-Health can come together to produce a powerful focus for current and future, patient-focussed, practice. We encourage researchers in similar fields to include Populomics into relevant E-Health studies.

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References

[1] R.K. Bali, N. Wickramasinghe and B. Lehaney. *Knowledge Management Primer*, Routledge:USA, 2009.

[2] N. Wickramasinghe, R.K. Bali, B. Lehaney, J. Schaffer and M.C. Gibbons. *Healthcare Knowledge Management Primer*, Routledge:USA, 2009.

[3] G. Eysenbach, Editorial, *Journal of Medical Internet Research*, 3(2):e20, 2001.

[4] C. Pagliari, D. Sloan, P. Gregor et al. What is eHealth?: a scoping exercise to map the field. *Journal of Medical Internet Research*, Mar 31;7(1):e9, 2005.

[5] H. Oh, C. Rizo, M. Enkin and A. Jadad. What is eHealth: a systematic review of published definitions. *Journal of Medical Internet Research*. Feb 24;7(1), 2005.

[6] OpenClinical.org. E-Health [online], [updated 13 Sept 2005; cited 24 April 2010]. Available from http://www.openclinical.org/e-Health.html.

[7] R.D. Putnam, L. M. Feldstein and D. Cohen. *Bowling Alone: The Collapse and Revival of American Community*. Simon & Schuster: New York, 2000.

[8] J. Field, *Social Capital*, Routledge: London, 2003.

[9] C. Beem. *The Necessity of Politics: Reclaiming American public life*, University of Chicago Press: Chicago, 1999.

[10] NHS Faculty of Health Informatics. The power and the perils of using social networking tools in the NHS [online]. 2008. Available from: http://kingsfundlibrary.co.uk/commissioning/Social-networking-tools-in-the-NHS-FINAL%5B1%5D%5B1%5D.pdf (last accessed 13 March 2010).

[11] E. Wenger. *Communities of Practice: Learning, Meaning, and Identity*, Cambridge University Press: Cambridge, 1998.

[12] W.L. French and C.H. Bell, *Organisation Development: Behavioural Science Interventions for Organisation Improvement*, Prentice-Hall: Englewood Cliffs, 1995.

[13] R. Ackoff. "From Mechanistic to Social Systematic Thinking", *Systems Thinking in Action Conference*, Pegasus Communications, Inc., 1993.

[14] Galea S, Vlahov D (2005) Urban health: Evidence, challenges and directions. *Annual Review of Public Health*, 26:341–65

[15] Gibbons MC, Brock M, Alberg AJ, Glass T, LaVeist TA, Baylin SB et al. (2007) The Socio-biologic integrative model: Enhancing the integration of socio-behavioural, environmental and bio-molecular knowledge in urban health and disparities research. *Journal of Urban Health*, 84(2):198-211

[16] S. Macintyre. The Black Report and beyond: what are the issues?, *Soc Sci Med*, 44(6), 723-745, 1997.

[17] D. Acheson. Independant Inquiry into Inequalities in Health, UK Department of Health: London, 1998.

[18] D. R. Williams. Race, socioeconomic status, and health: The added effects of racism and discrimination, *Ann NY Acad Sci*, 896, 173-188, 1999.

[19] M. LaLonde, A new perspective on the health of Canadians, Government of Canada, 1981.

[20] R. G. Evans and G. L. Stoddart. Producing health, consuming health care, *Soc Sci Med*, 31(12), 1347-1363, 1990.

[21] R. Burger and A. Gimelfarb. Genetic variation maintained in multilocus models of additive quantitative traits under stabilizing selection, *Genetics*, 152(2), 807-820, 1999.

[22] T. J. Phillips and J. K. Belknap. Complex-trait genetics: emergence of multivariate strategies, *Nat Rev Neurosci*, 3(6), 478-485, 2002.

[23] A. M. Sharma. The thrifty-genotype hypothesis and its implications for the study of complex genetic disorders in man, *J Mol Med*, 76(8), 568-571, 1998.

[24] J. M. Meyer and J. C. Breitner. Multiple threshold model for the onset of Alzheimer's disease in the NAS-NRC twin panel, *Am J Med Genet*, 81(1), 92-97, 1998.

[25] Office of Behavioral and Social Sciences Research (OBSSR), *Strategic Plan*, 2010. http://obssr.od.nih.gov/about_obssr/strategic_planning/strategicPlanning.aspx (last accessed 3 May 2010)

[26] Cancer Research UK. CancerStats Incidence-UK. 2005. http://www.cancerresearchuk.org/aboutcancer/statistics/statsmisc/pdfs/cancerstats_incidence_apr05.pdf (last accessed 10 August 2005).

[27] American Cancer Society Inc. Cancer Reference Information [online]. 2005. Available from: www.cancer.org/docroot/CRI/content/CRI_2_4_1X_What_is_ breast _cancer_5.asp> [10 August 2005].

[28] R. G. Blanks, S. M. Moss, C. E. McGahan, M. J. Quinn et al. Effect of NHS breast screening programme on mortality from breast cancer in England and Wales, 1990-8: comparison of observed with predicted mortality. *British Medical Journal*, 321, (7262) 665–9, 2000.

[29] G. Burton. *Alternative Medicine*. Future Medicine Publishing: Washington, 1997.

[30] P. Forrest. *Breast Cancer Screening - A report to the Health Ministers of England, Scotland, Wales and Northern Ireland*, HMSO: London, 1986.

[31] Medicine net. *Breast Cancer*, 2002. http://www.medicinenet.com/breast_cancer/page3.htm (last accessed 10 August 2005)

[32] NHS Review. *The Breast Screening Programme Annual Review 2005*, 2005. http://www.cancerscreening.nhs.uk/breastscreen//publications/ 2005review.html (last accessed 14 July 2007)

[33] Cancer Research UK. *Breast Cancer Factsheet.* 2004. http://publications.cancerresearchuk.org/epages/crukstore.sf/en_GB/?ObjectPath=/Shops/crukstore/Categories/BrowseBySubject/BreastCancer (last accessed 18 September 2004)

[34] C. Bankhead, J. Austoker, D. Sharp, T. Peters, et al. A practice based randomized controlled trial of two simple interventions aimed to increase uptake of breast cancer screening., *Journal of Medical Screening* 8(2), 91-98, 2001.

[35] D. Wanless. *Securing our Future Health: Taking a Long-Term View*. HMSO: London. 2002.

[36] J. Carvel. *NHS plan for central patient database alarms doctors*, The Guardian, 21 November 2006.

[37] D. Leigh. What health professionals say about the new NHS database, *The Guardian*, 1 November 2006.

[38] Department of Health, *Health Reform in England: update and commissioning framework*, HMSO: London, 2006.

[39] HM Treasury. *Spending Review: Public Service Agreements 2005-2008*, HMSO:London, 2004.

Why RFID projects in hospitals (necessarily) fail

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Abstract
Innovative technologies like RFID offer new opportunities for hospitals to improve clinical processes and quality. However, introducing innovations in the field of information technology (IT) differs from other IT projects. Implementations often seem to be motivated by a bandwagon effect, which is a dangerous attitude especially in life-critical processes in the healthcare sector. This article describes learnings from comparative case studies about the introduction of RFID technology for patient tracking in hospitals.

1. Why RFID projects are compelling for healthcare

New information technologies usually offer new, innovative opportunities for businesses. Using the example of hospitals, innovative clinical processes can improve medical quality and thus save lives. In addition to the improvement of medical processing, information technology promises to solve economic challenges like process redesign or data handling.

Although there is hardly any doubt about the generation of competitive advantages from IT investments, it is still a complex and crucial question for managers whether and when to innovate with IT (Swanson and Ramiller 2004). Many organizations do not have either the competence or the motivation to make such decisions in an appropriate manner. They often couple decisions on IT investments to the behavior of other institutions. Such behavior can often be observed in practical IT cases, and can be characterized as "jumping on the band-wagon" phenomenon (Abrahamson 1991).

By showing "bandwagon" or "me too" behavior, institutions tend to copy innovative behavior or success stories from others. This should be regarded as commonplace and unsurprising. For many institutions it is an insolvable challenge to determine their specific needs for IT innovations. They are not capable to fully adopt innovations to the particular circum-stances of the organization itself. Following some widely touted "best practice" they try to avoid mistakes in a field, which they largely not understand (Swanson and Ramiller 2004). This is potentially more dangerous in healthcare than in other fields, because mistakes are usually fatal.

In particular, hospitals are high reliability organizations (HROs) (Weick and Sutcliffe 2001) where the scale of consequences prohibits learning by experimentation. HROs, like hospitals and other healthcare organizations operate in an environment in which it is easy to make mistakes and where errors normally come along with fatal consequences. Learning by experimentation is intolerable and thus organizational mindfulness should be a basic requirement.

However, just staying away from new technology is not an option either. On the one hand, a growing concern for cost-effective processes in hospitals is a main driver for a successful adaptation of information technology in many areas. On the other hand, the particular capabilities and resources of the innovative organization help to develop competitive advantages. In the following section, we discuss that issue with the use case of RFID-supported patient logistics.

2. Supporting Patient Logistics with IT

In classical information systems, a centralized scheduler using allocation rules creates an optimized appointment plan; however, due to the high dynamics of the hospital environment, the appointments have to be constantly adapted. This way scheduling becomes a continuous, never-ending process. Especially in life-crucial environments, as in hospitals, any hold-ups can have severe consequences. This chapter addresses a flexible real-time reaction to hold-ups. Scheduling patient logistics can be regarded as an ill-structured task, since it requires the assessment of treatment priorities and the allocation of resources, e.g. doctors' time and availability. Unforeseeable hold-ups due to emergencies, delayed patients and varying treatment times prevent a complete advance mapping of the entire tasks and thereby a reliable planning of individual treatment schedules.

Various planning goals compete with one another. A minimum throughput time of patients and a maximum allocation of resources cannot be simultaneously optimized. Different scheduling mechanisms work in parallel. Outpatients are summoned to prefixed appointments; emergency patients always lead to a real-time adaptation of whatever schedule exists at that point in time and inpatients are summoned from the wards in the event of under-allocated resources. All three scheduling types have in common that, for treatment, patients need resources in the form of a doctor and diverse medical equipment.

However, even when only a limited number of auxiliary conditions are observed, this is an NP-hard problem due to the exponential number of alternate solution paths (Garey and Johnson 1979). The non-observance of dependencies on other appointments, the full utilization of the resources and the aims of the actors would create further disruptions in a 'domino effect' and thereby lead to a generally less efficient coordination result. Because the requirements and general conditions in a hospital are not precisely known in advance, uncertainty is inherent in the system and makes exact planning almost impossible. Job-shop scheduling using deterministic data cannot be applied, as hospital processes cannot assume having a given quantity of orders, production facilities and constant processing time..

Radio Frequency Identification Technology (RFID) proposes some solution to this problem, by allowing consistently and continuously tracking and locating actors in the hospital environment. RFID-tagged resources are a rather simple technology, consisting of RFID transponders (tags) and RFID readers. While readers have a fixed location within a building, tags identify individual actors and must be with their particular actor at all times. Since tags are very small, they could be embedded in identification badges for medical staff or in wrist-bands for patients. Often, the technical configuration mostly comprises RFID readers on door frames and RFID tags on all movable resources, whose change in location can be recorded in the physical world and transmitted to the information system. The resources generate a data stream when they pass through the doors, which yield location information through pre-processing in the receiver process and logical interconnection with the previous location.

The main goal is to allocate all resources in the hospital in a near optimal manner, in order to reduce waiting times for patients and idle times for medical staff and (potentially expensive) equipment. In addition, RFID allows for further benefits, such as secure identification of patients to avoid application of mixed up medications. Even if a complex, realtime scheduling information system is the final goal, applying RFID wristbands for patients, just for identification, is a valuable first step with its own business case. Already in this simple use case, physical hospital procedures can be supported by providing a constant up-to-date picture of the locations of hospital resources and actors. It is not surprising that RFID wristbands have been one of the main innovation ideas of introducing the "Internet of Things" into the hospital environment.

In the "Internet of Things", we thus divide the application scenario into the physical world and its information system model, the logical world as seen in Figure 1. The physical world encompasses the concrete, tangible hospital environment, which is occupied by patients, physicians and other hospital staff. Parameters of the physical world, such as the location of a resource, the current task of a physician and the waiting time of a patient are sensed by information technology and modelled using digital data structures of the logical world. The projection of the physical world generates a logical mirror image, which is closer to reality the more often the projection is made – preferably in real time (Hohl et al. 2004). At the same time, the complex real world data is retrieved in digitalized form – the mirror image is always a simplified model. The logical mirror image enables hold-ups and alternative treatment paths to be identified and is the precondition for further flexible reactions.

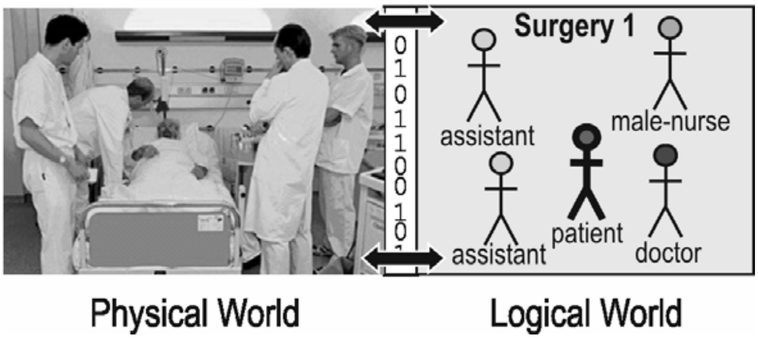

Figure 1. Physical and logical world

It becomes clear that the "Internet of Things" is more a vision than a concrete, procurable piece of software. At the same time, it should be clear that this vision could be something that is useful for hospitals and other healthcare facilities in the long run. The question is then, under what prerequisites and conditions would a healthcare institution "buy" this vision and start implementing RFID wristbands – and under which conditions would it abstain from doing so, be contempt with its running processes and rely on "never change a running system"? In general: how can innovative information technology find its way into hospitals?

3. A framework for innovating healthcare institutions

We use a model from process research (Soh and Markus 1995) as a foundation to derive a theoretical framework, and to develop propositions to explain the impact of the "Internet of Things" on clinical processes.

In their work, Soh and Markus developed a process model by joining different research approaches. Their goal was, to explain causes and effects between IT investments and the resulting benefit for the company. This benefit is defined as „*improved organizational performance*“for the organization. It comprises the benefit from changing one or more processes – the source of the benefit are thus not external market return figures, but the increased performance within the company.

In this paper, we use that concept as a theoretical framework for an explorative analysis of the impact of RFID systems of hospital processes. Our goal is to investigate which influences are dominant, and which are moderators. A particular question is the differences that arise from the original concept of Soh and Markus, when applied to hospitals as *High Reliability Organizations.*

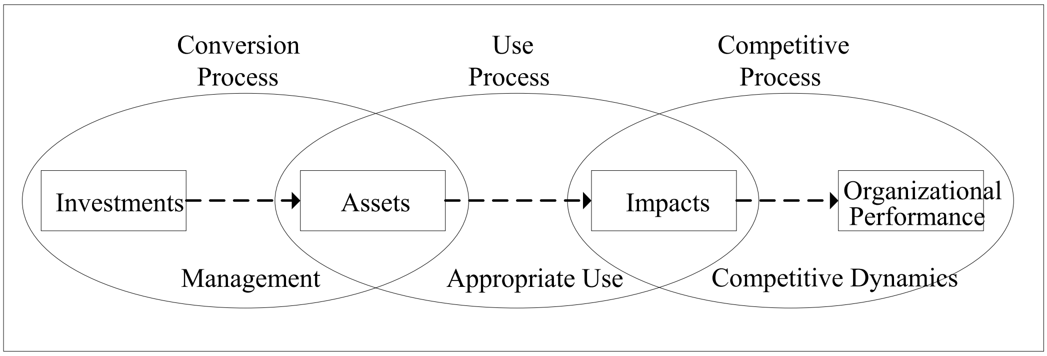

Figure 2: The original process model of Soh/Markus

The total model is a synthesis of three individual process models. The *Conversion Process* discusses the implementation of information technology; the *Use Process* looks at the successful (or not) usage of the technology within the organization; and the *Competitive Process*, which points at the changes in the competitive position of the organization in its external market. These three process build upon each other and form a cumulative model that depicts cause-and-effect-relations from the investment decision until the generation of lasting profit for the organization. To achieve a successful result in total, all single processes have to be organized accordingly. In practice, many innovation processes in hospitals fail – this is due to a multitude of limiting factors and conditions.

The focus of the *Competitive process* is on the organization in its competitive market environment. With regard to hospitals, this would require to define a customer side (individual patients, or independent health practitioners who admit patients to hospitals), however, this is on the one hand very specific for the different regional healthcare systems, on the other hand is RFID an information technology that works foremost on the internal processes. According to Hitt and Brynjolfsson (1996), the relation between competitive market position and investments in information technology is less than clear anyway.

So, for the remainder of the paper, we will abstain from discussing the competitive process further and concentrate of the proceeding parts of the Soh/Markus model, the internal process of the hospital. The *business value* of the *Conversion process* is based on these changed internal processes anyway. If their performance can be influenced by using RFID, even without looking at the competition between hospitals this very change gives us information about the effects of using RFID. In total, the changed innovation process model is given in Figure 3. In addition, we also want to look at complementary and contextual influences, for example the technology acceptance and the influence of the work satisfaction of hospital staff and patients on the process performance.

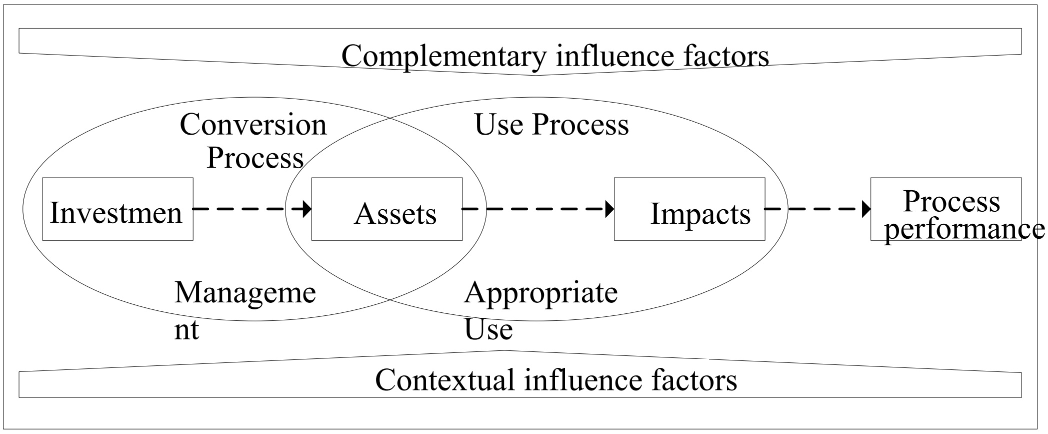

Figure 3: Application of the process model to hospitals

4. Results from explorative case studies

Our information comes from experts who knew about implementation and use of the analyzed solutions. In total, we have looked at about 20 RFID wristband projects in the German-speaking countries, and sampled information about ca. 60 RFID projects worldwide. The experts were physicians and nurses (users), system developers and technology manufacturers (supplier), hospital managers and administrative staff (customers). In addition, we considered patients' experiences (technological users), because of the service character of the healthcare service, patient's cooperation is a necessary prerequisite for the successful use of the technology. Based on this expert survey (by telephone and personal interviews in the second half of 2009), a general analysis and interpretation of the results were done.

