A SURVEY OF INTEROPERABILITY IN E-HEALTH SYSTEMS
The European Approach

Marcos Da Silveira, Nicolas Guelfi
Laboratory for Advanced Software Systems, University of Luxembourg, 6, rue Coudenhove-Kalergi, L-1359 Luxembourg

Jerry-David Baldacchino, Pierre Plumer, Marc Seil, Anke Wienecke
Centre de Recherche Public Henri Tudor 2A, rue Kalchesbrück, L-1852 Luxembourg

Keywords: Interoperability, standards, e-health, information technology.

Abstract: The interoperability is often associated with the capacity of exchanging information that belongs to different workflows in a distributed environment. In e-health, the implementation of interoperable systems has a direct impact on the access of medical services, the costs and the quality of those services. This paper summarizes the efforts of standardization done by a selected group of Europeans researchers in the healthcare domain. The assessment of this standardization effort is made through a study of its impact in 20 FP5 and FP6 European projects that address the healthcare domain. The objectives are identify the new trends on interoperability technologies and to point out the importance of approximate industrials and research institutes.

1 INTRODUCTION

During the last century advances in medicine have significantly contributed to the reduction of the mortality rates. New medical practices, healthcare supporting tools (equipments, methods, medications, etc.), and the more participative role of the patients and their families in the treatments allow many patients to surpass physical and mental illnesses. But these practices are frequently isolated and information exchanges are done later when good results are obtained. The next challenge for healthcare domain is to implement collaborative works in a comprehensive environment where information exchanged between physicians are simple, fast and reliable. Consequently, this environment can contribute to reduce or to avoid misuse of new medicine practices, to improve the quality of healthcare services and to facility (and control) the medical information's access.

According to the lessons learned from Canada, Denmark and New Zeland (GAO, 2005), the standards' definition, the free access of national classification from all stakeholders, the education, the founding for implementation, and the proactive position of the government to solve privacy protection problems are important topics to be considered during the definition of national e-health programs. It has been obtained by means of a common effort of industries and public institutions to define and to diffuse standards like HL7 (HL7, 2007), Cen/TC 251 (CEN/TC, 2007) and DICOM (DICOM, 2003) in order to improve the interoperability between healthcare systems. The aim of this paper is to verify if these in facto standards have been taking into account in researches funded by the European community.

The next section we present the impact that a set of standards has in a selected set of Framework Projects (FP5 and FP6).

2 STANDARDS IN RESEARCH PROJECTS

According to (IEEE, 1990), interoperability *is the ability of two or more systems or components to exchange information and to use the information that has been exchanged*. The scope of this paper covers only the interoperability between e-health IT systems. The importance of interoperability in the e-health market has increased with the rising number of healthcare professionals that use computers and

Da Silveira M., Guelfi N., Baldacchino J., Plumer P., Seil M. and Wienecke A. (2008).
A SURVEY OF INTEROPERABILITY IN E-HEALTH SYSTEMS - The European Approach.
In *Proceedings of the First International Conference on Health Informatics*, pages 172-175

electronic devices to improve their services. Proprietary solutions have gradually been substituted by standard-based technologies. However, the implementation of these products has still facing a large number of barriers as well as unclear legislation, high implementation costs, physicians' reluctance (to adopt those technologies) and disorganization within healthcare structure. According to the Department of Health and Human Service of USA (HHS), healthcare is the largest sector of the economy that has not fully embraced information technology. The Medical Group Management Association and the Healthcare Information and Management Systems Society (GAO, 2005) reported that only 31% of physician group and only 19% of hospitals practices use fully operational Electronic Health Records (EHRs). This reality is often the result of adopting equipments and IT solutions that were not developed to interoperate with other systems. Changing these technologies is very expensive and takes time. The healthcare system is not ready to invest money without any guarantee of world interoperability and the market is not mature enough to give this guarantee.

This work contributes to analyze the European market trends based on the information took from a selected number of research projects in the e-health domain. We also point out if the interoperability challenge has really been attacked by scientist and industrials. During our researches, we evaluated two distinct levels of standards: One coming to integrate medical equipment (named physical level standards) and the other used to integrate customers' applications (named application level). In the first level, the selected standards are: CAN, I2C, Bluetooth, Zigbee, USB, FireWire, RS232, IEEE 1284, Ethernet, GSM/GPRS, UMTS and IEEE 802.11x. In the second level the following standards are addressed: HL7, DICOM, ebXML and VITAL.

The analyze procedure starts by looking for references of this set of standards in the homepage of European projects (and in open source documents) available in the internet. In a second phase, we searched for partners of these projects that also participate on the specification of the selected group of standards. In the next section, the projects considered in our researches are presented.

