Smart Cards in Healthcare Information Systems: Benefits and Limitations

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***Abstract*—Smart cards in Health Information Services (HIS) are considered to have great potential to improve the delivery of healthcare services and reduce healthcare costs. On the other hand, HIS smart cards also introduce new challenges and limitations that require further analysis before a full-scale implementation. In this paper, smart cards in HIS are presented, along with current implementations and the benefits and the limitations that arise from their use.**

I. Introduction

HEALTHCARE Information Services (HIS) have great potential to enhance the services offered by the healthcare industry, towards increasing productivity, lowering costs, reducing medication errors, increasing transparency and fraud detection and easing the manpower shortage in healthcare. Although the various benefits that HIS offer to all parties involved – healthcare professionals, patients and investors – are indisputable, there are several limitations that have to be alleviated for the successful adoption of HIS. Key elements that have to be taken into consideration for a successful HIS deployment is the need for patient-centric, ubiquitous healthcare, independent of time and location, given the increased population mobility nowadays, and the need for greater assurance of patients' privacy considering the high sensitivity of medical records.

The increased security and mobility requirements of modern HIS, make smart cards a possible solution, since smart cards can provide security assurance and obviously solve the mobility problem. Smart cards can grant convenient and flexible access to patient data, to both healthcare professionals and patients. Many implementations of smart card based systems have been theoretically studied, pilot projects have been funded, while some countries have adopted the use of smart cards [1].

There exist two main approaches regarding the role of smart cards in HIS. They can either be used as a security token, a media enabling access to a patient's health data stored on a network, or as storage on which the medical data is stored [2]. Data that can be stored on the smart card, besides the security tokens, may be patient information for use in emergency situations, such as name, date of birth, blood type, allergies, prescribed medication, medical conditions and if the card holder is an organ donor, audit information for health insurance companies and medical information such as biochemical test results, X-rays and other medical records. The amount of data that smart cards are able to store depends on storage space availability. Smart cards can therefore be used in HIS that aim to keep an Electronic Health Record (EHR) for their patients, e-Prescription systems and health insurance information systems, as an identification and/or storage media.

In this study, we present the use of smart cards in HIS and the main benefits and limitations that arise from the use of smart cards in HIS, as they derive from a broad literature review.

The rest of the paper is organized as follows. Section II describes the main technologies that enable smart cards and their architecture. Implementations of smart cards in HIS and related projects are presented in Section III, whereas Sections IV and V present the benefits and limitations, respectively, of the use of smart cards in HIS.

II. Main Technologies and Architecture

Smart cards are plastic, pocket-sized cards including integrated circuits. They were first realized in 1974, mainly for use as an electronic purse for telephone services. Since then, the applications of smart cards have expanded in many domains; they are used in financial transactions, for identification and personnel monitoring, tickets for public transit and healthcare services. A typical smart card example used in healthcare is shown in Fig. 1, the French Carte Vitale, used for health insurance purposes in France [3].

Fig. 1. An example of a smart card: The Carte Vitale used for health insurance purposes in France [3]

Smart cards can be categorized, depending on their contact technology, in contact smart cards, contactless smart cards and hybrids. Contact smart cards have a contact area, comprising several gold-plated contact pads which provide electrical connectivity when the card is inserted into a card reader while power is supplied by the reader. Contactless smart cards on the contrary communicate and are powered wirelessly through RF induction technology and only require proximity with an antenna for communication establishment. Hybrids implement both approaches on one card allowing both contact and contactless communication. We will further

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analyze contact smart cards since the contactless technology infers greater security risks and is not recommended in applications where security requirements are very strict. The term smart card in this paper implies contact smart cards.

The physical dimensions, shape, electrical characteristics, communication protocols, functionality of a contact smart card and the electrical connector's positions and shapes are defined through the series of standards ISO/IEC 7810 [4] and ISO/IEC 7816 [5].

The integrated circuits embedded in a smart card can either be a microcontroller chip or just a memory chip with non-programmable logic. Most smart cards are currently equipped with an operating system, stored on the Read-Only-Memory (ROM) of the chip. This operating system uses, for the needs of every application, the available Random-Access-Memory (RAM) and the Electrically-Erasable-Programmable-Read-Only-Memory (EEPROM) for the implementation and execution of a standard preprogrammed set of commands [6]. The structure and packaging of a smart card's chip is illustrated in Fig. 2.

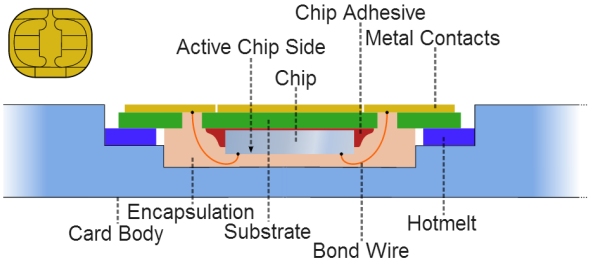

Fig. 2. Structure and packaging of a contact smart card [7]

III. Smart Card Implementations

A. Health card pilot and test projects

The use of cards in the health care sector is not recent; the idea has been around since the early nineties, when Germany and France deployed health cards in large scale for healthcare services. Since then many projects have been funded worldwide aiming to get insights to the limitations of health cards and gain experience from their use. Europe is leading the path in the use of smart cards in the healthcare sector, as shown by the numerous projects that the European Commission and the European Union have funded, but other countries such as the USA, Canada and Australia are showing increasing interest and have implemented smart cards in HIS [8]. Related projects include InterCare [9], DIABCARD [10], and NETC@RDS [11]. The first three projects are examples of completed pilot projects, each dealing with different aspects of health cards [12]. The latter is an ambitious on going European project, with the aim to fully integrate the emerging eHealth infrastructures throughout Europe [11].