The result shows that RFID solutions could only partly fulfill the high expectations in the hospitals, so that the judgment of the earnings becomes ambivalent. On the one hand, the hospitals were capable of implementing and running the planned IT systems. On the other hand, however, it was not possible to demonstrate economic efficiency. In addition, during implementation and use many new problems arose, so that we could identify relevant factors and influences on the process performance that were not accounted for earlier. We will briefly sketch those "lessons learned" here.

One of the most important factors is still the usability of the IT systems. Criticized by many, the necessary identification link between RFID tag and patient could not be guaranteed for the whole duration of the treatment process. In all systems, sometimes due to technical restrictions, but very often due to incorrect handling on the side of the hospital staff, some degree of uncertainty cumulated over time of the process. If the identification of the patient cannot be assured and needs to be re-checked by offline measures, the business case of the technology is clearly at stake.

Material costs are another issue, particularly when comparing RFID to e.g. barcode printed on paper. The tag (and reader) costs had not decreased so fast as promised, so that at the end of the duration of the projects under investigation, there still was no positive business case.

Common to all wireless computing projects, unclear results concerning electromagnetic interference with other medical equipment contributes to mixed conclusions. After a report by the University of Amsterdam that raised doubts, several systems had been proactively de-installed. The non-existence of technological standards and commonly accepted frequency bands currently allows only for beacon or research projects. The problem is not so much a technological one, but refers directly to the High Reliability Organization (HRO) status of a hospital; the hospitals need proof that the technology is risk free. This could be achieved by extensive testing leading to document electromagnetic compatibility certificates by ISO, IEEE and other standard bodies – however, this process needs time and financial resources.

Installation of RFID in hospitals was another issue, as it requires domain-specific knowledge. In most projects, the technology provider comes from other industry sectors, such as automotive or logistics. Because of the high individuality and flexibility of hospital processes, established concepts from other application domains can fail even for superficially simple functions. Technology providers should thus be capable to provide flexible systems which can adapt to a rapidly changing environment (e.g. medical emergencies) and react to process changes that nobody could have predicted. According to our research, the existing IT systems cannot match these requirements by far.

The primary recipient suffering from negative effects by mindless innovation is the end user, both the patient, but also the hospital staff. In hospitals individual healthcare services are defined under great mental stress of the employees. If they are unconfident, frustrated and confused by the new technology, it is hard to imagine that they will totally adopt it. Unclear communication between hospital administration and hospital staff in combination with ambivalent information about RFID in the public media is a major influence for possible non-acceptance by staff members. Fearing absolute transparence of staff work times and 100% tracking of personal activities throughout the day created a bigger problem than expected. This requires a common understanding of clinical and non-clinical staff, and hospital managers about the usefulness of the technology and the reasons for its introduction to the hospital environment.

Contrary to earlier expectations, patient satisfaction was not an issue in the projects analyzed. Being positive towards a new technology is not a patient issue, but seems to be linked with the preceding factor. If the hospital staff is technologically open-minded, this feeling is transferable to the patient. The particular point in time is the patient education phase at the very beginning of the treatment. In this phase, the patient is brought into contact with RFID wristbands for the first time, and the hospital staff explains their use and utility. A negative technological attitude by the hospital staff transfers here as well as a positive one.

Summarizing, currently only those hospitals should consider introducing RFID which already have intensive knowledge about their process and a running integrated hospital information system, favorably implementing an electronic health record. In this environment, RFID technology can unfold its potential at best, as long as the still high investment and operation costs can be justified.

Reference List

ABRAHAMSON, E. (1991): Managerial Fads and Fashions: The Diffusion and Rejection of Innovations. In: The Academy of Management Review, Jg. 16, H. 3, S. 586–612.

BRYNJOLFSSON, E., HITT, L. (1996): Paradox lost? Firm-level evidence on the returns to information systems spending. In: Management Science, Jg. 42, S. 541□558.

GAREY, M.R., JOHNSON, D.S. (2009): Computers and intractability. A guide to the theory of NP-completeness. 27. print. New York u.a: Freeman (A series of books in the mathematical sciences).

HOHL, A., NOPPER, N., EYMANN, T. (2004): Automatisierte und Interaktive Kontextverarbeitung zur Unterstützung der Patientenlogistik. In: Kirn, Stefan; Anhalt, Christian; Heine, Christian (Hg.): Mobiles Computing in der Medizin. Proceedings zum 4. Workshop der GMDS-Projektgruppe Mobiles Computing in der Medizin, Universität Hohenheim, Stuttgart, 19.-20. April 2004. Aachen: Shaker (Berichte aus der Medizinischen Informatik und Bioinformatik), S. 14–26.

KIRN, S. (2006): Flexibility of Multiagent Systems. In: Kirn, S.; Herzog, O.; Lockemann, P.; Spaniol, O. (Hg.): Multiagent engineering. Theory and applications in enterprises. Berlin: Springer (International handbooks on information systems), S. 53–69.

NIEMANN, C., EYMANN, T. (2006): Softwareagenten in der Krankenhauslogistik – ein Ansatz zur effizienten Ressourcenallokation. In: HMD - Praxis der Wirtschaftsinformatik, H. 251. Online at http://hmd.dpunkt.de/251/07.html.

SOH, C., MARKUS, M. L. (1995): How IT Creates Business Value: A Process Theory Synthesis. In: DeGross, J.; Ariav, G.; Beath, C.; Hoyer, R.; Kemerer, C. (Hg.): Proceedings of the Sixteenth International Conference on Information Systems, December 10□13, 1995. Atlanta, GA: Association for Information Systems, S. 29□41.

Swanson, E. Burton; Ramiller, Neil C. (2004): Innovating mindfully with Information Technology. In: MIS Quarterly, Jg. 28, S. 553□583.

WEICK, K. E., SUTCLIFFE, K. M. (2007): Managing the unexpected. Resilient performance in an age of uncertainty. 2. ed. San Francisco, Calif.: Jossey-Bass.

ZWICKER, F., REIHER, M., EYMANN, T. (2006): RFID im Krankenhaus – neue Wege in der Logistik. In: Eymann, Torsten; Hampe, J. Felix; Koop, Andreas; Niemann, Christoph (Hg.): Mobiles Computing in der Medizin. 6. Workshop der GMDS-Arbeitsgruppe Mobiles Computing in der Medizin, Frankfurt, 2. Juni 2006. Aachen: Shaker Verlag (Berichte aus der Medizinischen Informatik und Bioinformatik), S. 68–74.

Designing an intelligent risk detection framework using knowledge discovery techniques to improve efficiency and accuracy of healthcare care decision making[1]

N. Wickramasinghe, F. Moghimi and J.Schaffer

Abstract

As we enter into the next decade of the 21st century it becomes even more important for all organizations to maximize their knowledge assets. One industry that must pay great attention to this if it is ever going to stem the ever increasing costs and provide superior patient centric care is the healthcare industry. To date a noted laggard with respect to embracing key tools and techniques of the knowledge economy the following serves to outline the important role for the application of knowledge discovery techniques to improve efficiency and accuracy of healthcare decision making.

1. Introduction

Effective decision making is vital in all healthcare activities. While this decision making is typically complex and unstructured, it requires the decision maker to gather multi-spectral data and information in order to make an effective choice when faced with numerous options. Unstructured decision making in dynamic and complex environments is challenging and in almost every situation the decision maker is undoubtedly faced with information inferiority. The need for germane knowledge, pertinent information and relevant data are critical and hence the value of harnessing knowledge and embracing the tools, techniques, technologies and tactics of knowledge management are essential to ensuring efficiency and efficacy in the decision making process. The systematic approach and application of knowledge management (KM) principles and tools can provide the necessary foundation for improving the decision making processes in healthcare. A combination of Boyd's OODA Loop (Observe, Orient, Decide, Act) and the Intelligence Continuum provide an integrated, systematic and dynamic model for ensuring that the healthcare decision maker is always provided with the appropriate and necessary knowledge elements that will help to ensure that the healthcare decision making process outcomes are optimized for maximal patient benefit. The example of the orthopaedic operating room processes will illustrate the application of the integrated model to support effective decision making in the clinical environment.

2. Background

As the population ages, an increasing number of people will experience debilitating degenerative arthritis of the knee and hip joint. In degenerative arthritis, the articular, gliding surface of the joint becomes worn and exposes the underlying bone of the joint. This is a painful condition for which

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patients seek medical care to decrease their pain and increase their functional status. In fact, the number of persons age 65 or older is expected to double between the year 2000 and the year 2040(US Census Bureau, 2008). One of the most successful procedures in the treatment of knee and hip arthritis is to replace the worn surfaces with the metal and plastic components of a hip or knee joint replacement. This procedure is completed in a hospital's operating room; the patient stays in hospital for a few days to start their recovery and is then discharged to home or a rehabilitation facility for further rehabilitation. Within the next twenty years, domestic demand for joint replacements is expected to increase by 174% for hips and 673% for knees (Kurts et al., 2007). The demands on the healthcare system for effective decision making in this patient population will be staggering.

3. Challenges

Once the patient's arthritis is end-stage and the articular cartilage is worn away, patients with painful degenerative arthritis will seek the expertise of an orthopaedic surgeon. Replacement of the degenerative surfaces of the hip and knee joint has become one of healthcare's most successful procedures in terms of providing the patient with pain relief and improved function. These operations are performed by the surgeon in a hospital in which the surgeon has been credentialed and has privileges to admit their patients and perform operations in which the surgeon has expertise. As the population requiring medical care increases, hospitals worldwide are being challenged to provide sufficient resources, including operating rooms, for these patients. These is also more pressure on the hospitals to decrease their cost structure in the face of increasing volumes while the introduction of newer medical technology, including new and presumably more advanced implants complicates the situation.

Patient preparation for a hip or knee replacement is dependant on their surgeon's evaluation and treatment plan as well as the preoperative evaluation by anesthesia providers. In many cases, a medical evaluation is also needed to ensure that the operative procedure is done in the safest manner possible. Ensuring that patients are optimally prepared for the day of surgery is critical to keeping both the surgeon's schedule and an operating room schedule accurate and optimal and not affected by the late cancellations that lead to lost opportunity costs. Additionally, the healthcare system must provide sufficient hospital resources so that patients can efficiently move from the operating room to the recovery room to their nursing floor bed and then to either a rehabilitation hospital bed or home with the provision of home care services such as physical therapy.

The entire process can initially be represented by three distinct phases: preoperative, intraoperative and postoperative (figure 1). Each of these phases is dependant on a previous state or event and the capture of the data from that previous state is important to the optimization of the next phase. Many surgeons focus their practice on joint replacement surgery and will attest that their methods and procedures don't change significantly from operation to operation. While this statement may be disputed to some extent by the operating room personnel, every joint replacement follows a very similar pattern of events. The surgeon's performance of a joint replacement is fairly similar across hundreds of procedures but the most significant difference between each of the operations is the substrate changes, i.e. each patient is different. Successful execution of the processes in the operating room are dependent on the preoperative, intraoperative and postoperative processes that comprise the spectrum of orthopaedic care.

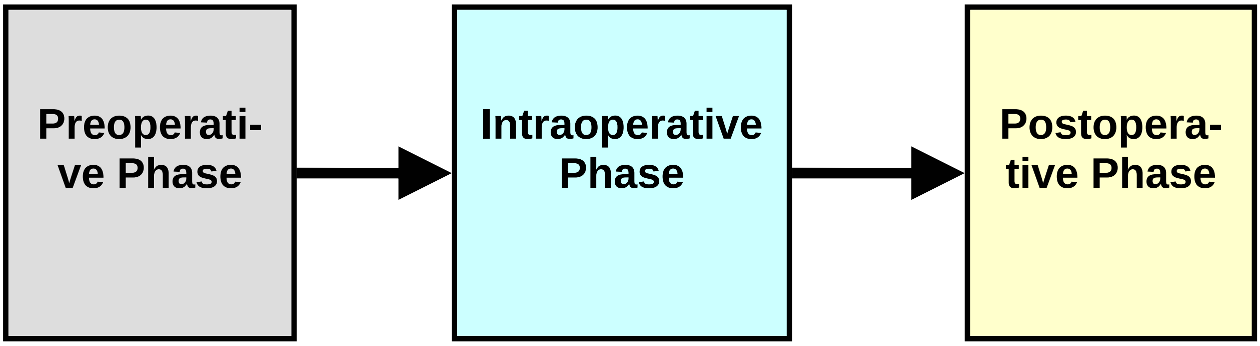

Figure 1: The phases of care and processes for patients undergoing joint replacement

4. Stakeholders and Objectives

The process stream begins with a patient experiencing pain and decreased function sufficient to present with their complaints to an orthopedic surgeon. Once the decision is made to proceed with the procedure, the patient is scheduled for the necessary preoperative evaluations and the surgery is scheduled at the hospital. The surgeon will also indicate their preference for a specific implant system and the hospital will ensure that those implants and the instruments used for their insertion are present for the surgery. In further preparation for the day of surgery, the sterilization and supply teams at the hospital are charged with assembling all of the necessary materials, the operating room nursing team sets up the sterile instruments and equipment and the operating room and the anesthesia team is tasked with providing the patient with a pain-free operative experience. The surgeon and their assistants then can complete the operative procedure as scheduled. The postoperative recovery room nursing team provides the next step in the process by helping the patient recover from the operative episode. Then the patient will go to the most appropriate nursing floor to start their recuperation with the assistance of the nursing team, the physical and occupational therapists, the surgical team and when necessary, various medical consultants. Once specific surgeon and institutional milestones have been reached, the patient is discharged to a rehabilitation nursing facility or to home where further physical therapy is provided. In all over 250 people and over 435 individual processes are involved with a single patient's operative procedure (Choi et al., 2007). Each entity, hospital and surgeon's office has specific fixed and variable expenses that are greatly influenced by every process in the patient's care.

5. Technology

Hip and knee implants are undergoing a constant state of innovation and improved technology. While the benefits of these purported improvements are not always proven in a stringent or conclusive examination, the implant companies are under immense pressure to improve their market share and their profitability. As technologic advances in implants evolve in the marketplace, the implant companies are challenged to maintain pricing levels that provide the desired financial margins. As with all products, as the time from initial introduction increases, the products are seen as a commodity and the downward pricing pressures increase. In many cases, the hospital bears the increased costs of the new technology that the surgeons want to use while the margins of the implant companies increase. In the last 10 years, additional developments in implant insertion methodologies have included computerized navigation systems, newer instrument sets, new bearing surfaces and newer imaging based custom insertion instrument development. While direct to consumer marketing efforts have attempted to influence and pressure the surgeon's behavior through the demands of the

consumer, the market has not been significantly influenced (Schaffer et al., 2008). Additionally, the value of these newer technologies has not yet been conclusively demonstrated.
Many hospitals are also involved in the implementation of electronic medical records systems to document and make available for dissemination the details of the care processes through nursing and physician notes and provide clinical decision support and computerized order entry processes. Hospital supply chain management and human resource teams have also been implementing electronic systems to improve the scheduling of personnel and the stocking, ordering and billing reconciliation of supplies and implants. The incremental costs of implementing these electronic systems have been borne by hospitals and doctor's offices while the payers' "reimbursement" for services rendered have been consistently decreasing.

6. Creating Value from Knowledge

As in the context of the orthopaedic operating room, in most healthcare activities, a critical function in the care process is decision making. While providers strive to bring order and structure to the care process, most decision making processes are more typically complex and unstructured. Unstructured decision making requires the gathering of multi-spectral data and information if the decision maker is to make a prudent choice (wickramasinghe and von Lubitz, 2007; Wickramasinghe, 2006). Unstructured decision making in dynamic and complex environments is challenging and the decision maker is always at a point of information inferiority (von Lubitz and Wickramasinghe, 2006c) as the decision maker is almost always missing information. It is in such situations that the need for germane knowledge, pertinent information and relevant data are critical (ibid) and hence the value of knowledge and the tools, techniques, technologies and tactics of KM are most beneficial.

Hierarchically, the gathering of information precedes the transformation of information into useable knowledge (Massey et al., 2002; Alavi and Leidner, 1999). Hence, the rate of information collection and the quality of the collected information will have a major impact on the quality (usefulness) of the generated knowledge(Award and Ghaziri, 2004) . In the dynamic and, to a large degree, unpredictable world of global healthcare, "action space awareness" (or synonymous "competitive space awareness") and information superiority(Boyd, 1976; von Lubitz and Wickramasinghe, 2006b) have become the key factors to all successful operations. Such awareness however, can only be enabled through the extraction of multi-spectral data.

Boyd's OODA Loop (figure 2) provides a formalized analysis of the processes involved in the development of a superior strategy (Alberts et al., 2000; Cebrowski and Garstka, 1998; Boyd, 1987; von Lubitz and Wickramasinghe, 2006bd) and a suitable model to facilitate the organizing of germane knowledge. Boyd created the OODA loop to describe air warfare systems and has been credited as a predecessor and influencer of many management programs. The OODA Loop is based on a cycle of four interrelated stages revolving in time and space: Observation followed by Orientation, then by Decision, and finally Action. At the Observation and Orientation stages, multispectral implicit and explicit inputs are gathered (Observation) and converted into coherent information (Orientation). The latter determines the sequential Determination (knowledge generation) and Action (practical implementation of knowledge) steps. The outcome of the latter affects, in turn, the character of the starting point (Observation) of the next revolution in the forward progression of the rolling loop. The Orientation stage specifies the characteristics and the nature of the "center of thrust" at which the effort is to concentrate during the Determination and Action stages. Hence, the OODA Loop implicitly incorporates the rule of "economy of force," i.e., the requirement that only minimum but adequate (containment) effort is applied to insignificant aspects of competitive interaction. The Loop exists as a network of simultaneous and intertwined events that characterize the multidimensional action space (competition space), and both influence and are influenced by the actor (e.g., an organization) at the centre of the network. Moreover, the events provide the context and search criteria for extracting germane knowledge.