2.1 Looking for Projects

In the previous sections we showed that the association of informatics with healthcare domains brings up many advantages and that the Healthcare industry is positioned to beneficiate of the advancements in technology and connectivity. High technological devices and software are available for healthcare services' providers and are adapted to the patient needs (patient-centered systems) (LAU et al., 2002). Customers of these technologies can expect to achieve greater performance, to reduce costs and to improve patient care. Consequently, they are expanding marketshare and pushing the transition to a digital era of e-Health. An example of the

Table 1: The selected list of European projects and the standards adopted.

#	Project	Area/objective	Supported Standards
1	C-CARE	EHR	XML, HL7, CEN, ISO
2	CHS	Home monitoring of Diabetes, heart failure, post trauma patients	UMTS, GPRS
3	HEALTHMATE	Telecare, Tele-consultation	XML, Bluetooth, GPRS, UMTS
4	HUMAN	Telemedicine, domotic	UMTS, GPRS
5	IDEAS	Multimedia architecture for e-health	XML, Bluetooth, GPRS, DICOM,
6	MOBIDEV	Secure access of medical database	Bluetooth, UMTS
7	MOBIHEALTH	Telemedicine, remote assistance	GPRS, UMTS
8	TOPCARE	Telecommunication support to Telecare	---
9	WIDENET	European EHRs interconnectivity	---
10	ARTEMIS	Semantic Web-Services	---
11	AUBADE	Neurology, psychology. Recognition of emotional state of the patient	Bleutooth, GPRS, UMTS
12	BIOPATTERN	Identification of European bioprofile	---
13	CLINICIP	Automatic injection of Insulin in ICU	---
14	COCOON	Healthcare risk management	---
15	DICOEMS	Integrated medical environment and database for critical situations	GPRS
16	INTREPID	Phobias' monitoring and treatment.	---
17	MYHEART	Intelligent clothes for heart failures prevention	Bleutooth, GPRS
18	NOESIS	Diagnosis supporting tools and Web-services	---
19	SEMANTICMINING	Data mining of medical information	---
20	PIPS	Generic medical database	---

Table 2: Synergy between standards and European projects FP5 & FP6.

PROJECT	STANDARD	STANDARD DEVELOPERS' MEMBER	INDUSTRIAL PARTNERS
C-CARE	XML, HL7, CEN, ISO	NO	HEALTH INFORMATION MANAGEMENT, STACKS CONSUTION E INGENIERIA EN SOFTWARE, OLIVETTI SANITA, MEDIGRIDGE, PROGEA, DATASOFT, INTRASOFT
CHS	UMTS, GPRS	YES (I2C, BLUETOOTH, ZIGBEE, FIREWIRE, USB, 802.11, HL7, DICOM)	PHILIPS, PAULADIS, AMERICAN MEDICAL DEVELOPMENT, CARD-GUARD
HEALTHMATE	XML, BLEUTOOTH, GPRS, UMTS	YES (CAN, I2C, BLUETOOTH, ZIGBEE, USB, 802.11, HL7, DICOM)	AIRTEL, BULL, SIEMENS, APLITEC, KNOSOS
HUMAN	UMTS, GPRS	NO	SYNAPSIS, SEMA, EUTAELSAT, MBI
IDEAS	XML, BLEUTOOTH, GPRS, DICOM,	NO	APLITEC
MOBIDEV	BLEUTOOTH, UMTS	NO	AIRTEL, ARAKNE, INTERCEM, RELATIONAL TECHNOLOGY
MOBIHEALTH	GPRS, UMTS	YES (I2C, BLUETOOTH, ZIGBEE, FIREWIRE, USB, 802.11, HL7, DICOM)	PHILIPS, TELEFONICA, LOGICAM, TELIASONERA, HP, YUCAT, GESUNDHEITSCOUT
TOPCARE	---	NO	CALEA, GMD, DATAMED, DRAGER
WIDENET	---	NO	SADIEL, PROREC
ARTEMIS	---	NO	ALTEC, TEPE
AUBADE	BLEUTOOTH, GPRS, UMTS	YES (CAN, I2C, BLUETOOTH, ZIGBEE, USB, 802.11, HL7, DICOM)	ANCO, MARSERATI, SIEMENS
BIOPATTERN	---	NO	DAEDALUS, GAP, HELLENIC, HOEGSKOLAN, NEOVENTOR, SYNAPSIS
CLINICIP	---	NO	BRAUN, CARMEDA SISETRONIC, GAMBRO, SENSLAB
COCOON	---	YES (USB, FIREWIRE, 802.11, HL7)	AQUITAINE, CEFRIEL, ELYROS, ENPHASIS, MICROSOFT, ICSF, IDS, LOGICOM
DICOEMS	GPRS	NO	SYNERGIA 2000 , SSM
INTREPID	---	NO	AURELIA, ELYROS, INOCUS, PALLADION
MYHEART	BLEUTOOTH, GPRS	YES (I2C, BLUETOOTH, ZIGBEE, FIREWIRE, USB, 802.11, HL7, DICOM)	CSEM, HEIN, LINEAPIU, MANIFATURE, MEDGATE, MEDTRONIC, NOKIA, NYLSTAR, PHILLIPS
NOESIS	---	YES (CAN, I2C, BLUETOOTH, ZIGBEE, USB, 802.11, HL7, DICOM)	AIRAL, SIEMENS
SEMANTIC-MINING	---	NO	KITHAS, MERALL-ROSS
PIPS	---	YES (HL7)	ASTRAZENECA, ATENA, ATOS, GLAXOSMITHKLINE, MEDIC4ALL

