Enterprise System Architecture to Sustain Cross-Domain e-Healthcare Applications

Natalia Costetchi, Cristian Danila and Aurelian Mihai Stanescu

Abstract Romania's Healthcare Complex Adaptive System of Systems is in progress to support a very ambitious process of structural, but behavioral also, transformation. Healthcare domain, e-Health systems and e-Healthcare subsystems are facing, worldwide, with objective phenomena: ageing population, increasing prevalence of chronic diseases, degenerative diseases, healthcare costs rising, and so on. One topics to be under debate due to present paper contributions is concerning with care diseases information capturing, but knowledge management by both sharing best practice and explicit recommendations within a holistic approach for cross-domain investigations. Information Technology and Communication Tools (ICT) within the new Future Internet Enterprise Systems (FInES) paradigms is a major key to reach high Quality of Services, efficient implementation of Web interoperability oriented new methodology to develop complex composite Web services and last but not least, new System Architecture of e-Healthcare systems. A research programme so called E4H CAS [Environment, Economics, Education and Entrepreneurship to sustain e-Healthcare Complex Adaptive Systems] is aiming at populating the e-Health framework with focused prototypes and applications like knowledge capture, repository archiving and best practices of rare diseases multidisciplinary diagnoses and therapy.

Keywords Information system · Service architecture · e-Healthcare framework

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1 Introduction

"Human development is a process of enlarging people's choices; the most critical of these wide-ranging choices are to live a long and healthy life, to be educated and to have access to resources for a decent standard of living" [1]. By focusing the key concept "healthy life", the worldwide accepted definition for health is "A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [2].

All societies are deeply concerned within health domain reforming process sustained by new "wave" ICT technology under the FInES paradigm shift. This topic is actual and burning in entire context: local, national, transnational, international and global. Due to globalization process the issue of health became global.

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1.1 e-Healthcare Application with Respect to Rare Disease Patient

One of the complex problems to be solved urgently worldwide is the domain of rare diseases [3]. This area is now one of the priorities in the second programme of Community action in health field [4]. According to [5] rare diseases, including those of genetic origin, are life-threatening or chronically debilitating diseases which are of such low prevalence that special combined efforts are needed to address them so as to prevent significant morbidity, perinatal or early mortality, or a considerable reduction in an individual's quality of life or socio-economic potential. EU considers diseases to be rare when they affect not more than 5 per 10,000 persons [6].

In Romania the estimated number of persons affected by rare diseases is about 1,300,000 but approximately 1,250,000 persons have not been diagnosed properly or didn't receive the appropriate therapy [7].

Based on European Council recommendation [8], the Nation Health System (NHS) of Member States (MS) is engaged to: concentrate on supporting and strengthening the adoption of national plans and strategy for responding to rare diseases by the end of 2013; improve recognition and visibility of rare diseases,

encourage more research into this area, establish link between centres of expertise and professionals in different countries through European reference networks in order to share knowledge and expertise; identify where patients should go when such expertise cannot be made available to them at local or national level. European action aims to support and help patients and professionals collaborate across MS to share and coordinate expertise and information through linking centres of expertise in different countries and making use of new information and communication technologies such as e-Health.

E-Health plays a clear role and is a key to achieve significant improvements in access to care, quality of care, and the efficiency and productivity of the health sector. There are many examples of successful e-Health developments and deployments [9]. The definition of e-Health is "the use of information and communication technologies (ICT) for health to, for example, treat patients, peruse research, educate students, track diseases and monitor public health" (WHO).

Romania as part of European Union starts to apply the European policies into national strategy programmes. In this respect was established a National Program for Rare Diseases (2010–2014) [10] in order to meet the requirements for collaborative relationships in rare diseases area. However, at national Romanian level there is a lot of work to be performed. In 2012 a qualitative study of quality of life of people diagnosed with rare diseases in Romania [11] was highlighted a set of difficulties for patients that suffer from a rare disease.