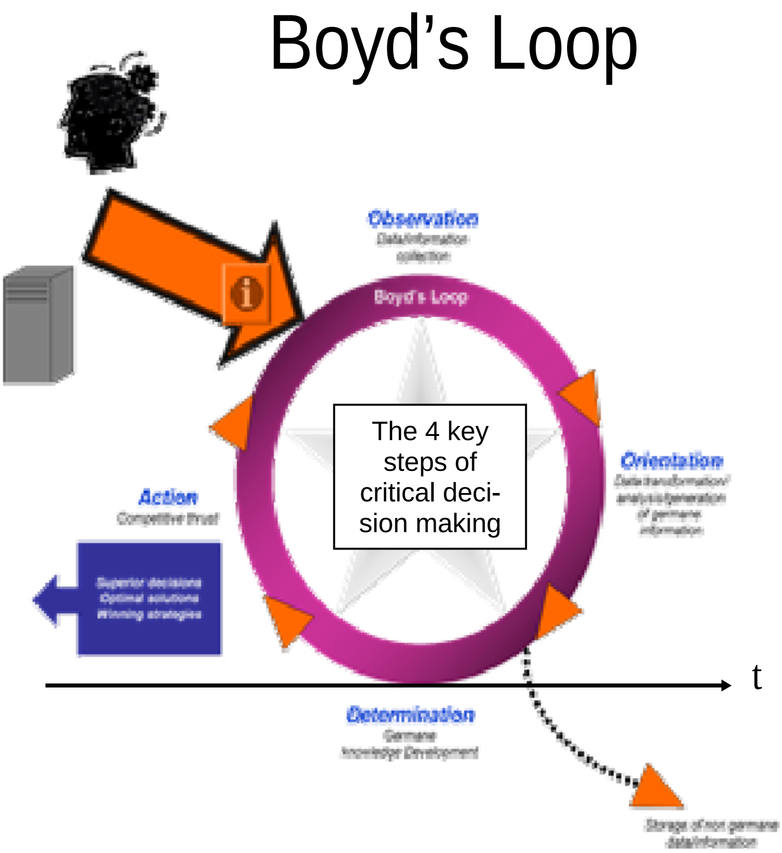

Figure 2 Boyd's OODA Loop

7. The Nature of Knowledge Management

Knowledge is a critical resource in any organization and is also crucial in the provision of healthcare. Access to the latest medical research knowledge is often the difference between life and death, between accurate or erroneous diagnosis, and between early intervention or a prolonged and costly hospital stay. Knowledge management deals with the process of creating value from an organization's intangible assets (Wickramasinghe and Mills, 2001; Edwards et al., 2005). It is an amalgamation of concepts borrowed from the artificial intelligence/knowledge based systems, software engineering, BPR (business process re-engineering), human resources management, and organizational behavior (Purvis et al. 2001). Knowledge management deals with conceptualization, review, consolidation, and action phases of creating, securing, storing, combing, coordinating, and retrieving knowledge. In essence, then, knowledge management is a process by which organizations collect, preserve, and utilize what their employees and members know about their jobs and about activities and procedures in their organization (Xu and Quaddus, 2005).

8. The Need for Knowledge Management

Sustainable competitive advantage is dependent on building and exploiting core competencies. In order to sustain competitive advantage, resources which are idiosyncratic (thus scarce) and difficult to transfer or replicate are required. A knowledge-based view of the firm identifies knowledge as the organizational asset that enables sustainable competitive advantage especially in hyper competitive environments or in environments experiencing radical discontinuous change.

Thus, it makes sense that the organization that knows more about its customers, products, technologies, markets, and their linkages should perform better Gafni and Birch, 1993). Many organizations are drowning in information overload yet starving for knowledge. Knowledge management is believed to be the current savior of organizations, but its successful use entails much more than developing Lotus Notes' lessons learnt databases. Rather it involves the thoughtful design of various technologies to support the knowledge architecture of a specific organization (Wickramasinghe and Mills, 2001).

9. The Value of Knowledge Management to Healthcare Organizations

Knowledge management is a still relatively new phenomenon and a somewhat nebulous topic that needs to be explored. However, organizations in all industries, both large and small, are racing to integrate this new management tool into their infrastructure. Knowledge management caters to the critical issues of organizational adaptation, survival, and competence in the face of increasingly discontinuous environmental change (Wickramasinghe, 2006). Essentially, it embodies organizational processes that seek synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings.

Knowledge management realizes the importance of safeguarding and using the collective knowledge and information of an organization. Through surveys, interviews, and analysis, knowledge management seeks to excavate, measure, assess, and evaluate the knowledge and
information held within an organization with the intention of making the organization more efficient and profitable. Essentially, knowledge management sifts through the collective knowledge of an organization, codifies it into an information base, and then spreads it throughout the organization so it can be easily accessed (Wickramasinghe and Mills, 2001).

The knowledge management system is extremely helpful in internal and external sectors of an organization. Internally, knowledge management is designed to enhance the maintenance and organization of the data bases. Externally, it aims to make a better impact on the customer and external partners.

10. The Role of Knowledge Management in Healthcare Organizations

The healthcare sector is characterized by its diversity and the distributiveness of its component organizations. There is a continuous process of generation of knowledge within each of these components (such as providers, patients, suppliers, payers, and regulators), as well as an immense volume of knowledge created at the interfaces among these organizations(Jadad et al., 2000; Pavia, 2001, Dwivedi, 2006).

Healthcare provider organizations are special type of organizations in that they are for the most part motivated by topics such as quality and service, but without the profit drivers that animate private industry. At the same time they are highly professional institutions, populated by people with specialized knowledge that needs to be constantly updated, shared, and leveraged (van Beveren, 2003).

This phenomenon creates even more pressure on healthcare providers and others in the sector to manage the knowledge that flows through the sector.

Although there has been little empirical investigation of how knowledge management benefits healthcare organizations, it is safe to assume that its contributions would be at least as positive as they are being shown in other sectors of the economy (Eid, 2005).

The role of knowledge management in healthcare organizations would be important in both clinical and administrative practices. Clinical care would be much more effective with increased sharing of medical knowledge and “evidence-based” experience within and among healthcare delivery organizations (Nykanen and Karimaa, 2006; Wickramasinghe, 2007).

Administrative practices in healthcare organizations will benefit from the systemic interfaces of knowledge about technology, costs, “best-practices,” efficiencies, and the value of cooperation. Such effects of knowledge creation and sharing would make it easier and more effective to manage the healthcare organization.

Finally, the role of knowledge management is especially crucial in the *interface* between the clinical and administrative functions. By and large these two categories of activities are separated by differentiations such as professional specializations, role in the organization, and goals and standards of practice. Hence, there is a tendency to avoid sharing knowledge and exchanging experience-based lessons so as not to upset the existing balance of power of the organization.

11. Tools and Techniques of KM

KM tools and techniques are defined by their social and community role in the organization in 1) the facilitation of knowledge sharing and socialization of knowledge (production of organizational knowledge); 2) the conversion of information into knowledge through easy access, opportunities of internalization and learning (supported by the right work environment and culture); 3) the conversion of tacit knowledge into "explicit knowledge" or information, for purposes of efficient and systematic storage, retrieval, wider sharing and application (Wickramasinghe et al., 2006). The most useful KM tools and techniques can be grouped as those that capture and codify knowledge and those that share and distribute knowledge (Duffy, 2001; Maier, 2001).

a) Capture and codify knowledge
There are various tools that can be used for capture and codify knowledge. These include databases, various types of artificial intelligence systems including expert systems, neural networks, fuzzy logic, genetic algorithms and intelligent or software agents.

i) Databases
Databases store structured information and assist in the storing and sharing of knowledge. Knowledge can be acquired from the relationships that exist among different tables in a database. For example; the relationship that might exist between a customer table and a product table could show those products that are producing adequate margins, providing decision-makers with strategic marketing knowledge. Many different relations can exist and are only limited by the human imagination. These relational databases help users to make knowledgeable decisions, which is a goal of knowledge management. Discrete, structured information still is managed best by a database management system. However, the quest for a universal user interface has led to the requirement for access to existing database information through a web browser.

ii) Case-Based Reasoning Applications

Case-Based Reasoning (CBR) applications combine narratives and knowledge codification to assist in problem solving. Descriptions and facts about processes and solutions to problems are recorded and categorized. When a problem is encountered, queries or searches point to the solution. CBR applications store limited knowledge from individuals who have encountered a problem and found the solution and are useful in transferring this knowledge to others.

iii) Expert Systems

Expert systems represent the knowledge of experts and typically query and guide users during a decision making process. They focus on specific processes and typically lead the user, step by step, toward a solution. The level of knowledge required to operate these applications is usually not as high as for CBR applications. Expert systems have not been as successful as CBR in commercial applications but can still be used to teach knowledge management.

Iv) Using I-net Agents - Creating Individual Views from Unstructured Content

The world of human communication and information has long been too voluminous and complex for any one individual to monitor and track. Agents and I-net standards are the building blocks that make individual customization of information possible in the unstructured environment of I-nets. Agents will begin to specialize and become much more than today's general purpose search engines and "push" technologies.

Two complimentary technologies have emerged that allow us to coordinate, communicate and even organize information, without rigid, one-size-fits-all structures. The first is the Internet/Web technologies that are referred as I-net technology and the second is the evolution of software agents. Together, these technologies are the new-age building blocks for robust information architectures, designed to help information consumers find what they are looking for in the way that they want to find it. The web and software agents make it possible to build sophisticated, well performing information brokers designed to deliver content, from multiple sources, to each individual, in the individual's specific context and under the individual's own control. The software agents supported with I-net infrastructure can be highly effective tools for individualizing the organization and management of distributed information.

b) Systems to share and distribute Knowledge

Computer networks provide an effective medium for the communication and development of knowledge management. The Internet and organizational intranets are used as a basic infrastructure for knowledge management. Intranets are rapidly becoming the primary information infrastructure for enterprises. An intranet is basically a platform based on internet principles accessible only to members of an organization/community. The intranet can provide the platform for a safe and secured information management system within the organization, help people to collaborate as of virtual teams, crossing boundaries of geography and time. While the internet is an open-access platform, the intranet, however, is restricted to members of a community/organization through multi-layered security controls. The same platform, can be extended to an outer ring (e.g. dealer networks, registered customers, online members, etc.), with limited accessibility, as an extranet. The extranet can be a meaningful platform for knowledge generation and sharing, in building relationships, and in enhancing the quality and effectiveness of service/support. The systems that are used to share and distribute knowledge could include; Group collaboration systems; Groupware, intranets, extranets and internet, office systems; word processing, desktop publishing, or web publishing.

12. The Intelligence Continuum

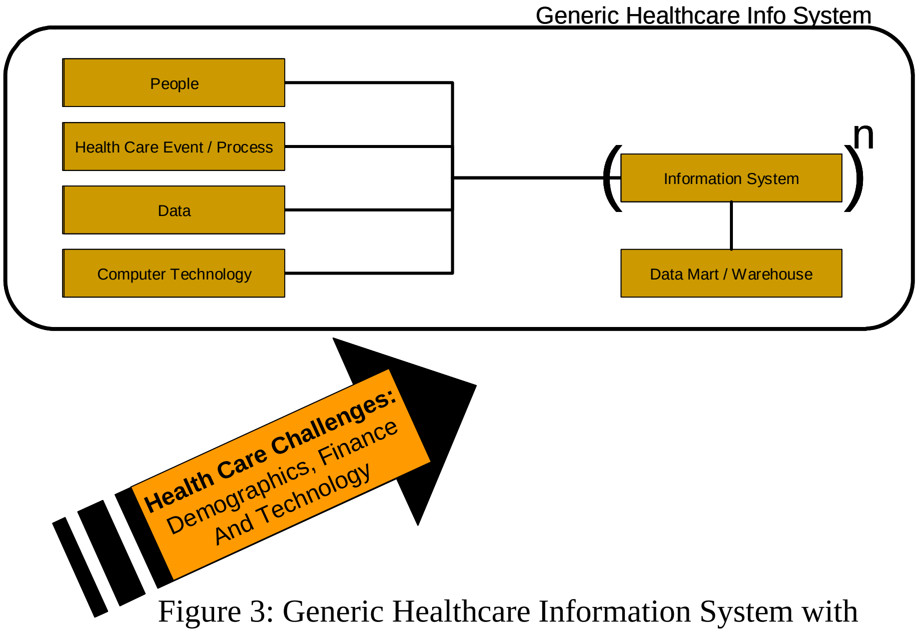

Figure 3: Generic Healthcare Information System with Healthcare Challenges

To understand the role of the intelligence continuum, an examination of a generic healthcare information system is necessary (figure 3). The important aspects in this generic system include the socio-technical perspective; i.e. the people, processes and technology inputs required in conjunction with data as a key input. The combination of these elements comprises an information system and within any one organization, multiple such systems could exist. To this generic system, we add the influences of healthcare challenges; i.e. the challenges of demographics, technology and finance. As baby boomers age, the incidence of people over the age of 65 is projected to increase for the next forty years (US Census Bureau, 2008). Moreover, as people age, improved healthcare is providing those people over the age of 65 a longer lifespan and the ability to tell about it while also ultimately enduring many complicated medical problems and diseases. Certainly technology is helping to keep everyone alive and younger and in better health but the cost to do so is escalating exponentially(Wickramasinghe and Silvers, 2003).

Addressing these challenges is best approached through a closer examination of the data generated by the information systems and stored in the larger data warehouses and/or smaller data marts. In particular, it is important to make decisions and invoke the intelligence continuum; apply the tools, techniques and processes of data mining, business intelligence/analytics and knowledge management respectively. On applying these tools and techniques to the data generated from healthcare information systems, it is first possible to diagnose the "as is" or current state processes in order to make further decisions regarding how existing processes should be modified and thereby provide appropriate prescriptions to enable the achievement of a better future state; i.e. improve the respective inputs of the people, process, technology and data so that the system as a whole is significantly improved.

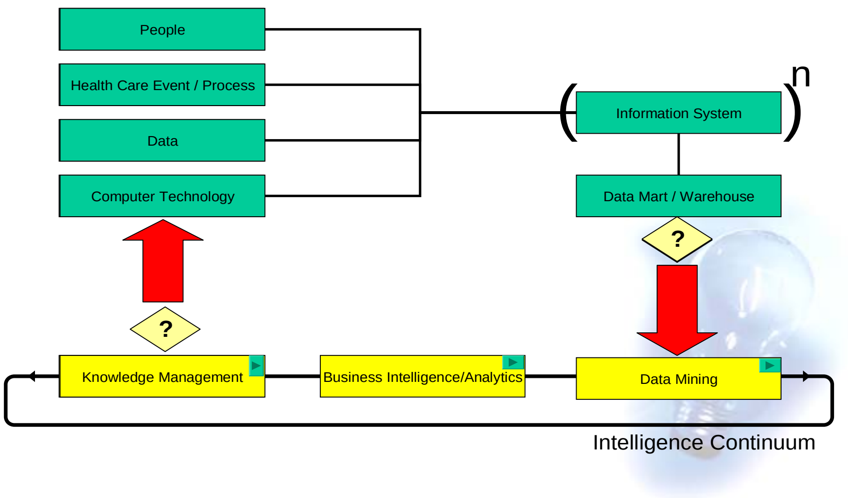

Figure 4a: The Intelligence Continuum (Wickramasinghe and Schaffer)

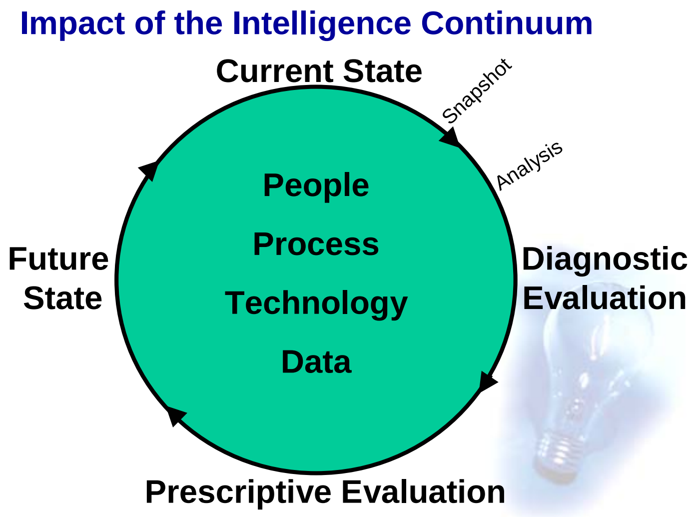

Figure 4b The impact of the Intelligence Continuum (Wickramasinghe and Schaffer, 2006)

The Intelligence Continuum (Wickramasinghe and Schaffer, 2006; figure 4a) is a representation of the collection of key tools, techniques and processes of today's knowledge economy; i.e. including but not limited to data mining, business intelligence/analytics and knowledge management.
Taken together they represent a very powerful system for refining the data raw material stored in data marts and/or data warehouses and thereby maximizing the value and utility of these data assets for any organization. The first component is a generic information system which generates data that is then captured in a data repository. In order to maximize the value of the data and use it to improve processes, the techniques and tools of data mining, business intelligence and analytics and knowledge management must be applied to the data warehouse. Once applied, the results become part of the data set that are reintroduced into the system and combined with the other inputs of people, processes, and technology to develop an improvement continuum. Thus, the Intelligence Continuum includes the generation of data, the analysis of these data to provide a "diagnosis" and the reintroduction into the cycle as a "prescriptive" solution (figure 4a,4b).

In today's context of escalating costs in healthcare, managed care in the US, regulations and a technology and health information savvy patient, the healthcare industry can no longer be complacent regarding embracing key processes and techniques to enable better, more effective and efficient practice management. The proliferation of databases in every quadrant of healthcare practice and research is evident in the large number of isolated claims databases, registries, electronic medical record data warehouses, disease surveillance systems, and other ad hoc research database systems (Lawrence et al., 2009).

Not only does the number of databases grow daily, but even more importantly, so does the amount of data within them. Pattern-identification tasks such as detecting associations between certain risk factors and outcomes, ascertaining trends in healthcare utilization, or discovering new models of disease in populations of individuals rapidly becomes daunting even to the most experienced healthcare researcher or manager (Holmes et al. 2002).

Yet these tasks may hold the answers to many clinical issues such as treatment protocols or the identification across geographic areas of newly emerging pathogens and thus are important.

Add to all of this the daily volumes of data generated and then accumulated from a healthcare organization administrative system, clearly then, the gap between data collection and data comprehension and analysis becomes even more problematic.

Information technology (IT) tools coupled with new business approaches such as data mining, business intelligence/analytics and knowledge management should be embraced in an attempt to address such healthcare woes (Berinato, 2002; McGee, 1997). Figure 5 highlights important aspects of knowledge in essential healthcare operations.