increasing interest on e-health solutions are the quantity of research projects supported by the European Union, in particular in the *Framework Project 5 (FP5) and 6 (FP6)*.

The work presented on this section summarizes the main area/objectives of a selected list of e-health projects founded by FP5 and FP6. The objective is to verify how interoperability was considered in those works.

The selection procedure had started with a list of 80 projects and finished with 20 projects (after applying the filter). This filter consists on verify if the keywords e-services, standard, platform, telemonitoring, telemedicine, protocols, e-services, security and devices were present in the context of the research projects. Table 1 shows the selected projects' name, their main area/objective and the standards that were explicitly indicated in their homepages. The evaluation methodology consists on the identification of industrial partners of each European project and cross it with the members' list of each emerging standard. The expected results are: Verification that European projects take into account emerging standards; Identification of new trends on the e-health domain; Point out the importance of industrial partners for those projects.

Table 2 presents the firsts results of these researches. The colon "*standards developers' members*" indicates that at least one of the partners belongs to

at least one of the standard members' list. The considered standards are: USB; CAN; ZIGBEE; Bluetooth; I2C (internet research with the keywords: company name + I2C); HL7; DICOM; FIREWIRE; IEEE 802.11; ebXML (the considered websites are in the references).

3 CONCLUSIONS

A list of interoperability standards used in healthcare systems was compared in this paper with a selected set of projects of framework programs 5 and 6. It is important to highlight that some projects have an incomplete/out-of-date website and the access to their technical reports were sometimes impossible. The available information led us to conclude that the international standards have not been taken into account by the majority of the considered FP projects. It identifies a gap between the industrial perspectives, the governmental efforts and the research trends. Lessons learned from New Zealand experiences (GAO, 2005) show that educating stakeholders about the value of developing health IT and using standards is very important to the success of a national plan. Diffusing the successes is also an important tool. This analysis allows us to highlight some weaknesses in the European research trends and can be useful to define new research strategies, in particular giving priority to projects that include international standards' promoters and participants (users, providers and developers). The participation of more research institutes in these committees can also contribute to the education of stakeholders.

REFERENCES

CEN/TC 251, European Standardization of Health Informatics. Retrieved June 10, 2007, from http://www.centc251.org

DICOM - Part 1 (2003). Introduction and Overview. Retrieved June 10, 2007, from http://medical.nema.org/dicom/2003/03_01PU.PDF

GAO - United States Government Accountability Office. Health information technology: HHS is taking steps to develop a national strategy. Report to the Chairman, Committee on the Budget, House of Representatives, May, 2005. Retrieved June 10, 2007, from http://www.gao.gov/new.items/d05628.pdf

HL7 - Health Level Seven. Retrieved June 10, 2007, from http://www.hl7.org

IEEE - Institute of Electrical and Electronics Engineers. IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries. New York, NY: 1990.

Lau C., Chruchill R. S., Kim J., Marsen F. A., Klim Y. (2001). Asynchronous Web-based patient-centered home telemedicine system. IEEE Transactions on biomedical engineering, Vol. 49, No. 12, December 2002, pgs 1452-1462.

The websites of standards members' lists are:

http://www.usb.org/members_landing/directory/complex_search_companies_form/process

http://www.can-cia.org/cia/member-list/index.php?m=2&ss=&sa=Search&sl=100

http://www.zigbee.org/en/about/members.asp

https://programs.bluetooth.org/apps/directory/default.aspx

http://www.hl7.org/about/benefactors.htm

http://medical.nema.org/members.pdf

http://www.1394ta.org/About/Members/

http://www.ieee802.org/11/Voters/votingmembers.htm

http://www.oasis-open.org/about/foundational_sponsors.php