B. Country-wide smart card implementations in HIS

The current state of the most important implementations of smart cards use in the healthcare sector worldwide is summarized in Table I [1], [8], [12], [13], and two important country-wide implementations, those of Germany and France, are briefly analyzed in this section.

The German health card, *electronische GesundheitsKarte* (eGK), is often described as one of the largest IT projects in the world [14], and aims to redesign the way health services are provided. Germany started considering the use of smart cards in 1996 with the Krankenversichertenkarte, and started development in 2000 for the eGK project which was then publicly introduced in 2006 [15]. In the eGK two types of smart cards are involved; a card for healthcare services recipients and one for healthcare professionals [14]. Data on the patient smart card include patient, e-Prescription and health insurance information for the card holder's identification. The patient can voluntarily store on the smart card history of prescribed medication, medical data in case of emergency admission and medical records [12]. The card is used mainly as an identification media, providing healthcare professionals with the patients' medical and insurance information fast and securely.

France was the first country to launch large scale use of smart cards in the healthcare sector with the Sesam-Vitale system in 1998, a fully automated system using microprocessor cards called *Carte Vitale* (Fig. 1) [3]. The smart cards initially included only some information about health insurance, but later on complementary health insurance administrative data information was added. The second generation of the Vitale Card, Carte Vitale 2 that was rolled out in 2007, provides emergency data set and other medical parameters to authenticated healthcare professionals and is used as a key to the holder's medical history, which is stored on secure servers [13].

IV. Benefits and Opportunities

The introduction of smart cards in HIS provides a lot of benefits to all parties involved: the users of healthcare services – patients, the healthcare professionals and providers, governments involved and the health managers and planners.

A. Health data consistency, availability and management

Inconsistency of patient data and incomplete medical records represent major problems in healthcare delivery. Patients cannot be trusted 100% to be accurate and truthful regarding their medical history. Through the use of smart cards, access to accurate information is provided on a timely basis. Smart cards can be used as a trusted primary data repository, held by the patient, granting access to a dynamic data repository, invaluable to healthcare professionals and providers. Furthermore, the ownership of personal medical information is given back to patients, away from providers and insurance companies, empowering the patients to be active about the healthcare services they receive, as was realized by the Health Insurance Portability and Accountability Act (HIPAA) legislation in 1996 [16].

TABLE I
MAIN COUNTRY-WIDE SMART CARD IMPLEMENTATIONS [1], [8], [12], [13]

Country	Project Name/ Roll-out year	Data included on the smart card	Smart card uses
Germany	Gesundheitskarte 2006	Informational[a], e-Prescription, Health insurance Voluntarily: Medical treatment history, Emergency data[b]	e-Prescribing Insurance check, Medication Log, EHR, e-Referral
France	Carte Vitale 1998 & Carte Vitale 2 2007	Informational[a], Health insurance Emergency data[b] Medication for chronic diseases Emergency Contact information	e-Prescribing Insurance check, EHR
Austria	eCard 2005	Informational[a], e-Prescription	e-Prescribing Insurance check, e-Referral, e-Government
Belgium	Social Identity System (SIS) 1998	Informational[a], Health insurance	e-Prescribing Insurance check, e-Referral e-Government
Italy - Lombard y Region	Carta Regionale dei Servizi (CRS) 2004	Informational[a], Health insurance, Emergency data[b]	e-Prescribing Insurance check, EHR, e-Referral
Slovenia	Health Insurance Card (HIC) 1999	Informational[a] Emergency data[b]	Insurance check
Taiwan	Healthcare Card 2002	Informational[a] Emergency data[b] Chronic diseases Medical information	e-Prescribing Insurance Check, HER
Mexico	Sealys Health Insurance Cards 2006	Informational[a] Health insurance	e-Prescribing Insurance Check, EHR

[a]Informational patient data, stored on the smart card's chip, depends on each implementation and can include: name, surname, date-of-birth, sex, address, card number, social security number, card issue/expiration date, a security token for identification etc.

[b]Emergency data can include: allergies, blood type, prescribed medication, chronic diseases, vaccinations, latest test results, organ donation information etc.

The ease with which smart cards can provide instant information to authorized personnel can speed-up manual processes that are costly and reduce the efficiency of healthcare providers. For example admissions, often described as the least efficient area of a hospital, can foreshorten its processes with the use of smart cards. Patient authentication, patient history and standard paperwork can be available with only a presentation and read of the holder's smart card. Improved and secure authentication can also reduce the event of medical identity theft and facilitate patient health insurance checks.