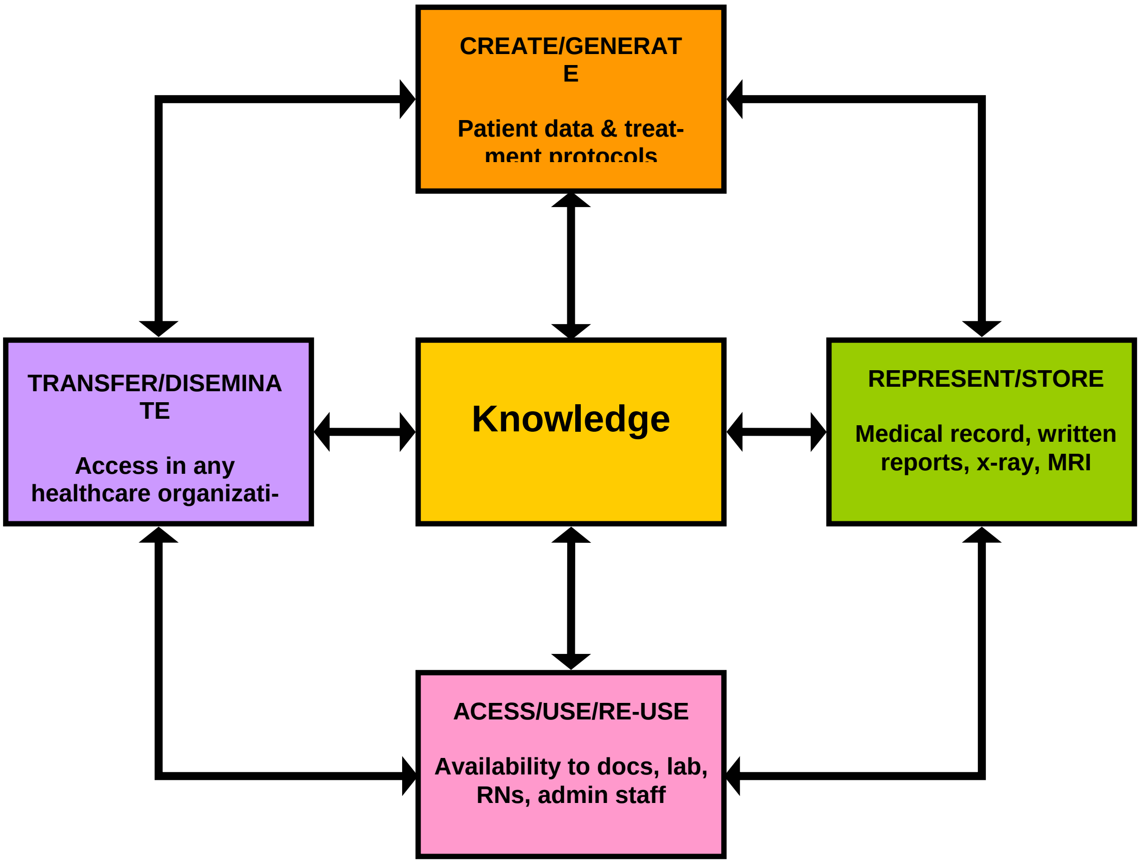

Figure 5: The Key Steps of Knowledge Management

13. Returning to the Orthopaedic Operating Room

The orthopaedic operating room represents an ideal environment for the application of a continuous improvement cycle that is dependant on the Intelligence Continuum. For those patients with advanced degeneration of their hips and knees, arthroplasty of the knee and hip represent an opportunity to regain their function. Before the operation ever begins in the operating room, there are a large number of interdependent individual processes that must be completed. Each process requires data input and produces a data output such as patient history, diagnostic tests and consultations. Keeping the process moving for each patient and maintaining a full schedule for the surgeon and the hospital are challenges that require accurate and timely information for successful process completion and achieving the goals for each patient, surgeon and the hospital simultaneously. The interaction between these data elements is not always maximized in terms of operating room scheduling and completion of the procedure. Moreover, as the population ages and patients' functional expectations continue to increase with their advanced knowledge of medical issues, reconstructive orthopaedic surgeons are being presented with an increasing patient population requiring hip and knee arthroplasty. Simultaneously, the implants are becoming more sophisticated and thus more expensive. In turn, the surgeons are experiencing little change in system capacity, but are being told to improve efficiency and output, improve procedure time and eliminate redundancy. However, the system legacy is for insufficient room designs that have not been updated with the introduction of new equipment, poor integration of the equipment, inefficient scheduling and time consuming procedure preparation. Although there are many barriers to re-engineering the Operating Room and the processes involved in the complex choreography of the perioperative processes, a dearth of data and the difficulty of aligning incentives, it is indeed possible to effect significant improvements through the application of the intelligence continuum.

The entire process of getting a patient to the operating room for a surgical procedure can be represented by three distinct phases: preoperative, intraopertive and postoperative (refer to figure 1). In turn, each of these phases can be further subdivided into the individual yet interdependent processes that represent each step on the surgical trajectory. As each of the individual processes are often dependant on a previous event, the capture of event and process data in a data warehouse is necessary. The diagnostic evaluation of this data set and the re-engineering of each of the deficient processes will then lead to increased efficiency. For example, many patients are allergic to the penicillin family of antibiotics that are often administered preoperatively in order to minimize the risk of infection. For those patients who are allergic, a substitute drug requires a 60 minute monitored administration time as opposed to the much shorter administration time of the default agent. Since the antibiotic is only effective when administered prior to starting the procedure, this often means that a delay is experienced. When identified in the preoperative phase, these patients should be prepared earlier on the day of surgery and the medication administered in sufficient time such that the schedule is not delayed. This prescriptive reengineering has directly resulted from mining of the data in the information system in conjunction with an examination of the business processes and their flows. By scrutinizing the delivery of care and each individual process, increased efficiency and improved quality should be realized while maximizing value. For knee and hip arthroplasty, there are over 432 discrete processes that can be evaluated and reengineered as necessary through the application of the Intelligence Continuum (Schaffer et al, 2004).

14. Further Development of the Model

Given the need for- and the benefit of- the IC to support superior healthcare delivery the story should not end here, rather the model should be extended and developed further. In particular, it is essential to expand upon the capabilities afforded by the tools and techniques of KM and incorporate more intelligence capabilities through the addition of further data mining techniques.

In summary, the key idea of more intelligent sampling assumes the existence of subsets of sufficiently similar tuples within the focusing input. We presume that each subset contains more information than necessary to generate appropriate data mining results, and that smaller set of prototypes are able to represent the entire information in the focusing input hence. In order to implement the key idea of more intelligent sampling techniques, we first apply clustering to identify subsets of sufficiently similar tuples. Moreover prototyping approaches in statistics and machine learning provide mechanisms for prototype selection or prototype construction. The general advantage is the generation of more condensed deceptions of the entire focusing input. The proposed conceptual model is given in figure 6 below. Note the KPIs (key performance indices) depicted in figure 6 would be generated from the outputs of the IC model (ie from the data mart/ data warehouse in figure 4a).

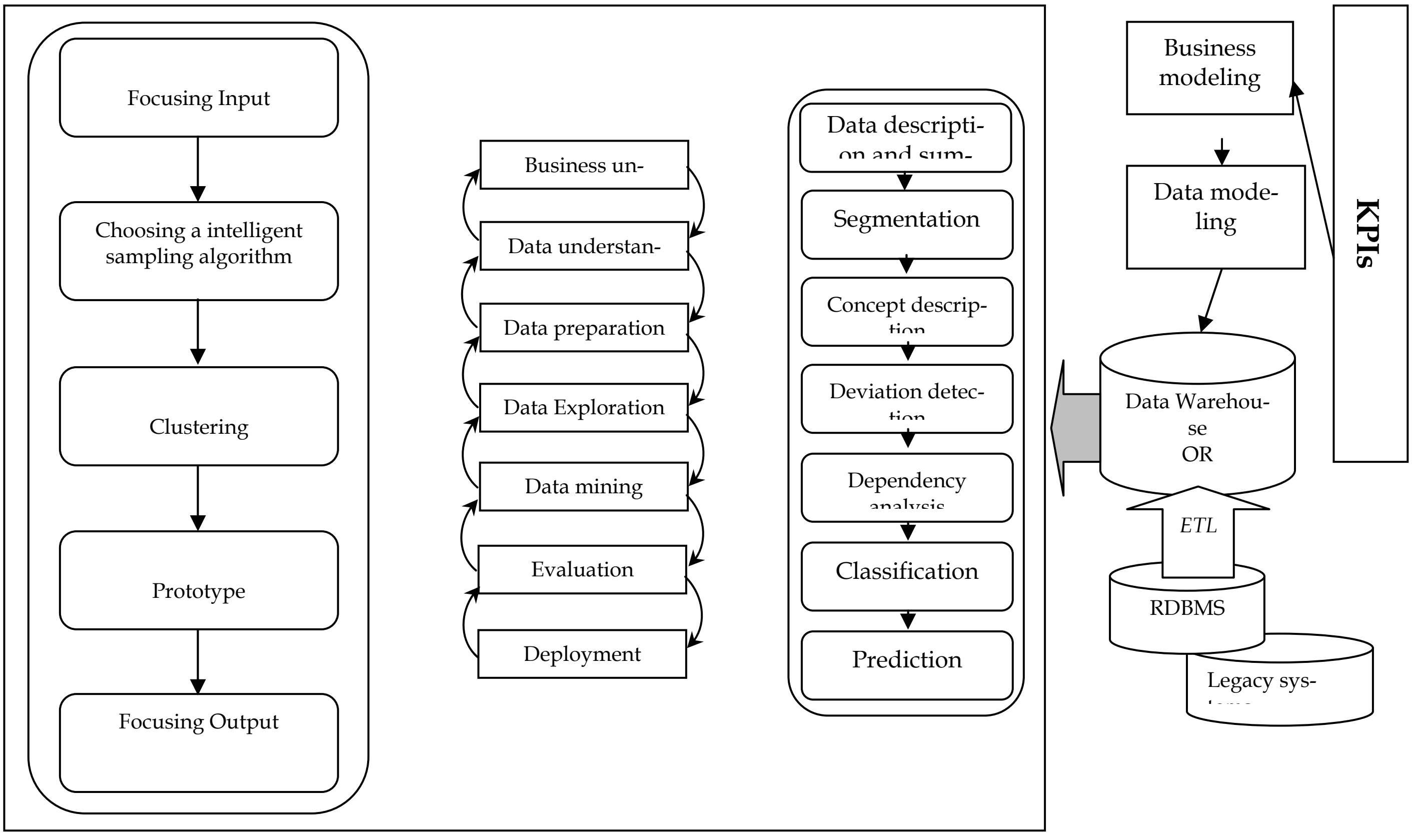

Figure 6: Proposed enhanced knowledge discovery model to establish intelligent sampling into health care databases

15. Conclusions

To improve the efficiency and efficacy of patient care especially for those patients requiring hip or knee replacement, every healthcare process on the pathway from evaluation to operation to recovery should be optimized – the inputs, transformation and outputs should be measured against specification for process time, scheduling, expenses, personnel, etc. Each individual in the long chain of processes has tacit knowledge that increases with each day of experience while the explicit knowledge in the institutional or surgeon's policies and procedures manual are infrequently updated. The opportunity to improve the knowledge spiral and use the Intelligence Continuum to capitalize on realizing the full value of the system is unparalleled. The inherent limitations of organizational structure must be overcome to make these improvements.

The first steps in a process improvement project include the identification of each knowledge point, i.e. the process mapping for joint replacement procedures with the goal of improving performance and predictability while minimizing variances, decreasing “waste” and increasing value while minimizing costs. The generation, representation, storage, transfer and transformation of knowledge are key steps in making the desired improvements in clinical and management practices and incorporating continuous innovation. The current state is that the daily volume data that is generated and accumulated is often lost, further increasing the gaps between data collection, comprehension and analysis. Boyd’s OODA loop model of observation, orientation, decision, and action can organize the inputs and provide a structure for improvement. More patients with degenerative knee and hip arthritis will need joint replacement. Surgeons and hospitals with successful clinical outcomes will use process engineering tools to identify critical path processes and the stakeholders to optimize process efficiency, efficacy, productivity, safety and satisfaction.

The preceding has served to highlight the critical role for knowledge discovery tools and techniques to facilitate superior decision making in healthcare. The case vignette of the othorpedic OR has illustrated the benefits in a clinical context. Moreover we have also presented and described the next steps to further enhance the intelligence capabilities of our model. We close by encouraging researchers to continue to investigate this vital area.[2]

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In Search of an Appropriate and Well-Accepted Service Model for Telehealth in Germany

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Abstract
Introduction: In Germany, telemedical support for allowing patients with long-term chronic conditions to remain in their homes ('Telehealth') has been in practice for more then ten years in small pilot projects, large clinical trials, and selective reimbursement agreements between providers and payors. However, a standard service model for telehealth has thus far not been established. Therefore, we need to learn more from the experiences of these existing programs to clarify how a telemedical service centre (TSC), as a new type of healthcare partner, should be positioned in order to use resources effectively and to achieve improved patient outcomes. This paper shows which service models for telehealth in Germany are possible and what kind of specific requirements, advantages or disadvantages can be seen for each of those models.
Methods: After an extensive literature and internet search, the four basic types of service models for telehealth were extracted and characterized. (a) TSC based at a care management organisation (CMO), (b) TSC based at a hospital, (c) TSC based at primary care physician network, or (d) TSC based at a health insurance company. The appropriateness of each model has been empirically analysed from different stakeholders' perspectives (healthcare providers, payors, patients) using delphi method. Seventeen experts have been surveyed in semi-structured interview and focus-group settings.
Results: The "hospital-based TSC" service model is widely seen as the most appropriate one for Germany, whereas two of the alternative models, "CMO-based TSC" and "payor-based TSC", tend to fit better with long-term oriented therapy-management approaches. Telemedical support that is provided and managed directly by the primary-care physicians (c) is considered by most of the interviewees as inappropriate or unrealistic due to resource restrictions. However, it plays an important role for getting telehealth successfully adopted in usual care practice (e.g., for enrolment of patients, data-based consultations).
Discussion: There could be several models to let a telemedical service centre become an active partner in healthcare. Depending on the goal-setting of each program, patients at high risk due to their chronic condition seem to be better suited for service models with high involvement of interdisciplinary clinical centres. Patients with less-acute long-term conditions seem to be more suited for service models using a centralised call-centre infrastructure.

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1. Introduction

Telemedical support for patients with long-term conditions at their home (usually described as ‘Telemonitoring’ or ‘Telehealth’) has gained general interest of several stakeholders in healthcare systems all over the world. The evidence has been surveyed in several systematic literature reviews (see, among others: Pare et al. 2007; Clark et al. 2007; Chaudhry et al. 2007).

In Germany, Telemonitoring has been implemented into practice for more then ten years within smaller pilot projects, larger clinical trials, or selective reimbursement agreements between healthcare providers and payors (see, among others: Morguet et al. 2008; Kielblock et al. 2007.; Zugck et al. 2005).

However, the local scientific community has paid only little attention to the development of standardized service model for telehealth so far. To the author’s best knowledge, the work of Köhler et al. (2006, p. 38-40) makes a sole exception to this statement. They describe three generations of telemonitoring systems that differ not only by the underlying technology but also by the necessary service level, e.g. the involvement of physicians in a telemedical service centre (TSC) and the level of therapeutic decisions they make.

Since the service model mentioned above represents only one part of all telehealth activities in Germany, we need to learn more from the experience that already has been made. This leads to the central question of which way a telemedical service centre (TSC) should be ideally positioned as a new healthcare provider. This paper shows which service models for telehealth in Germany are possible and what kind of specific requirements, advantages or disadvantages can be seen for each of those models.

2. Methods

An extensive, but non-systematic literature and internet search has been conducted to identify basic types of organisational service models for telehealth in Germany as groundwork for the subsequent empirical analysis. The authors browsed literature databases like ‘Medline’ and ‘DIMDI SmartSearch’ as well as relevant journals like ‘Telemedicine Journal and e-Health’, ‘Journal of Telemedicine and Telecare’, ‘E-Health-Com’, and ‘Telmedizinführer Deutschland’. Additionally, reference lists of books and monographs has been searched as well as the websites from Germany’s major telehealth providers (SHL Telemedicine, Vitaphone, Almeda, 4sigma, Anycare, Stiftung Chronisch Kranker, IFAT) and organisations (like DGTelemed, ZTG, or VhitG).

The appropriateness of each model has been empirically analysed from different stakeholder’s perspectives (healthcare providers, payors, industry, patients) by applying the delphi method. Herein, 17 experts have been surveyed either in semi-structured interviews or within a focus group. In table 1, the participants who were recruited due to their practical experience with telehealth or high sector knowledge are described by their affiliation and function. All discussions were voice-recorded, transliterated and evaluated by applying qualitative content analysis according to Mayring (2007).

Table 1: Affiliation and function of interview partners (one-to-one and focus group)

Stakeholder Group	*Organisational Function*
Hospital	Clinical Director, University Hospital
	Senior Physician/ Director, Telemedical Service Center
	Senior Physician, Cardiology
	Project Manager, Telemedicine
Primary Care Physician (Network)	Representative member on behalf of the German Physician Association in the Federal Joint Committee (GBA)/ Director, outpatient clinic
	Manager, Primary Care Physician Network
	Manager, Integrated Delivery Network
Health Insurance Company	Chairman, Statutory Health Insurance (SHI)
	Member of Executive Board, Statutory Health Insurance
	Manager Integrated Care, Statutory Health Insurance
MedTech Industry	Director, Telehealth System Vendor 1
	Director, Telehealth System Vendor 2
	Representative Chairman, Industry Association
Others	Manager, Care Management Organisation
	President, Association for Biomedical Technology
	Organizer of Telehealth Conferences
	Patient, participant telehealth project

3. Results

3.1. Basic types of organisational service models for telehealth

After an extensive literature and internet search, we extracted and characterised from the material four basic types of organisational service models for telehealth (illustration 1). Each of these models has been already implemented into practice in Germany.

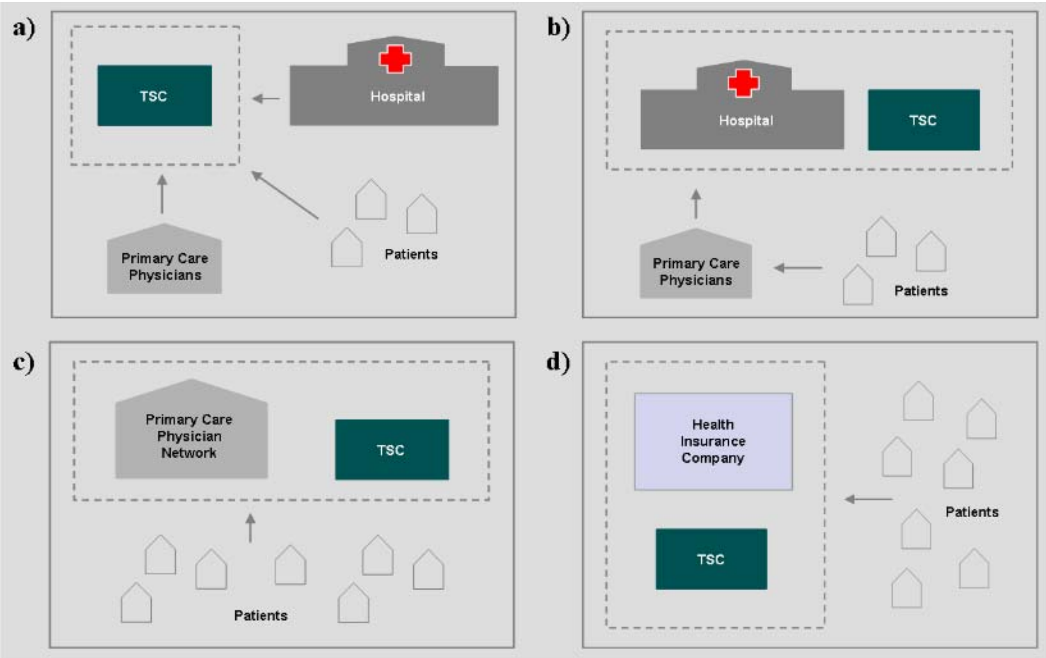

Illustration 1: Basic types of organisational service models for telehealth. a) TSC based at a care management organisation; b) TSC based at a hospital; c) TSC based at a primary care physician network; d) TSC based at a health insurance company.