A Romanian patient diagnosed with a rare disease based on health legal framework [12, 13] has the chance to be treated outside the country if NHS couldn't assure appropriate treatment. The issue of delays and breakpoints in the health information flow of health system should be addressed and solved.

Our hypothesis is whether the e-Health solutions should be developed and integrated in health care system based on an agile e-Health Enterprise Architecture (EA) Framework. Our aim is to propose a system architecture that could be applied for macro vision of National e-Health strategy and/or micro vision of specific domain strategy, like e-Health for rare diseases. Health Information Exchange (HIE) should be based on an iterative implementation of collection and aggregation of all legal requested health information for Electronic Health File Patient Rare Disease to evaluate and release cross-border appropriate treatment.

To integrate stakeholders and e-Health solutions in a citizen-centred e-Healthcare agile Complex Adaptive System is a very promising challenge within "Horizon 2020" Digital Agenda.

1.2 Preliminary Research

A research methodology based on mixed techniques was selected in order to evaluate the possibility of HIE about rare diseases patients in Romanian NHS.

Our research has been initially based (phase 1—empirical study) on: domain literature and legal framework; up-to-date establishment according to both

quantitative and qualitative research methods. Through quantitative research we have been focused on discovering and understanding of experience, perspective of health professionals in informational health system context. As regarding qualitative research we aim at exploring a real perception of already using e-Health solution implemented in the health units or data interexchange in National Integrated Informational System (NIIS).

1.2.1 Quantitative Research

In order to perform quantitative research there was created a survey for understanding personal involvement and experience of using communication and information technologies by healthcare professionals. The statements were grouped by following main areas: information about health information system (HIS) in the organization (components, level of data collection, patient related information, standard of implementation, integration of HIS with other health systems like: Diagnosis Related Groups (DRG) [14] and NIIS [15] in order to interexchange data; and perception of health care professionals about current e-Health tools.

1.2.2 Qualitative Research

For qualitative research there were selected two tools:

- Interview

The first goal was to collect valuable data and opinions from cross disciplinary and sectorial professionals about e-Health public solution implemented and outcome of its use. Participants were from following domain: IT Health Information Systems provider, statisticians from public hospitals, family and specialist doctors, CFO from private hospital, expert from District Health Insurance Houses, expert from National School of Public Health, Management and Professional (NSPHMPDB), former president of health Statistic Institute, experts from Romanian National Alliance for Rare Diseases and National Committee for Rare Diseases.

All of them are linked together, through health informational flow used in the day-to-day business.

The second aim was to analyse the possibility of integration of stakeholders in the Enterprise Architecture e-Health Framework and interoperability issue to be addressed.

- Case study

We have studied a patient, diagnosed with a rare disease (di George complete syndrome) and we observed the patient pathway from the first interaction with Romanian health care system up to the approval by Health Ministry the thymus

transplant in paediatric hospital in London [16]. This study emphasizes the breakpoints and delays in health care system that could be critical for a patient with the mentioned disease.

The study was performed based on all discharged medical documents and files, laboratory analysis, the documents released from Health Information System Paediatric Hospital "Gr. Alexandrescu" and actual interoperability of data for health information exchange across actors.

Each stage for data collection contributed to redefine the question asked and problematic of rare disease domain. The mistrust of patients and professionals in Romanian Healthcare System made difficult to achieve a holistic approach in this research.

Some findings obtained by empirical traditional quantitative research pointed that 45 % of participants do not have a valid email address on the official hospital site.

In qualitative research based on interviews, we found a lack of connection point between the decision bodies and the units that hold the primary information that is needed to the decisional process. This connection point is vital for validation of the decisions with some values and real economic results collected during the medical act that is provided by the medical units. The information is spread out and split into varied interest domains, in some cases, hold by different public institutions, and the treated aspects do not make a system, a whole.

We propose a paradigm shift from service oriented to patient centred Health System. The paradigm changes will allow developing future cross-domain and interdisciplinary approach for address appropriate treatment for patient with rare disease. Moreover, after implementing and integration of Electronic Health Record (EHR) in National Health Information System, a next step is Electronic Health File Patient Rare Disease.