Another significant improvement to healthcare services provided by smart cards, is the information flow management. Healthcare providers are currently neither inter-connected, nor intra-connected in large-scale (some are not even connected in small scale, e.g. within a single hospital). Smart cards provide mobility to a patient's data, making them as mobile as the patient is, since they can act as security tokens, allowing access to various trusted data sources, regardless of the number of access points.

An indisputable benefit is the instant accessibility that smart cards provide to emergency patient data. In the unfortunate event of an emergency admission, the card holder's important medical information such as blood type, allergies, prescribed medication etc. can be crucial to the patient's life. The retrieval of this information from a smart card is very easy and fast and can prove to be life-saving for the patient.

B. *Indirect benefits for other parties involved*

Cost can be significantly reduced through the use of smart cards. Simple but costly tasks, such as insurance verification, paper prescription and doctor referrals can be all made digital, saving both employee time and money. This digitalization will besides reducing routine paperwork, eliminate errors during these procedures, e.g. medication errors, or prescribed medication incompatibility, that can be proved life-saving. Furthermore, healthcare costs can be reduced with the avoidance of redundant healthcare tests.

Health managers, planners and governments can also benefit from the introduction of smart cards in healthcare. Smart cards are an enabler for e-Health structures, which can provide important health and administrative data. These data can be used for disease surveillance and planning, population based data collection, closer monitoring of the healthcare system leading to shorter cycles of measurement and improvement, as well as timely reports and feedback. The quality of healthcare services can be thus improved and costs can be reduced since electronic systems are more transparent and can detect fraud incidents.

Lastly, data collected through smart card HIS can be of tremendous help to health researchers, after the application of anonymization techniques, boosting health related research.

V. LIMITATIONS AND CHALLENGES

Despite the many benefits and opportunities that result from the use of smart cards in the healthcare sector, smart cards haven't taken over as the default technology in healthcare data management due to several limitations related with their use.

A. *Cost*

One of the main limitations is the cost of replacing the existing infrastructure, with smart card HIS. The current system does not totally fail, rendering the use of modern HIS not an inevitable necessity. The cost of healthcare services is, long term thinking, reduced with the use of HIS and smart cards, but the initial capital required to start such a wide implementation, is too high, making the political and

economic decision prohibitive, especially in the middle of an economic crisis. Indicatively, the German eGK project, not yet fully complete, has cost the German government 1.7 billion €, and has running costs of approximately 150 million € each year [8].

The lack of interoperability between healthcare professionals and providers is an impediment to the adoption of smart cards and HIS. Additionally, the current standardization regarding medical records and health data is not sufficient and this problem must be resolved in order for true ubiquitous healthcare services to be realized across jurisdictional boundaries. These problems in order to be resolved, are translated in huge investments and lengthy studies, increasing the already high, implementation cost.

B. *Health data management and security*

Problems occur in data consistency, as the use of digital files and management does not guarantee the proper use and accurate filling of medical information. Consistency and accuracy are of paramount importance in smart card HIS implementations, and training of the users of these systems is required. It should be noted that the whole point of HIS systems is making the healthcare services delivery simpler and easier and thus systems need to be designed with ease-of-use in mind, helping the involved end-users instead of introducing more complexity for the sake of technology advancement.

A point of intense discussions and disputes is private data security. Whether data is to be stored on the smart card or on online servers, what data to be included in the smart cards' memory, what encryption technique to be used, who will have access to what data, and data ownership are just some of the problems that should be handled regarding data security. Sensitive health data privacy is protected by the HIPAA [16] and in EU by the Directive 95/46/EC [17] and the Article 8 of the European Convention for the Protection of Human Rights and Fundamental Freedoms [18]. Several studies have dealt with data security but the high sensitivity and social and political pressure call for a higher level of security reassurance [2], [19].

C. *Public reaction and new technologies*

An obstacle that must be overcome is some involved parties reactions to the implementation of a smart card HIS. The technical training needed to operate it, the system's high complexity and security concerns, as well as the high transparency of such a system, are just some of the reasons that some healthcare involved parties are adversary to a smart card HIS adoption.

The benefits and opportunities from the use of smart cards in HIS are overwhelming, but the limitations and drawbacks from a possible implementation are not inconsiderable. Furthermore, a smart card implementation requires the agreement between all those involved: governments, healthcare providers, health insurance companies and the people, and thus demands their right cooperation.

The fact that smart cards are not a new technology, along with the increasing invasion of new technologies in developed and developing countries raises the question if smart cards are the best solution to the problems mentioned. Mobile smartphone technologies are being adopted rapidly, and may render the use of smart cards obsolete by the time smart card HIS are fully studied and launched.

VI. Conclusion

The use of smart cards in HIS has been the topic of very little academic research, despite the intense interest that it attracts. Therefore, deeper analysis of the benefits and limitations, given the complexity of such a system, and the privacy and security concerns it raises, is required. Solutions to the drawbacks of this technology have to be studied, and knowledge is to be gained from countries that have already implemented smart cards in their healthcare sector, if smart cards are to be deployed in HIS at an even larger scale, so that they can be exploited to their full potential.

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