In model a), the telehealth service emanates from an independent care management organisation (CMO) that is not directly affiliated with other institutional healthcare providers. Hospitals or primary care physicians (PCPs) will refer patients to such a centre when selective reimbursement agreements with payors guarantee them a lump sum for enrolment. Patients may also request the centre's service directly and use out-of-pocket payments for services. The TSC in this model acts mainly as a complementary service provider for other institutional healthcare providers or payors. Its services are dominantly nurse-led and built on a call-centre infrastructure such as those of established Disease Management Programs. It seems to be the dominating organisational service model in Germany at the moment.

In model b), the TSC is based at a hospital. In the event of selective reimbursement agreements for integrated care, patients can be enrolled by their primary care physicians in the telehealth program. In addition, there is a post-acute-care model where patients are enrolled subsequent to their hospital discharge in order to prevent avoidable re-hospitalisations. In some respects, this model provides a direct economic incentive to the hospital by the DRG system, as early re-hospitalisations (usually within 30 days) due to the same diagnosis cannot be reimbursed again.

The primary care physicians can also take the lead in telemonitoring services as outlined in model c) rather than limiting themselves to enrolment activities. This could happen within networks where physicians share a service desk for their patients or as a result of innovative monitoring technologies (e.g., mobile alerts from implantable devices to the physician's cell phone). New types of managed care organisations where physicians take over (partial) budget responsibility from the payor might encourage them to do so because they participate in monetary savings from prevented hospitalisations.

With regard to model d), there has been a fundamental shift in Germany's (statutory) health insurance organisations in their role 'from payor to player' over the last decade. Meanwhile, most of them offer a group of services that can influence the course of their members' healthcare such as care management, disease management and health coaching programs. Telehealth programs that focus on educating and motivating patients with long-term chronic conditions in order to improve their self-management competencies offer, in that particular respect, an effective and efficient way for health insurers to contain costs by offering high quality care management.

3.2. Positioning of Telemedical Service Centres

As shown in illustration 2, the hospital-based TSC model (b) is seen as highly appropriate for Germany. All but one of the experts were of a positive opinion towards this model and stated inter alia the following arguments in favour of it: high operational availability of high-qualified staff, interdisciplinary teams with specialised competencies, well accepted institution by patients, standardised workflow procedures and quality management.

There were equivalent opinions, both, in favour and against the CMO-based TSC model (a) which was discussed very controversial in the focus group. On the one hand, this model seems to offer cost advantages, centralised/ more appropriate call-centre infrastructure, and easier relations to payors for contract closings. On the other hand, the experts impute impersonal treatment of patients, a lack of medical expert knowledge, and less confidence by referring physicians to that model.

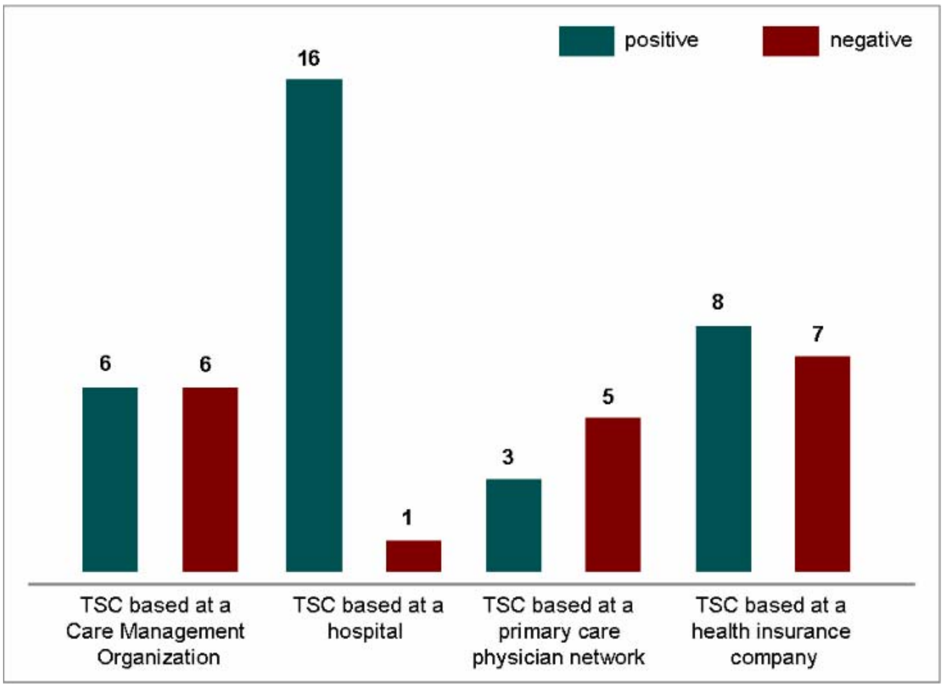

Illustration 2: Positive and negative opinions towards differing service models for Telehealth (absolute number of opinions from, both, members of the focus group and one-to-one interviews)**.**

A telemedical support that is provided and managed directly by the PCPs (c) is considered by most of the experts as inappropriate or unrealistic mainly due to resource restrictions. However, they play a crucial role in getting telehealth successfully adopted in usual care practice, e.g., for enrolment of patients or data-based consultations because of their close and personal relationship to the patients.

With regard to the payor-based TSC model (d), similar advantages were seen as to the CMO-based model. It seems best suited for patients with less-acute long-term conditions with special emphasis on educational and motivational aspects of care management. However, many clinical experts were highly concerned about the trend of health insurance organisations becoming more and more involved in care-management activities.

3.3. Further aspects

Most of the experts (6 out of 7) considered a disease-specific division between several service centres as reasonable in order to provide high quality care to patients with complex chronic conditions at high risk. The argument in favour of such a division is, that different chronic conditions also imply different requirements for staff qualification. The more severe a condition is, the more important it is of the role of a specialist.

The service model has to be different for managing patients with less severe conditions at high volume. Here, 7 out of 8 experts stated that a TSC is ideally managed by high qualified nurses than physicians. standardised procedures and the role of highly qualified nurses become crucial, last but not least because of economical reasons.

The relationship between primary care physicians and specialists on the one hand and hospitals on the other hand has been strained since mayor haealthcare reforms allow hospitals to provide more and more ambulatory services. According to 6 out of 7 experts this has to be taken into account by implementing telehealth into practice in order to gain acceptance by PCPs.

4. Discussion

There could be several models that could facilitate telemedical service centres becoming active partners in healthcare. Depending on the goals of each programme, patients at high risk of their chronic condition seem to be better suited for service models with high involvement of interdisciplinary clinical centres. Patients with less-acute, long-term conditions seem to be more eligible for service models using a centralised call-centre infrastructure. However, the leader in the entire process is the primary care physician and/or the specialist who has overall responsibility for the patient on an outpatient basis.

The results of this work provide beneficial insight in the perceptions and opinions of relevant healthcare stakeholders with regard to an appropiate service model for telehealth in Germany. These should be taken into account by future implementation of telehealth service models into practice. In comparison to other countries, the role of specialists in the ambulatory care sector is crucial to gain general acceptance. This could be the mayor reason that a hospital led TSC model is seen as the most feasible option.

However, the results of this work have to be considered with caution. The opinions of that expert panel might not be fully representative for all healthcare stakeholders in Germany, since they have been selected according to to their practical telehealth experience rather than their functional levels.

Reference list

Chaudhry SI, Phillips CO, Stewart SS, Riegel B, Mattera JA, Jerant AF, Krumholz HM (2007) Telemonitoring for Patients with Chronic Heart Failure – A Systematic Review. Journal of Cardiac Failure 13: 56–62. doi: 10.1016/j.cardfail.2006.09.001

Kielblock B, Frye C, Kottmair S, Hudler T, Siegmund-Schultze E, Middeke M (2007) Einfluss einer telemedizinisch unterstützten Betreung auf Gesamtbehandlungskosten und Mortalität bei chronischer Herzinsuffizienz. Deutsche Medizinische Wochenschrift 132: 417-22. doi: 10.1055/s-2007-970350

Köhler F, Nettlau H, Schweizer T, Waller T, Anker SD (2006) The Research Project of the German Federal Ministry of Economics and Technology 'Partnership for the Heart' – A New Approach in Telemedicine. Dis Manage Health Outcomes 14 (Suppl 1): 37-41.

Clark RA, Inglis SC, McAlister FA, Cleland JGF, Stewart S (2007) Telemonitoring or Structured Telephone Support Programmes for Patients with Chronic Heart Failure – Systematic Review and Meta-analysis. BMJ 334: 942. doi: 10.1136/bmj.39156.536968.55

Paré G, Jaana M, Sicotte C (2007) Systematic Review of Home Telemonitoring for Chronic Diseases – The Evidence Base. J Am Med Inform Assoc 14: 269-277. doi: 10.1197/jamia.M2270

Morguet AJ, Kühnelt P, Kallel A, Jaster M, Schultheiss H-P (2008) Impact of Telemedical Care and Monitoring on Morbidity in Mild to Moderate Chronic Heart Failure. Cardiology 111: 134-9. doi: 10.1159/000119701

Mayring, P (2007) Qualitative Inhaltsanalyse – Grundlagen und Techniken 9th ed. Beltz Verlag; Weinheim / Basel.

Zugck C, Nelles M, Frankenstein L, Schultz C, Helms T, Korb H, Katus HA, Remppis A (2005) Telemedizinisches Monitoring bei herzinsuffizienten Patienten Herzschr Elektrophys 16:176–182. doi: 10.1007/s00399-005-0476-7

Towards a reference model for telemedicine

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Abstract
In the domain of health care, processes and actions changed through the increasing applications of Information and Communication Technology (ICT). This results in specific advantages in particular for patients with chronic diseases. The use of telematic in health care, which enables an independent action in space and time, is called telemedicine. In recent years telemedicine is widely tested and translated in German research projects. But there are no reference schemes known for the class of telemedicine-specific problems so far. This paper addresses this gap. Subject of this paper are application systems for and organizations of telemedicine. The approach of the ARIS-house is used as the basis. From the perspective of reference modelling this basis is checked for its usefulness to develop a reference model for telemedicine. In this context an empirical application serves to evaluate previously identified requirements for reference models and for telemedicine.

1. Introduction

The effects of a more individual way of life and of a higher quality of life resulting from the use of ICT are of paramount importance, especially for patients with chronic diseases. In particular for new applications it therefore seems appropriate to orientate them on existing (reference-) models.
The science has always been used models to represent complex situations, including the still young discipline of Information Systems Science in Germany. In the discipline of Information Systems Science they are called information models. Often models are characterized as reference models which mean that they are generic conceptual models for a certain domain.
Reference models provide a conceptual framework for the description of relevant characteristics of information systems. They are considered as a guideline from which special models can be derived by specialization or refinement. There have been numerous approaches to define the term reference model why we are not trying to pursue this list. For example: the definition of Nonnenmacher (1994), Marten (1995), Rosemann (1996) and Fettke and Loss (2004). Profound analysis of the reference model term can be found at Schütte (1998), vom Brocke (2003) and Thomas (2006). The most recent overview of definitions of the term reference model used in the German Information Systems Science community, can be found in Thomas (2006, p. 21-26). After Thomas (2006) the reference model term has been essentially formed by August-Wilhelm Scheer who defined the ARIS-approach. In his statement he criticizes the neglect of a justification based on facts for using the term reference model for a model. In his opinion the characteristics generally accepted and the recommendation character are insufficient to name a model as reference model. His approach is the *user-oriented* reference model. That means that the use of an information model by a user is considered as an essential criterion to define this model as a reference (Thomas 2006, p. 15). What the

majority of these definition approaches have in common is that they see reference models as a reference for the development for domain specific models because they represent a class of application cases.

As a central concept of this paper telemedicine includes the application of telematics in the medical environment. Telematics is a sufficient but not a necessary prerequisite for telemedicine. Telematics is defined as the integration of telecommunication- and information technology. That means in the medical environment the overcoming of spacial separation between doctor and patient or two doctors among themselves is the focal point (Bundesärztekammer 2010). The term `telemedicine` was subject to constant change in the last years. While in early discussions `telemedicine` was mentioned, this notion was later partially replaced by `eHealth`, `telehealth` or `health telematics`. At this point is referred to the definition of Link (2007), Haas (2006) and a systematic analysis of published definitions at Oh et al. (2005). Basically these definition approaches have in common that they are focused at space and time independent applications and services that are performed by modern ICT.

There are already reference models for the german health care domain such like the Simoneit's reference model (Simoneit 1998) or the IS-H reference model (Bihr and Seelos 1997). The first named model is focused on an intraorganizational hospital information system. A communication with outside involved actors is not considered. The IS-H model is focused on an organization wide data model. Other perspectives of an organization have not been taking into account. It seems obvious that the majority of those approaches concern internal hospital information systems.

The structure of this paper is organized as follows. Section 2 analysis related work and requirements for reference models and telemedical applications, derived from a literature review. Section 3 describes the ARIS-approach as one of the most widely known information multiperspectival architectures. Afterwards we modelled an exemplary telemedicine application with ARIS. Subsequent to the modelling in Section 4 we evaluate those exemplary ARIS-models against the predefined requirements. Section 5 concludes the paper.

2. Requirements for reference modelling and telemedicine

2.1. Reference modelling

Requirements for reference models are divided into general modeling requirements and specific requirements especially for reference models (Schütte 1998, Becker et al. 1995). In this paper, we put our focus on these specific requirements: construction adequacy and language adequacy. Based on the `principles of orderly modelling`, approaches in literature can be found which specify the requirements for modelling (Fettke and Loos 2004/1; Becker et al. 1995; Schütte 1998; Matyas et al. 2007). Table 1 shows a representation of the relevant requirements for reference models to differentiate them from conventional models. The identified requirements are explained and criteria for the evaluation are formulated. By Schütte (1998, p. 111) those two requirements are the essential criterion respectively principle for reference models. This is not an exhaustive description but rather one of a description where the authors consider relevant requirements for the development of a telemedicine reference model, based on a critical-rational understanding of science.

Requirement	Explanation	Criteria for evaluation
Construction adequacy	The traceability of the constructed model has to be appropriate to the problem which had to be solved. Adequateness of the model's content with regards to the user's goals.	- Existence of consensus between the developers of the model and the users? - Existence of consensus between the developers and users of the model concerning the contained information objects in the model?
Language adequacy	The used language has to be suitable and the syntax has to be applied correctly.	- Is a language based meta-model available? - Is a formal semantic available? - Is a well-defined syntax available?

Table 1: Requirements for reference models

2.2. Telemedicine

As part of the literature analysis, two different approaches have been identified for the determination of telemedical requirements. Either the requirements were focused on very specific technical characteristics (e.g. Widya et al. 2003; Ausseresses 1995) or more strategic goals respectively requirements have been formulated (e.g. Haas 2006, p.8f; Bundesärztekammer et al. 2006). For the research purpose of the authors, the development of a telemedicine reference model, the orientation of technical requirements, such as audio echo suppression or upstream push mechanism, are too precise. The identified requirements have to present an adequate and appropriate level of abstraction as otherwise they are no longer meet the requirements of a reference model. It is assumed that a running system is guaranteed so that technical properties don't have to be considered. Under these conditions Table 2 shows a representation of relevant requirements that were identified through a literature review and then subsumed into concrete characteristics (Haas 2006, p.8f; Bundesärztekammer et al. 2006; Mairinger and Ferrer-Roca 2002, p. 185). The identified requirements are explained and questions for the evaluation are formulated. This is not an exhaustive description but rather one of a description where the authors consider relevant requirements for the development of a telemedicine reference model, based on a critical-rational understanding of science.

Requirement	Explanation	Criteria for evaluation
Interface bridging	The bridging of sectors must be ensured.	- Is an interorganizational bridging taking place?
Temporal bridging	An asynchronous communication has to be possible.	- Is a sending and receiving of data at different times possible without blocking the process?
Improvement of decision making	It has to be ensured, that the decisions which are made improved by the transmitted data.	- Can be assumed that the decisions turn out in better quality related to the past? - Do the patients perceive a improved medical supply?

Table 2: Requirements for telemedicine

3. The ARIS-approach as the basis - A exemplary telemedical application

Until now, there is no established language for reference models in theory or practice. Fettke and Loos (2004) describe some requirements for reference modeling languages which defines concepts for the representation of a system. In detail, they require a formal semantic, a well-defined syntax. Although, Entity Releationship Models (ERM), Event Driven Process Chains (EPC) and Function trees (FT) are used to build reference models, it is not stated, if these models are adequate for telemedicine reference models.

Apart from offering medical care, hospitals have to meet economic requirements. Both medical and economic activities have process character. The ARIS architecture is geared on economic aspects and concentrates on business processes. ARIS describes a domain independent information system

architecture, which provides a regulation framework for derivation of reference models (Schütte 1998, p. 90; Scheer 1997, p. 10). The ARIS concept provides a basis for the reduction of complexity by structuring them into different views and phases of a life cycle model (Scheer 2001, p. 2).
The business processes take center stage of the approach and they are the connecting element of the considered institution. Each process is considered from different views – performance, organization, data, function and control. These different views are divided into three layers, depending on their closeness to information technology – concept, data processing concept and implementation. To describe the different views and to reduce complexity various methods of modeling are used. In our research we focused on the concept layer. In the following we first introduce the scenario of the "partnership of the heart" project and afterwards we model the four different views for this scenario. The empirical determination has been made by observation and a survey of experts in the Robert-Bosch-Hospital, one of the project partners.

"Partnership for the heart" is a controlled, multicentered telemedicine study TIM-HF ("Telemedical Interventional Monitoring in Heart Failure") for patients with chronic heart failure. The project is sponsored by the Federal Ministry for Education and Research. Partners are in addition to hospitals, doctors from the hospital inpatient and outpatient care, established specialists and general practitioners who are involved in the patient care. The hospitals have set up a telemedicine center (TMC), which is staffed by a cardiologist and 1-2 study assistants. In most cases, the processing of vital data collection takes place in a 24-hour interval, in the morning between 7 and 11 a.m.. The transmitted data are an electrocardiogram (ECG), blood pressure, body weight and a self-assessment. After the measurement the data are automatically separately transmitted. The transmission takes place via Bluetooth to the Mobile Medical Assistant (MMA). From there a transfer takes place via mobile communication to the TMC where the electronic health record (EHR) is updated. The TMC-doctor first generates diagnostic findings of the ECG and afterwards the study assistants check the other vital signs (blood pressure, pulse, weight and self-assessment) for irregularities. Anomalies in the diagnostic findings are reviewed by the responsible person (doctor, research assistant) and, if needed, they have to confer with the patient or a close relative. In addition there is a periodically patient call. Content of the call is the general well-being, if necessary past hospitalizations, medication changes by the doctor or in the course of the last hospitalization and other medically significant changes in the life of the patient. If the patient has questions or problems he has the opportunity to contact the doctors and study assistants in the TMC by phone.

3.1. Organization view

In the organization view the organization is described as different organizational units including different types of relation. Organizational units are divided into different positions which execute functions. A position is staffed with a person and normally they are created in a way, that one employee can execute one function (Scheer 2001, p.52-54). The most popular way of modeling the organization view is the tree diagram, which is used below.