The rest of the paper is organized as follows. Section 2 presents basic requirements e-Health Enterprise Systems. In Sect. 3, an Enterprise Architecture based e-Healthcare Framework is proposed. Section 4 represents the conclusions.

2 Basic Requirements for e-Health Enterprise Systems

Numerous standards have been developed in the e-Health domain. There is a need for quality assessment models that not only evaluate the performance of the e-Health Enterprise Systems but also cover important aspects such as: interoperability, adaptability and security. Two aspects should be considered: product quality and process quality. We propose a hierarchical model for quality of applications that takes into consideration all these factors.

The model has three quality dimensions [17] which assess the e-Health Enterprise System from a certain point of view: business, operational or systemic. Each quality dimension is composed of one or more quality aspects. For each aspect we consider one or more quality items, which can be measured based on a

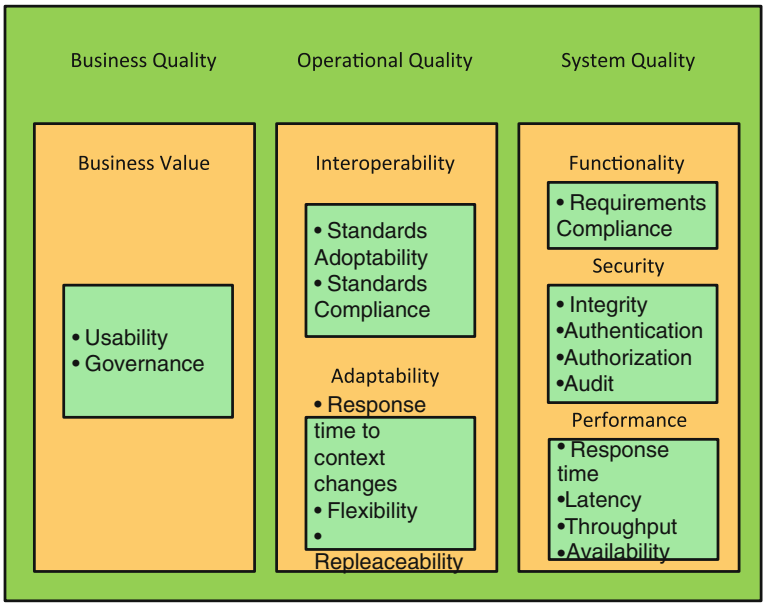

Fig. 1 Quality model for e-Health enterprise systems

quality criteria. The measurement can be either qualitative or quantitative. The three quality dimensions are: Business, Operational and System as represented in Fig. 1. The business quality dimension describes quality aspects that belong to the business value of the system. The operational quality dimension describes quality aspects related to interactions between applications while the system dimension includes quality aspects that apply to the entire e-Health Enterprise System.

Business quality dimension contains the following quality items: usability and governance. These items can be qualitatively evaluated based on a history of the application usage experience and user feedback.

Operational quality model includes application interoperability and adaptability quality aspects. Interoperability quality aspect is concerned with the evaluation of the compatibility level between applications. Although communication standards have been created, applications are still developed on different platforms and according to different specifications. Standards adoptability and standard compliance are quality items that evaluate the message exchangeability and conformity to a certain standard in order to make the applications interoperable. Adaptability quality aspect evaluates the ability of an application to respond to external stimuli. Adaptability implies three abilities: the ability to recognize an environmental change, the ability to determine the change to be applied to the application and the ability to effect the change.

System quality model evaluates the applications compliance with user defined requirements both functional and non-functional. It contains the following quality aspects: application functionality, application security and performance. The

quality of the security incorporated into the applications has the following quality items: authentication, authorization, encryption, non-repudiation, audit and integrity. The performance quality aspect of the applications can be composed of quality items like: response time, throughput, availability, accessibility, latency, accuracy.

The list of quality items is not exhaustive, but only describes most common quality features desired in an e-Health Enterprise System. The quality model includes not only product related quality characteristics but also process specific quality attributes. The quality model can be easily extended with more quality items according to the context of the applications.