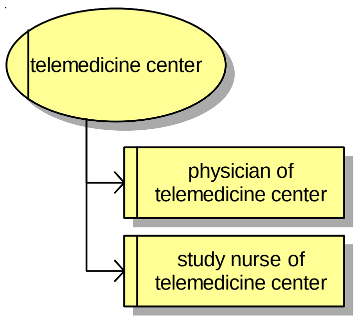

Illustration 1: organigram (hospital)

3.2. Data view

In the data view, data objects are manipulated by functions. For data modeling normally the entity relationship model (ERM) by Chen (1976) is used. The ERM is widely spread in practice (Scheer 2001, p.67ff.). The data model contains the date that is relevant for the patient view as well as for the hospital view because both co-operation partner relay on the same data base.

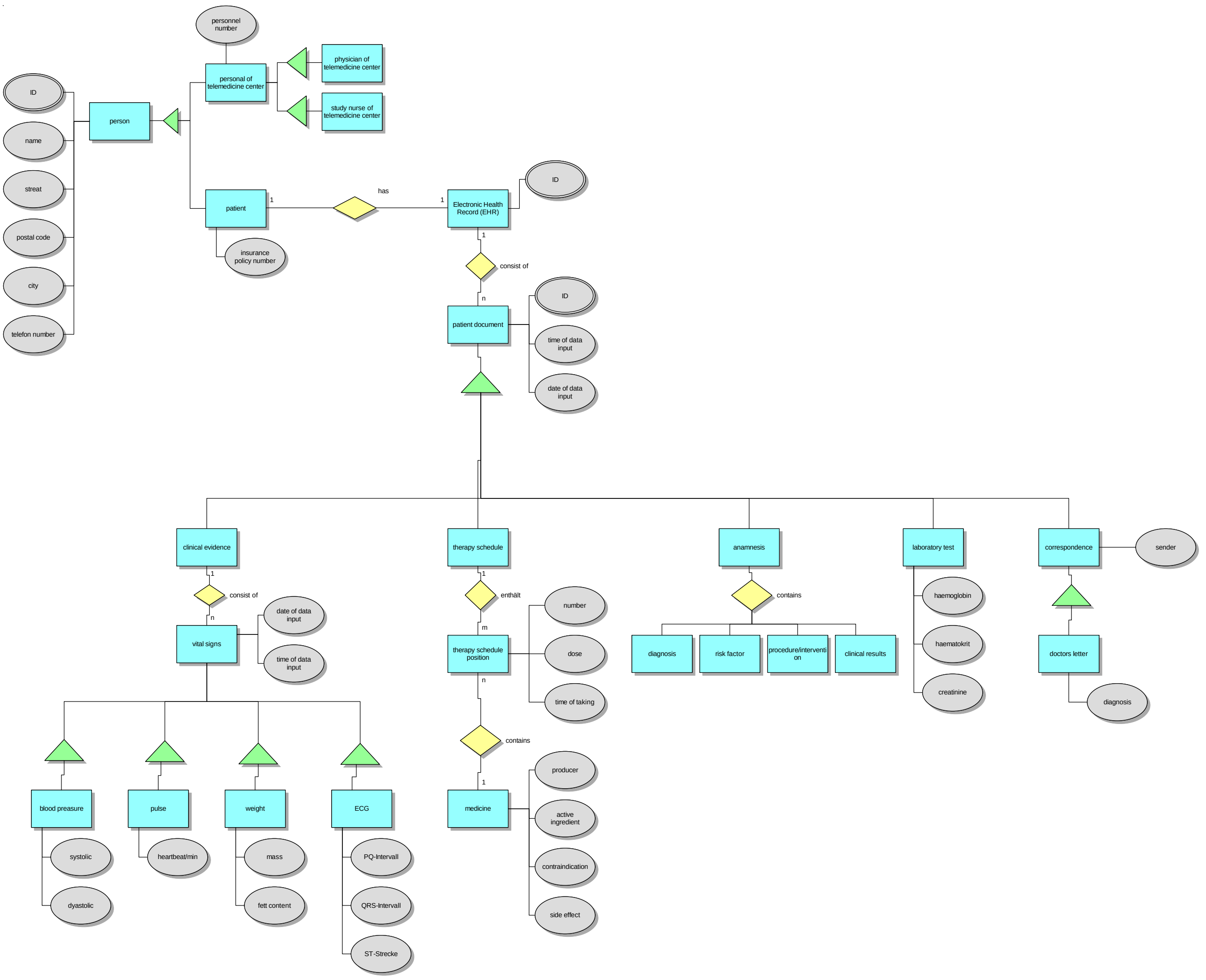

Illustration 2: data model (hospital and patient)

3.3. Performance view

The input and output of processes is modeled in the performance view. The content is illustrated as a product tree with the connection "consist of" (Scheer 2001, p.95).

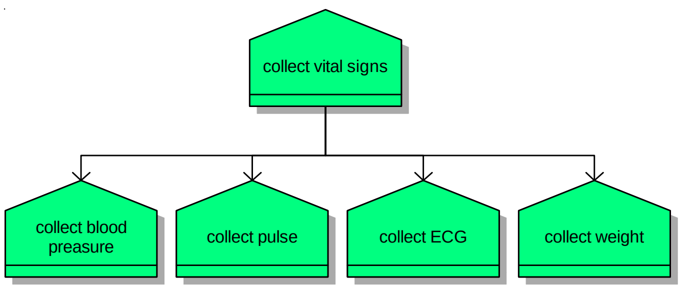

Illustration 3: product tree (patient)

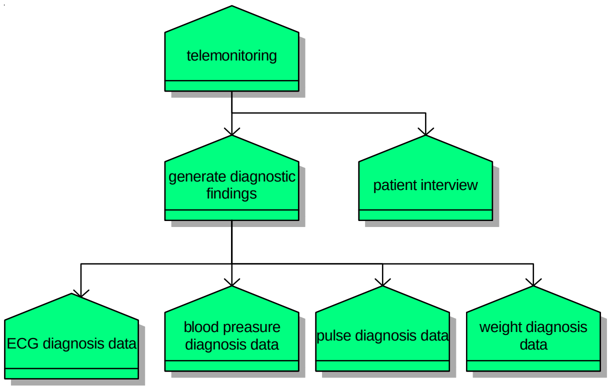

Illustration 4: product tree (hospital)

3.4. Function view

Scheer defines function as „…task on an object to support one or more aims“ (Scheer 2001, p.22, translated by authors). Tasks of the concept layer are the definition of the function structure and the estimation of the sequence of functions. The structure which is used most frequently is the tree diagram (Scheer 2001).

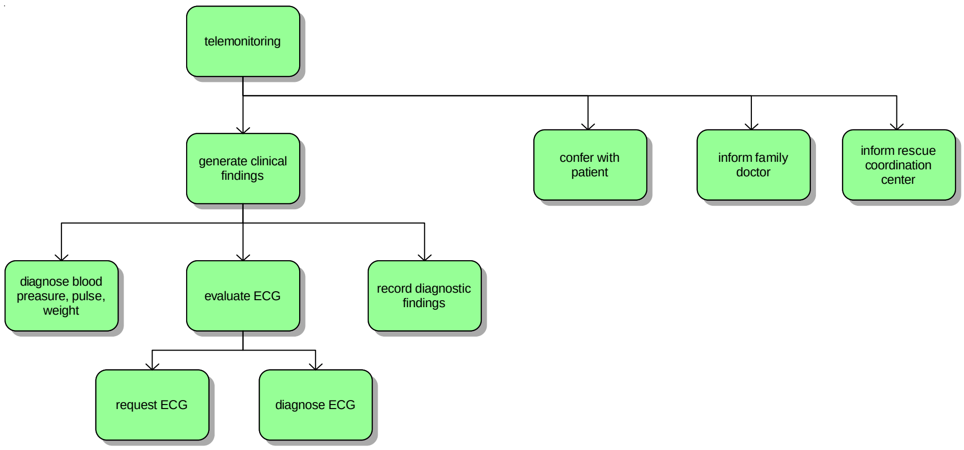

Illustration 5: function tree (hospital)

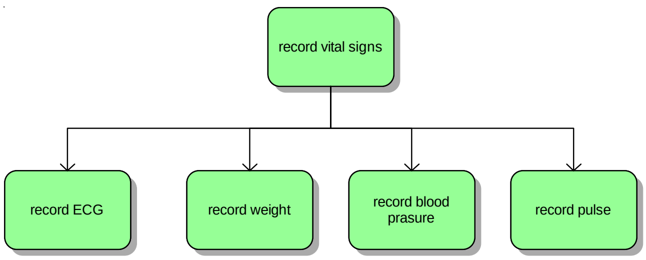

Illustration 6: function tree (patient)

3.5. Control view

The control view connects the function, organization, data and performance view.

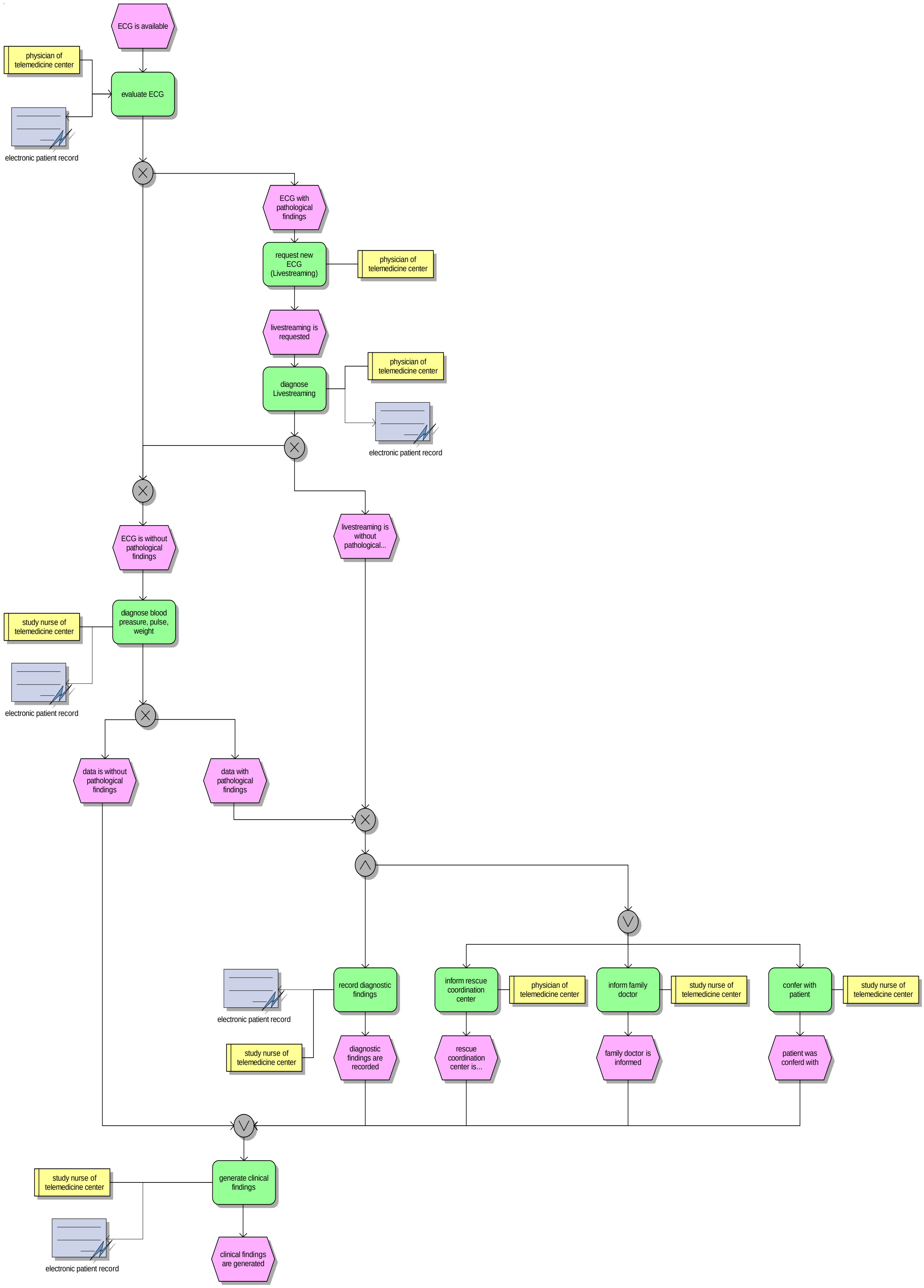

Illustration 7: EPC (hospital)

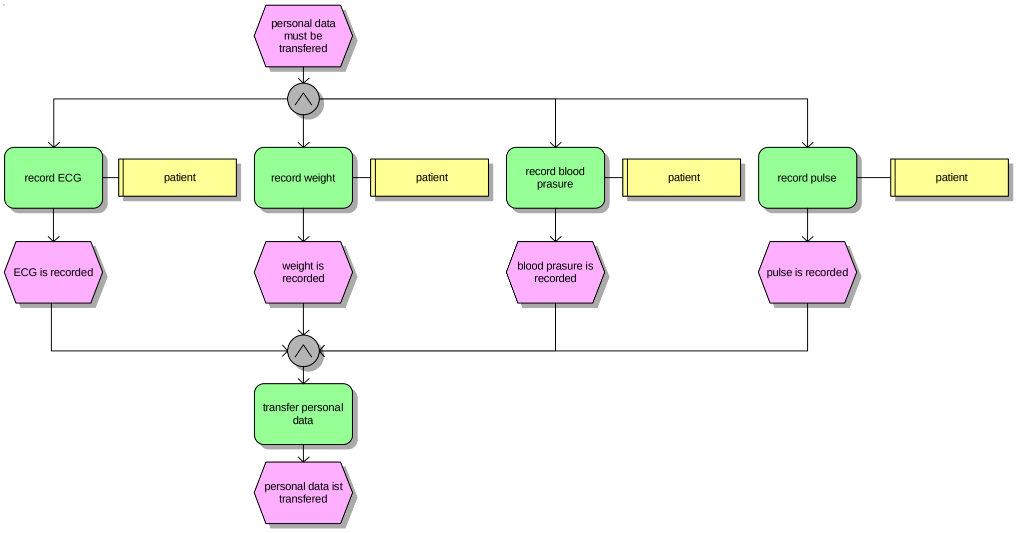

Illustration 8: EPC (patient)

4. Requirements Evaluation

The modelled dimensions of the telemedical application derived from the analysis of the TMC are evaluated with the previously identified requirements. The following table 3 shows the separate requirements and illustrates if the ARIS-approach, as a basis for deriving a reference model for telemedicine fulfils the reference model requirements or not. The same is done with the requirements for telemedicine and the scenario.

Reference model / Telemedicine requirements	**Requirement fulfilled / not fulfilled**
Construction adequacy	This requirement can be understand in two ways: adequateness of the whole construction result or adequateness with a view to specific aspects of the construction. Since we already mentioned specific aspects (i.e. requirements) of telemedicine application, we denote the fulfillment of construction adequacy if specific requirements for telemedicine applications as mentioned above are met.
Language adequacy	The availability of a language based meta model is given, because ARIS is based on a meta model. Further ARIS is based on a formal semantic and the ARIS-Toolset provides a tool for semantic checks, why the formal semantic is given. At least the defined syntax is fulfilled as ARIS comes with highly complex syntax rules and the toolset supports these rules while modelling.
Interface bridging	As it can be seen in the EPC the data is transferred from the patient to the TMC. And in case a livestream can be set up, where interfaces are bridged between the users. It can be said that this requirement is fulfilled.
Temporal bridging	It can not be recognized directly out of the models that a sending of data is possible 24-hours a day. But the expert survey showed that the patients have the opportunity to send their data when they want to. An essential prerequisite for the analysis of this data is that the TMC has to be occupied 24-hour, which is not been given in the described scenario. So this requirement is almost fulfilled.
Improvement of decision making	The scenario tells it and the EPC shows it that the patients get a feedback if any deviation is recognized by the TMC-staff. In an emergency case an emergency plan intervenes and informs the ambulance and the supervising doctor. The past showed that a patient has been saved from death because the TMC-staff did telephone help for a reanimation. Further said patients that they feel well cared through the daily data analysis, requirement meet.

Table 3: Overview of the requirement analysis

As it can be shown all requirements are met except the temporal bridging which is almost fulfilled.

5. Conclusion and Outlook to Forthcoming Research

This paper is a first step towards a reference model for telemedicine. To identify an appropriate basis for developing a reference model for telemedicine the ARIS-approach was analyzed for his usefulness. The ARIS-approach served as groundwork and the ARIS-languages were used to model a specific application of telemedicine, the telecardiology. These models have been evaluated with predefined requirements of reference models and telemedical applications.

Our experience revealed that ARIS is an appropriate instrument to derive telemedical specific applications. The collected requirements for the evaluation and the subsequent results do not claim to universal validity and completeness. It is a first orientation for a framework in order to formulate the development of a reference model. The goal is to design a model that overcome the limitations of existing reference models in the health care domain.

The next research steps will focus on an empirical survey to confirm the identified requirements for telemedical applications and probably receive more or detailed characteristics. In addition to expert interviews a questionnaire survey should be carried out to achieve this aim. Further it has to be considered that an enlargement on other telemedical applications such like teledialysis, teleradiology or telediabetes has to be made.

Literatur

Becker, Jörg; Rosemann, Michael; Schütte, Reinhard (1995) Grundsätze ordnungsmäßiger Modellierung. In: Wirtschaftsinformatik 37 (1995), Nr. 5, S. 435-445.

Bihr, Heike; Seelos, Hans-Jürgen (1997) Entwicklung eines Referenzdatenmodells für Krankenhäuser. In: Wirtschaftsinformatik 39 (1997) 4, S. 367-371.

Bundesärztekammer et al. (2006) Anforderungen der Leistungserbringer an eine anwendungsorientierte und sichere Telematikinfrastruktur im Gesundheitswesen. URL: http://www.bundesaerztekammer.de/downloads/Anforderungskatalog.pdf. Demand on 2010-04-05.

Bundesärztekammer (2010) Glossar zur Telematik im Gesundheitswesen. URL: http://bundesaerztekammer.de/page.asp?his=1.134.3418&all=true#Telemedizin. Demand on 2010-04-19.

Chen, Peter Pin-Shan (1976) The Entity-Relationship Model--Toward a Unified View of Data. In: ACM Transactions on Database Systems 1/1/1976 ACM-Press, S. 9–36.

Fettke, Peter; Loos, Peter (2004/1) Referenzmodelle für den Handel. In: HMD, Heft 235, 2004, S. 15-25.

Fettke, Peter; Loos, Peter (2004) Referenzmodellierungsforschung. In: Wirtschaftsinformatik 46 (2004) 5, S. 331-340.

Haas, Peter (2006) Gesundheitstelematik: Grundlagen, Anwendungen, Potenziale. Springer, Berlin Heidelberg.

Link, Christian (2007) Telemedizinische Anwendungen in Deutschland und in Frankreich: Eine rechtsvergleichende Untersuchung der Grundlagen und des Haftungsgefüges sowie des internationalen Privatrechts. Herbert Utz, München.

Mairinger, T.; Ferrer-Roca, O. (2002) Social Aspects of Technology Transfer. In: Ferrer-Roca, O.; Sosa-Iudicissa (Edt.) Handbook of Telemedicine. IOS Press, Amsterdam, p. 181-187.

Marent, Christian (1995) Branchenspezifische Referenzmodelle für betriebswirtschaftliche IV-Anwendungsbereiche. In: Wirtschaftsinformatik, 37 (1995) 3, S. 303-313.

Matyas, Kurt; Cantele, Manuel; Sihn, Wilfried (2007) Entwicklung eines Data Warehousing Referenzmodells für das Supply Chain Controlling. In: Engelhardt-Nowitzki, Corinna; Nowitzki, Olaf; Krenn, Barbara (Hrsg.) Management komplexer Materialflüsse mittels Simulation. State-of-the-Art und innovative Konzepte. GWV, Wiesbaden, 2007, S. 3-22.

Nonnemacher, Martin Georg (1994) Informationsmodellierung unter Nutzung von Referenzmodellen: Die Nutzung von Referenzmodellen zur Implementierung industriebetrieblicher Informationssysteme. Lang, Frankfurt a.M..

Oh, Hans; Rizo, Carlos; Enkin, Murray; Jadad, Alejandro (2005) What Is eHealth (3): A Systematic Review of Published Definitions. In: J Med Internet Res 2005;7(1):e1. URL: http://www.jmir.org/2005/1/e1/. Demand on 2010-04-19.

Rosemann, Michael (1996) Komplexitätsmanagement in Prozessmodellen: Methodenspezifische Gestaltungsempfehlungen für die Informationsmodellierung. Gabler, Wiesbaden.

Scheer, August-Wilhelm (2001) ARIS – Modellierungsmethoden, Metamodelle, Anwendungen. 4. Auflage, Springer, Berlin Heidelberg.

Scheer, August-Wilhelm (1997) Wirtschaftsinformatik - Referenzmodelle für industrielle Geschäftsprozesse. 7. Auflage, Springer, Berlin u.a..

Schütte, Reinhard (1998) Grundsätze ordnungsmäßiger Referenzmodellierung. Gabler, Wiesbaden.

Simoneit, M. (1998) Informationsmanagement in Universitätsklinika - Konzeption und Implementierung eines objektorientierten Referenzmodells. Wiesbaden: Gabler.

Thomas, Oliver (2006) Das Referenzmodellverständnis in der Wirtschaftsinformatik: Historie, Literaturanalyse und Begriffsexplikation. In: Institut für Wirtschaftsinformatik im Deutschen Forschungszentrum für Künstliche Intelligenz , Heft 187, Saarbrücken.

Vom Brocke, Jan (2003) Referenzmodellierung: Gestaltung und Verteilung von Konstruktionsprozessen. Logos, Münster.

I. Widya; A. Van Halteren; V. Jones; R. Bults; D. Konstantas; P. Vierhout; J. Peuscher (2003) Telematic Requirements for a Mobile and Wireless Healthcare System derived from Enterprise Models. In: Proceedings 7th Int. Conference on Telecommunications (ConTEL) 2003, S. 527-534.

TOWARDS REWARDS AWARENESS IN HEALTH CARE INFORMATION SYSTEMS

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Abstract

In all settings, including health care, people must be motivated to do right actions. Health care is a complicated system with interaction of many parties, and designing effective and efficient health care is not a minor task. One part of designing governance structures and processes for health care is that of designing rewards systems. Effective reward systems and mechanisms can greatly influence health care productivity and demand to the right direction. Still more demanding is the implementation of these reward mechanisms to information systems, which anyway is a necessity for their effective and user-friendly application.

1. Introduction

Reward systems are a part of studies in persuasive computing (Fogg 2003), a growing field of research activity within the IS field. Within economics, reward systems are a deeply studied topic, with main focus concentrating on rewarding top and upper management for their services to organizations (Bennis 1998; Crandall et al. 1997; Talmor et al. 1998). Reward mechanisms in virtual teams are also a very popular topic within IS (Crandall et al. 1998; Crandall et al. 1997; Struebing 1996).

Within health care, rewards are widely used, but little discussed. There is still the deep myth that health care especially is a profession of passion, vocation and mission are key driving factors, and where incentives, including money, would not play any role. The reality is different: in hardly any environment than health care there are so many financial compensations for performance as in health care, especially in the case of medical doctors. The Finnish official list (Kuntatyönantajat 2007) of procedures in health care that provide extra financial compensation for medical doctors is 16 pages long and contains some 250 different procedures. Practice and the myth clearly are far away from each other.

Rewards are easily connected with corruption and face value. That is why it is important that they strongly regulated and governed. A human distributing rewards is always subject to doubts about unfair activities. That’s why it is important that reward mechanisms are implemented to computerized systems.

A good metaphor in this discussion is the open source software community. There individuals contribute to the joint good (good and functional software) without visible financial compensations, mainly driven by other incentives. As well in health care, we should implement a culture where medical care providers would have financial and also non-financial incentives to deliver a joint good (health for the patient, and good and functional patient documentation). It is to be expected that especially the field of non-financial compensations, rewards and incentives is underdeveloped in health care, or at least its functioning is not well understood.

Empowering the patient is a hot topic within health care (Beun 2003; Wilson et al. 2004). Empowering should be supported by rewarding. Empowering means giving the tools for taking care of one-self, but rewarding gives the motivation. Of course the motivation to take care of one-self should be obvious and indisputable, but the masses of people consuming and even dying because of tobacco, drugs, alcohol, etc. witnesses a different trend.

2. Reward Systems

All human communication is about persuading the other communication party to something – to do something or not to do something. This persuasion is supported by explicit or implicit (a punishment) for the recipient undone (George 1995), if the recipient acts as hoped. Such – seen widely - all communication is about rewards, and all electronic communication can be included to the topic of ICT-based reward systems.

Traditionally, reward systems have been connected with monetary compensations, and with the rewarding of employees, especial management and top management. This kind of thinking can be seen for example in the definition of a reward system by (Kerr et al. 2005, 130): "*Reward systems are concerned with two major issues: performance and rewards. Performance includes defining and evaluating performance and providing employees with feedback. Rewards include bonus, salary increases, promotions, stock awards, and perquisites*"
Such a wide definition is anyway not operational. In practice we will have to limit our definition. Here a ICT-based reward system is defined as follows:

> *A network-based system that keeps track of the actual behaviour of an identified object, monitoring its behaviour and registering it to quantitative information, that can be transferred to rewards granted to the one monitored.*

The best known reward systems are connected to service businesses. The American Express credit card company reward system is one prime example. Another species of reward systems live with airline companies – flying mile collection involves maybe milliards of people in the word. Similar – often nationwide – systems are very usual also in banking and retail, just to give a few examples.

Rewards obey many different names. We can talk as well about incentives or compensations. The deeper analysis of these different concepts is beyond the scope of this article, and it should be noted that different languages have different words and meanings for rewards.

The need to control someone's behaviour can also be bound to a customer relationship, or to an employment relationship, among others.

Within health care, we can find three main groups of people needing rewards:
1. individuals for keeping themselves fit
2. family members and other fellow-men to take care of individuals close to them
3. health care service providers for providing better service.

The rewards systems based on customer relationship usually have very little effect on the total household of individuals. On the contrary, when we move on to an employment relationship, it emerges as a very critical area when the basis of individual's main income is being discussed. Reward systems based on performance in working relationship evaluation are a key area of academic research. The tendency seems to be, that different extras based on performance constitute an increasing share of the salary of most workers. How different information systems support this situation is not a marginal issues. The importance of reward systems in employment relationship has been documented in several studies. Kerr and Slocum (1997) conclude that there is no universal best reward system, but that different situations and different corporate cultures necessitate different reward systems. Whole industries, such as health care, can suffer from the consequences of badly functioning reward systems (Waldman et al. 2003).

On discussion item is who should be rewarded. In work relationships, both individuals as well as bigger organizational entities as well can be rewarded. The current trend seems to go towards rewarding groups (Pfeffer 1998).

When we talk about reward mechanisms, the first that comes to mind is the money and financial incentives. However, strong motivational factors are also those of reputation and social acceptance. We have three main forms of rewards:

- Financial incentives, such as the various bonus systems, such as banks, airlines and retail trade
- Reputation-based incentives, especially in the scientific community
- Community-based incentives, which encourage their members to efficiently produce high quality information technology artefacts.

3. Conclusion

Reward systems are already now in use in most sectors of live, including health care. Within the IS community, reward systems belong to the wider and more established topic of persuasive computing.

Within health care, reward systems are needed both for medical professionals as well as for individual citizens. The myth that health care would be something immune to financial rewards should be demolished.

Health care professionals should be motivated to a more efficient information systems use. The deficiencies with regard to patient care resulting from the fact that information is insufficient should be eliminated. For the patient continuity of care is important. This means that his treatment takes place at the right point, the point of treatment knows how he was treated before, and that everyone knows how he/she would continue to be treated. For the patient, it is significant also that the previous medical records are used to avoid unnecessarily repeated treats, which often are very unpleasant investigations for the patient.

REFERENCES

Bennis, W. "Just rewards," *Executive Excellence* (15:11) 1998, pp 3-4.

Beun, J.G. "Electronic healthcare record; a way to empower the patient," *International Journal of Medical Informatics* (69) 2003, pp 191-196.

Crandall, F.N., and Wallace, M.J. *Work & Rewards in the Virtual Workplace* AMACOM, 1998.

Crandall, N.F., and Wallace, M.J., Jr. "Inside the virtual workplace: Forging a new deal for work and rewards," *Compensation & Benefits Review* (29:1) 1997, pp 27-36.

Fogg, R.J. *Persuasive Technology. Using Computers to Change What We Think and Do* Morgan Kauffmann Publishers, San Francisco, 2003.

George, J.M. "Asymmetrical effects of rewards and punishments: The case of social loafing," *Journal of Occupational & Organizational Psychology* (68:Part 4)) 1995, pp 327-338.

Kerr, D.L., and Slocum, J.W., Jr. "Managing corporate culture through reward systems," *Academy of Management Executive* (1:2) 1997, pp 130-137.

Kerr, J., and Slocum, W., Jr. "Managing corporate culture through reward systems," *Academy of Management Executive* (19:4) 2005, pp 130-138.

Kuntatyönantajat "Terveyskeskusten lääkärien toimenpideluettelo," 2007.

Pfeffer, J. *The Human Equation: Building Profits by Putting People First* Harvard Business School Press, 1998.

Struebing, L. "Research shows rewarding individual goals can hinder team success," *Quality Progress* (29:10) 1996, pp 17-18.

Talmor, E., and Wallace, J.S. "Computer industry executives: An analysis of the new barons' compensation," *Information Systems Research* (9:4) 1998, pp 398-414.

Waldman, J.D., Smith, H.L., and Hood, J.N. "Corporate Culture: The Missing Piece of the Healthcare Puzzle," *Hospital Topics* (81:1) 2003, pp 5-14.

Wilson, P., Leitner, C., and Moussalli, A. "Mapping the Potential of eHealth: Empowering the Citizen through eHealth Tools and Services," in: *eHealth Conference*, Wilson, Petra - Leitner, Christine - Moussalli, Antoinette, Cork, Ireland, 5-6 May 2004, 2004.

ADAPTATIONS FOR E-KIOSK SYSTEMS TO DEVELOP BARRIER-FREE TERMINALS FOR HANDICAPPED PERSONS

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Abstract:
Today information and communication technologies represent an important part of our life. Over the years, these technologies and regular innovations have lead s to a changed community, who recognizes the advantages of these technologies. Irrespective of the branch of trade, each company and all actors connected can benefit from such innovations, which enable more effective and efficient operations in their daily processes.

In Germany, the e-health sector is especially is focused at this time on the new e-health card concept which is currently in the test stage and should be established within the next years. This e-health card will totally change our current system, because this concept allows several new functions. Some of the possible functions are compulsory for the enrollees while other functions are optional. Examples include electronic prescriptions, electronic patient records and the emergency data of the enrollee in case of an emergency. With these new innovations, the market actors are confronted with several advantages and also disadvantages. A sensitive point here is the aggregation of enrollee data, which brings some advantages, but also a threat regarding data security and access authorization. Therefore, the regulations and laws are very strict.

Because enrollees have concerns about their data, the health insurance companies have to ensure that enrollees have the possibility to check and to manage their data. Therefore, electronic kiosk systems (e-kiosks) are important, because these terminals are self-service terminals, where the enrollees can among other things manage their health data. It is important that these e-kiosks are also useable for handicapped persons. Hence, this paper will also identify possibilities pertaining to how these terminals can be adapted to ensure that the different groups of handicapped persons can also use these e-kiosks.

Keywords: e-health card, electronic prescriptions, electronic health professional card, emergency data, electronic health record, electronic kiosk

1. Introduction

The implementation of the German e-health card (eHC) will totally change the current healthcare system in Germany. New functions will be available and the focus will move more to the electronic-based view. These new functions are for example electronic prescriptions, electronic patient records and the emergency data of the individual or enrollee in case of an emergency.

But this does not mean that there are just advantages. There are also disadvantages. Furthermore, the guarantee of data security and data protection will be a big challenge.

Because the enrolled patients have strong concerns about their medical data, health insurance companies have to install e-kiosks, which are self-service terminals, throughout Germany. Further, because of the fact that handicapped persons should also have access to these terminals, adaptations are essential to guarantee barrier-free e-kiosks.

This paper will first give an overview about the German eHC and will show the new possible functions. Section 3 will mention the advantages and disadvantages of this eHC, whereas section 4 will give information about data security and data protection. Section 5 will be focused on e-kiosks and will show possible ideas, how these terminals can be adapted for the needs of disabled persons. Conclusions will eb drawn in section 6.

2. The concept of the e-health card

With the implementation of the e-health card (eHC), people in Germany can benefit from several new functions. Generally, the functions of the e-health card are divided into two category groups. Firstly, there is the area of administrative functions, which are compulsive for the card owners. Secondly, there is the area of medical functions, which are optional for the card holders. Both areas consist of two steps. (CW Haarfeld 2010)

The implementation of the e-health card in Germany begins with the implementation of the administrative functions. Therefore, in the first step of the implementation of the e-health card information about the insurance agreement and the necessity of additional payments will be stored. The data will be stored on the e-health card and can be updated for example during every consultation of a medical doctor through an online process. In addition, this first step includes data about the care provider, the personal information about the insurant as well as the lifelong valid insurance number. Furthermore, private insurance companies can also add information about the scope of services, which a private insurant can utilize during a stay in hospital. (CW Haarfeld 2010)

Finally, the first step of the administrative area includes an insurance-coverage for the insurants within the European Union. But the requirement here is that the appropriate countries have a social agreement among each other. The back side of the e-health card is ideal as identity card for this European Health Insurance Card (EHIC). (European Commission 2010)

The following pictures show the front and the back of a German eHC.

Picture 1: Front of the eHC (BMG 2008, p. 19)

Picture 2: Back of the eHC – EHIC (BMG 2008, p. 30)

The new e-health cards are equipped with this EHIC independent from the insurance company. Therefore, the "old" E-111-Formulars, which were used in the past during a stay abroad in another European country, are not longer required. (EU-Info Deutschland 2010) However, these EHICs are only applicable for insurants from a legal insurance, because private patients usually have insurance-protection worldwide. (Verband der privaten Krankenversicherung e.V. 2010, p. 10)

The second step of the administrative functions includes the electronic prescription (e-prescription), which is also compulsive for all involved actors of the German healthcare system. Based on this concept, it is possible to remove the nearly 700 million paper-based prescriptions and to process these transactions electronically. The proceeding looks like this: At first, the doctor has to look on the insurance data of the patient. Therefore, the doctor can use the eHC of the patient and can read all the essential data with a special reading device. When the patient needs some medicine, the doctor can store the data of the decreed medicine in electronically form (e-prescription) on the e-health card or on a special server. The necessary signature of the doctor will be generated electronically with the aid of an electronic health professional card (HPC). (gematik 2010a)

When a patient wants to redeem the electronic prescription in a pharmacy then the procedure goes the reverse direction. Firstly, the validity of the doctor's signature will be checked. After the following presentation of the medicine through a pharmacist or another authorized staff member, the electronic prescription will become invalid and the data will be transmitted to the pharmacy's data center. (gematik 2010a)

With the medical functions in step 3, the voluntary part begins for the insurants and their e-health card. This means nothing more than the insurants can decide for their own, if they want to use these additional functions or not. The main focus here is on the storage of personal health data from the insurants. Examples are the documentation of medicine, which an insurant has used or the storage of emergency data of the insurant in case of emergency. Through the medicine documentation it is possible to avoid interdependencies between the individual drugs. Furthermore, the emergency data should help the emergency doctor to medicate purposefully and effectively. For example, this could help the doctor to take allergy or chronic illness through the patient's therapy into consideration. (gematik 2010b)

The fourth and final step includes among other things the electronic health record (EHR). With this EHR it is possible to have access to all the patient's data. Thereby it is not important, if the data are stored at one place or at different places, because the patient's data can be accepted, processed and attended centrally. (GVG 2004, p. 9)

3. Advantages and disadvantages of the e-health card

The implementation of the eHC implicates advantages and also disadvantages. At this point, it is essential to differentiate between the enrollees, service providers – here for example medical doctors and pharmacists – and cost units – here the health insurance companies.

The eHC will help the insurants to get a qualitative higher therapy. The reason is that the eHC makes data of patients faster available, which means that redundant examinations and administration of inappropriate drugs can be avoided. (gematik 2010c)

Another advantage for the enrollees is that with the storage of the health data they will receive a better overview of their health status and thus their personal responsibility will be starched. (gematik 2010c). Moreover, the enrollees have great concern about their data and can therefore decide for their own, which medical data should be stored and which not. Based on the data protection and data security, the insurants can decide which doctor for example has access. In addition, the last fifty data accesses will be registered. (gematik 2010c)

The service providers have the advantage that they can get a fast and extensive overview of the patient's status of health owing to the eHC. Through the documentation of the medical data redundant examinations can be avoided. Additionally, in case of an emergency the doctor can take all former examinations from other service providers into account of their diagnosis. (gematik 2010d)

Furthermore, the service providers have the advantage that they can save time thanks to their optimized workflow. This time can be brought in the patient's examination and therapy. (gematik 2010d)

For the cost units, which are the health insurance companies, the eHC also brings a lot of advantages. For example, due to the reduction of redundant examinations the health insurance companies can realize cost savings. The documentation of the medicine avoid on the one hand that the patient will be examined with inadequate medicine and on the other hand this fact also results in cost savings for the health insurance companies. (gematik 2010e) As mentioned before, service providers write over 700 million prescriptions annually. Approximately 90% of all prescriptions can be imputed to the legal insurants, who will exclusively use the electronic prescription. (Monetos 2010) In addition, some of the 8.6 million private insurants will also use this e-prescription. (PKV 2009) Based on these facts, approximately 500 million Euros can be saved every year. (Scheer 2009, p. 5)

Finally, the fact that the eHC is definitely assignable to the card holder is also an advantage for the health insurance companies. The reason is that unauthorized usage of medical services through a third party can be avoided. (gematik 2010e)

The disadvantages, which are occurring through the implementation of the e-health card in Germany, can be summarized under the point of very high implementation costs of approximately 1.7 billion Euros and 150 million Euros running costs each year. (Scheer 2009, p. 5)

4. Data protection and data security related to the German e-health card

Based on the implementation of the eHC, the medical care of the patients is believed to become better. However, it should keep clearly in mind that the data protection and the data security have to be guaranteed, because the necessary data are personal data of the patient.

Paragraph 291a SGB V includes precise guidelines, how the access to the individual patient data has to be arranged. These rules were developed together with the federal commissioner for data security and were regulated by law. (gematik 2010f)

The goal of the paragraph 291a SGB V is that a very high security and protection in connection with the sensitive data of the patient and a maximum transparency for the patient can be guaranteed. For this reason, only data are allowed to be saved, which provide the medical care. (BMG 2010) Every patient, who will agree to the storage of personal medical data, will have a personal data security container, which is locked and strictly secured. Only the patients have the highness about their data. This means that the patient can decide for himself, in which amount his personal health data are allowed to be stored. This means that the patient can also decide at anytime when these data have to be deleted. Additionally, it is possible to restrict the access to these personal data and information to only selected doctors. (BMG 2010) This can be done at an electronic kiosk (e-kiosk), which will be discussed in section 5.

The data access will be realized with the two-key-principle. This means that the access to the personal data container needs two keys. One key holds the doctor or pharmacist, which is the already mentioned electronic health professional card (HPC). But this key alone does not allow an access to the data container of the patient. Only together with the second key, which is nothing more than the eHC with the personal PIN of the patient, allows the access to the patient's data container. (gematik 2010g, p. 7) Exceptions to this two-card-principle are for example the electronic prescriptions and the record of emergency data, because here the personal PIN of the patient is not necessary to get access to the data container. (BMG 2010)

An additional security attribute is that the last fifty accesses to the eHC will be registered and stored on this e-health card. (gematik 2010g, p. 17) Furthermore, the misuse of the eHC through a third party will be prosecuted criminally. In paragraph 307 SGB V the regulations for fines were enhanced, while paragraph 307a SGB V creates new elements of an offense in connection with the e-health card.

Because it is essential that all the requirements of the data security and protection will be included in the definition of the telematics infrastructure, the federal ministry – Bundesministerium für Gesundheit – has to approve all agreements of the autonomy, which refer to the e-health card. (BMG 2010)

5. Electronic kiosks (e-kiosks)

Section 4 mentioned that the insurants respectively the patients have the highness about their personal medical data. But this can only be achieved, if the health insurance companies will install such e-kiosk terminals all over the country. A definition from the Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH for an electronic kiosk (e-kiosk) is that an e-kiosk is a primary system for the maintenance of applications and data through an insurant. (gematik 2006a, p. 22)

With the usage of an e-kiosk, the insurant can, for example, remove electronic prescriptions and administrate access rights for doctors. Furthermore, these terminals should allow the patient to activate or deactivate the voluntary applications and to read the emergency data. (gematik 2006b, p. 81-83)

The technical specifications and requirements for a barrier-free e-kiosk are not determined so far and the e-health card is at this time in the test stage. (gematik 2006b, p. 81-83) The following chapter 5.1 will show the actual situation in Germany with disabled people and will mention general ideas, how e-kiosks can be barrier-free.

5.1 Specification for barrier-free e-kiosk terminals

Based on the information of the German Federal Statistical Office (Statistische Bundesamt), Germany had in the year 2007 6.9 million seriously disabled persons, which were 153,000 people more than in year 2005. This means that every twelfth inhabitant, which is 8.4% of the total population, was seriously disabled. Serious disabled are persons, if they have a degree of disability of at least 50%. (Statistisches Bundesamt Deutschland 2008)
Most frequently, with 64%, these seriously adapted persons had physical disabilities. 24% of these people were handicapped because of their viscera. 14% were constrained in their movements because of restricted leg and arm functions and 13% because of their backbone and body. 5% were blind or had a visual impairment. 4% were adversely affected by hardness of hearing, disturbance of equilibrium or speech disorder. 10% were mentally and 9% were cerebral disordered. For the rest of the people the disability were not reported. (Statistisches Bundesamt Deutschland 2008)

The BGG – Behindertengleichstellungsgesetz regulates the equalization of disabled persons. Paragraph 4 BGG especially defines the phrase barrier-free. Based on this, barrier-free is guaranteed when disabled persons can use the application or facility in a general common manner, without specific difficulty. Furthermore, these facilities have to be accessible and usable in principle unassisted.

Because of above mentioned information, it is essential now to have a look on e-kiosks and to develop specifications, which guarantee a barrier-free usage of the eHC and all the included functions. Because the specifications for e-kiosks are not defined through the gematik mbH so far, this paper will be oriented on comparable solutions used for ATMs or other self service terminals. There exists a list of requirements for barrier-free self service terminals, which was defined by the senate department for integration, labor and social affairs in Berlin. (Senatsverwaltung für Inneres in Berlin 2008)

As mentioned above, 24% of the 6.9 million disabled persons in Germany were handicapped because of their viscera. This fact has no consequence for the specifications and requirements of an e-kiosk, because they have no problems with the usage of these terminals.

However, 14% of all the disabled persons in Germany were constrained in their movements because of their restricted leg and arm functions. This is really a problem, because these people cannot use an e-kiosk in a usual way. For example, if these people need a wheelchair, the e-kiosk has to be adjustable in height, because when they sit in a wheelchair the standardized height of a terminal is not achievable for them. Furthermore, these height adjustments should be as easy as possible. Therefore, it is advisable to control this electronically with the aid of a switch. This switch should be placed in a position, where also people with a wheelchair can push them.

Based on the facts above, 13% of all handicapped persons had problems with their backbones and bodies. Here it is also essential, that e-kiosks are height adjustable, because these people need to stand upright. Furthermore, these terminals need a place of deposit, where these people can lay down their bags or their other baggage.

As published by the Statistische Bundesamt Deutschland, 5% of the 6.9 million handicapped persons in Germany were blind or had a visual impairment. Therefore, e-kiosks should have a telephone receiver. The computer will read the insurant's medical data and will reproduce this data to the patient by synthetic voice. Additionally, it is also essential that e-kiosks will have acoustic warning signals, a Braille keyboard and a Braille computer software, which will recognize this font and will translate this into standard text. Furthermore, the insurant should have the possibility to change the size of the font according to his visual impairment. But all these measurements create a conflict related to the data security and the data protection, because people, who are blind or have a visual impairment cannot prevent the situation, that a third person will see or listen to their data. For this reason, it is necessary that e-kiosks will be isolated in special prepared areas with enough space in the surrounding area.
For the 4% of the handicapped persons, who were adversely affected by hardness of hearing, disturbance of equilibrium or speech disorder and the 10% and 9% of the disabled persons, who were mentally and cerebral disordered, are no adaptations necessary, because usually they can read the information on the display of the e-kiosk.

Another important group, who will have big problems with a classical e-kiosk, is the group of illiterates. In Germany live around 4 million illiterates, who have problems with reading and writing. (Doebert and Hubertus 2000, p. 8). For these people, telephone receivers are again the solution. These people will hear all the information they want by synthetic voice. An additional point for this target group is that e-kiosks need a speech recognition software. This software should record all the spoken information. Furthermore, this software should also manage the e-kiosk in the point that the e-kiosk will search for the requested information and will reproduce the data by synthetic voice.

Another idea is that personal adjustments will be stored. If an insurant inserts his eHC into the e-kiosk, his personal adjustments will be loaded and the e-kiosk will transpose his settings. This means that the e-kiosk will change the height automatically based on the preferences of the insurant.

Finally e-kiosks should have an integrated printer, where insurants can print the information they want.

5.2 Additional benefits achieved through an e-kiosk

An e-kiosk is more than a machine, which gives information. These terminals can also be used to attract insurants. When the insurants will come to the health insurance company and will have a look on their medical data, this situation can be used for further affairs.

For example, e-kiosks can be featured with an integrated camera, which will make cost-free pictures of the insurant and will store the pictures in a database. Because of the fact that the new eHC must have a picture of the insurant on the front, this feature could help to save money for both insurants and health insurance companies. Especially socially deprived people will benefit from such a solution and health insurance companies can reduce their administration effort. (TrustTerminal AG 2010)

The following picture shows such an e-kiosk terminal.

Picture 3: e-kiosk with an integrated camera (TrustTerminal AG 2010)

Another aspect is that e-kiosks can be used to give insurants information about for example the city, actual events and weather forecasts. Even such aspects could help to achieve a higher customer acceptance of these e-kiosks.

6. Conclusion

It is often useful to think about the “e” in e-health as having several meanings including (JMIR, 2003):

Efficiency – one of the promises of e-health is to increase efficiency in healthcare, thereby decreasing costs. One possible way of decreasing costs would be by avoiding duplicative or unnecessary diagnostic or therapeutic interventions, through enhanced communication possibilities between healthcare establishments, and through patient involvement. The Internet will naturally serve as a great enabler for achieving this e in e-health.

Enhancing quality of care – increasing efficiency; i.e., involves not only reducing costs, is not an end in and of itself but rather should be considered in conjunction with improving quality which should be one of the ultimate goals of e-health. A more educated consumer (as a result of the informational aspects of e-health) would then communicate more effectively with their primary care provider which will, in turn, lead to improved quality of care.

Evidence based – e-health interventions should be evidence-based in the sense that their effectiveness and efficiency should not be assumed but proven by rigorous scientific evaluation and support from case histories. Web accessible case repositories facilitate the timely accessibility of such evidence and thus help in the achieving of the necessary support of a diagnosis or treatment decision. The evidence-based medicine component of e-health is currently one of the most active e-health research domains, yet much work still needs to be done in this area.

Empowerment of consumers and patients – by making the knowledge bases of medicine and personal electronic records accessible to consumers over the Internet, e-health opens new avenues for patient-centered medicine, and enables patient education and thus increases the likelihood of informed and more satisfactory patient choice.

Education of physicians through online sources (continuing medical education) and consumers (health education, tailored preventive information for consumers) makes it easier for physicians as well as consumers to keep up to date with all the latest developments in the medical areas of their respective interests. This in turn is likely to have a positive impact on the quality of care vis-à-vis the use of the latest medical treatments and preventive protocols.

Extending the scope of healthcare beyond its conventional boundaries, in both a geographical sense as well as in a conceptual sense leads to enabling such techniques as telemedicine and virtual operating rooms, both of which are invaluable in providing healthcare services to places where it may otherwise be difficult or impossible to do.

Ethics – e-health involves new forms of patient-physician interaction and poses new challenges and threats to ethical issues such as online professional practice, informed consent, privacy and security issues. However, this is not an intrinsic feature of e-health but rather a feature of the Internet technology which is the foundation for all e-business initiatives, therefore, e-health along with e-government, e-insurance, e-banking, e-finance and e-retailing must all contend with these ethical issues. Given the nature of healthcare, these issues could be more magnified.

Equity – to make healthcare more equitable is one of the aims of quality identified by the American Institute of Medicine (Institute of Medicine, 2001) generally and is one of the promises of e-health. However, at the same time there is a considerable threat that e-health, if improperly implemented and used, may deepen the gap between the "haves" and "have-nots", hence the need for a robust framework to ensure the proper implementation of any e-health initiative. In particular, some of the key issues for equity revolve around broad access and familiarity with the technology.

The e-health card challenges many of these "e's in particular equity so that able and disabled persons can use the system with similar ease a point that is particularly important given that Germany had 6.9 million seriously handicapped persons in year 2007 Other considerations include empowering enrollees and ensuring the system is efficient and effective. This paper has shown that with the implementation of the e-health card, the healthcare sector and all the actors will be confronted with a lot of new functions, which are partly compulsive and partly voluntary. For example, the paper-based prescriptions can be replaced by electronic prescriptions. Furthermore, enrollees have the possibility to check their medical data centrally, because e-kiosk terminals allow insurants to have a look on all their consolidated data aggregated from different medical doctors.

In addition, because the patients' medical data are very sensitive information, data security and data protection play an important role.
Because of the fact, that the specifications and requirements for barrier-free e-kiosks are not developed so far, however Germany had 6.9 million seriously handicapped persons in year 2007, this paper has shown possibilities to adapt e-kiosk terminals to the needs of handicapped persons. We close by calling for more research in this area so that the ehealth card will be a complete success.

References:

BMG – Bundesministerium für Gesundheit, 2008, Spezifikation der elektrischen Gesundheitskarte, Retrieved on 2010-02-25 from http://www.bmg.bund.de/nn_1191726/SharedDocs/Downloads/DE/GV/GT/Gesundheitskarte/Technische_20Festlegungen_20fuer_20die_20Testverfahren/Spezifikation_20elektronische_20Gesundheitskarte/Teil-3-Aeussere-Gestaltung,templateId=raw,property=publicationFile.pdf/Teil-3-Aeussere-Gestaltung.pdf

BMG – Bundesministerium für Gesundheit, 2010, Rechtliche Grundlagen, Retrieved on 2010-03-02 from http://www.bmg.bund.de/nn_1168248/SharedDocs/Standardartikel/DE/AZ/E/Glossar-Elektronische-Gesundheitskarte/Rechtliche-Grundlagen.html

CW Haarfeld, 2010, Stufenweise Einführung der Funktionen der elektronischen Gesundheitskarte, Retrieved on 2010-02-20 from http://www.cw-haarfeld.de/egk/suche/showpage.php?page=stufen&sesid=EKG7-1213381815297077

Doebert M., Hubertus P., Bundesverband Alphabetisierung e.V., 2000, Ihr Kreuz ist die Schrift – Analphabetismus und Alphabetisierung in Deutschland, 1. Aufl. Erst Klett Verlag GmbH, Stuttgart

EU-Info Deutschland, 2010, Die europäische Krankenversicherungskarte, Retrieved on 2010-02-25 from http://www.eu-info.de/sozialversicherung-eu/5873/7355/

European Commission, 2010, The European Health Insurance Card, Retrieved on 2010-02-26 from http://ec.europa.eu/social/main.jsp?catId=559

gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH, 2006a, Einführung der Gesundheitskarte - Glossar, Retrieved on 2010-03-12 from www.gematik.de/upload/gematik_QS_Glossar_V1_5_0_701.pdf

gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH, 2006b, Endbericht zur Kosten-Nutzen-Analyse der Einrichtung einer Telematik-Infrastruktur im deutschen Gesundheitswesen, Retrieved on 2010-03-17 from http://www.google.de/url?sa=t&source=web&ct=res&cd=1&ved=0CAYQFjAA&url=http%3A%2F%2Fwww.gkv.info%2Fgkv%2Ffileadmin%2Fuser_upload%2FProjekte%2FTelematik_im_Gesundheitswesen%2FKNA_Endbericht.pdf&ei=qHOnS_epFIaqmgPryvzbAg&usg=AFQjCNGZyroCq_t16tOflPSkZu8oY0FeTA

gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH, 2010a, Elektronisches Rezept, Retrieved on 2010-02-27 from http://www.gematik.de/%28S%28hs0lyaf4aiz2x1m354jen155%29%29/Anwendungen___Pflichtanwendungen___eRezept.Gematik

gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH, 2010b, Notfalldaten, Retrieved on 2010-02-27 from http://www.gematik.de/%28S%28hs0lyaf4aiz2x1m354jen155%29%29/Anwendungen___Freiwillige_Anwendungen___Notfalldaten.Gematik

gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH, 2010c, Vorteile für Versicherte, Retrieved on 2010-02-25 from http://www.gematik.de/%28S%28vp0xoaec301guw55hfcmqrzr%29%29/Vorteile_fuer_Versicherte.Gematik,

gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH, 2010d, Vorteile für Leistungserbringer, Retrieved on 2010-02-25 from http://www.gematik.de/%28S%28vp0xoaec301guw55hfcmqrzr%29%29/Vorteile_fuer_Leistungserbringer.Gematik

gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH, 2010e, Vorteile für Kostenträger, Retrieved on 2010-02-25 from http://www.gematik.de/%28S%28vp0xoaec301guw55hfcmqrzr%29%29/Vorteile_fuer_Kostentraeger.Gematik

gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH, 2010f, Gesetzliche Grundlagen, Retrieved on 2010-03-02 from http://www.gematik.de/%28S%28lowfwyrtioawjp55xi5ojczi%29%29/Gesetzliche_Grundlagen.Gematik

gematik – Gesellschaft für Telematikanwendungen der Gesundheitskarte mbH, 2010g, whitepaper Sicherheit, Retrieved on 2010-03-03 from http://www.gematik.de/upload/gematik_whitepaper_sicherheit_3571.pdf

GVG – Gesellschaft für Versicherungswissenschaft und –gestaltung, 2004, Managementpaper Elektronische Patientenakte, Retrieved on 2010-02-28 from http://ehealth.gvg-koeln.de//cms/medium/676/MP_ePa_050124.pdf

Institute of Medicine, 2001 "Crossing the Chasm-A New Health System for the 21st Century," (National Academy Press, Washington, DC: Committee on Quality of Healthcare in America).

JMIR (Journal of Medical Internet Research) http://www.jmir.org

Monetos – Independent Information and Research on the European Private Financial Sector, 2010, Gesetzliche Krankenversicherung, Retrieved on 2010-02-21 from http://www.monetos.de/versicherung/gesetzliche-krankenversicherung/

PKV – Private Krankenversicherungen.de, 2009, Zahl der privat Versicherten erreicht neuen Höchststand, Retrieved on 2010-03-05 from http://www.privatekrankenversicherungen.de/news/00082_Zahl-der-privat-Versicherten-erreicht-neuen-Hoechststand.php

Scheer A.-W., Bitkom – Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V., 2009, Wie stehen die Deutschen zur elektronischen Gesundheitskarte?, Retrieved on 2010-03-08 from http://www.bitkom.org/files/documents/BITKOM-Praesentation_Gesundheitskarte_22_10_2009.pdf

Senatsverwaltung für Inneres in Berlin, 2008, Katalog der Anforderungen an barrierefreie Kassenautomaten, Retrieved on 2010-03-20 from http://www.berlin.de/imperia/md/content/vergabeservice/musterauschreibungen/barrierefreiekassenautomaten/rs_wtf_08_02_tabelle_anforderungen_iii.doc

Statistisches Bundesamt Deutschland, 2008, 6,9 Millionen schwerbehinderte Menschen in Deutschland, Retrieved on 2010-03-14 from http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Presse/pm/2008/07/PD08__258__227,templateId=renderPrint.psml

TrustTerminal AG, 2010, eGK-TrustTerminal, Retrieved on 2010-03-20 from http://www.trustterminal.com/Produkte/eKiosk/eGKTrustTerminal/tabid/64/Default.aspx

Verband der privaten Krankenversicherung e.V., 2010, Die elektronische Gesundheitskarte in der privaten Krankenversicherung, Retrieved on 2010-02-22 from http://www.private-gesundheitskarte.de/broschueren_materialien/pkv_broschuere_zur_einfuehrung_der_egk.pdf

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