3 Enterprise Architecture Based e-Healthcare Framework

E-health represents the use of information and communication technologies (ICT) for supporting heath. The e-Health Enterprise System Architecture (EA) provides a framework to support e-Health in delivering coherent and interoperable e-Health solutions that can form together a true integrated e-Health System aiming to deliver shared data and applications to healthcare participants.

In this paper we introduce an e-Healthcare Framework (Fig. 2) for guiding the development and evolution of an integrated National Health Information System, inspired from Enterprise Architecture concepts [18–20].

In order to achieve a comprehensive e-Healthcare Framework several dimensions are addressed:

1. At the contextual level the following are addressed: Strategy, Objective, Goals. This allows a careful consideration and definition of what is appropriate and marks the highest priority for e-Health area.
2. The scope and strategy should be maintained by a legislative framework that supports and creates an appropriate behaviour for implementing and acting according to defined strategy. In order to integrate e-Health tools in health care services, political and policy background is necessary to meet nation's needs and capacities (conceptual level).
3. Business Architecture modelling is seen as a solution to bring technological innovations to successful deployment of the business. In order to define the Business architecture, one has to define: business domains, business processes and value streams, capabilities, models (domains, functions) and events. According to SAMBA (Structured Architecture for Medical Business Activities) project, a method to depict a process model was developed, which elucidates all essential parts of the process [21].
   This component is one of the most critical from EA due to an importance of organizational goals/strategy and Informational Technology alignment.

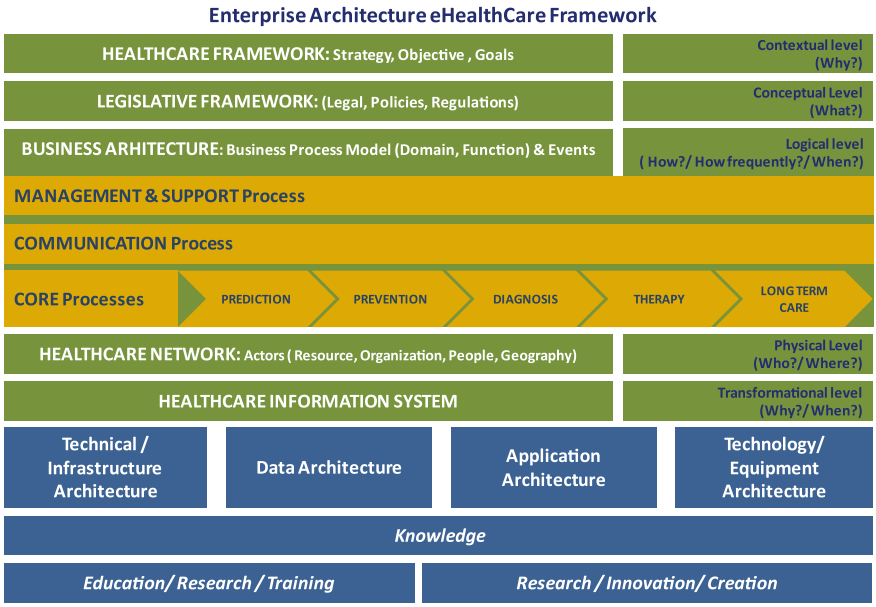

Fig. 2 E-Healthcare framework overview

The research findings [22] show that developing the BA can improve business and IT alignment and provide inputs to other architectures, i.e. information, application and technical components of EA.

4. Health systems are networks of actors: define resources, organizations, people, geography, actors, parties and roles.
   This section identifies the resources used to define EAs and architecture solutions.
5. Healthcare Information System includes: Information management Principles Information Management Policies and Rules.
   Information Architecture describes the components for managing information across the enterprise. High-level enterprise data model and the data flow patterns around a particular architecture scope.
6. Technical/Infrastructure Architecture includes: Hardware platforms, Data centres, Local and wide area network, Operating system interoperability (semantic and syntactic), Security Infrastructure, Client technology platforms, Protocols and technology choices.
   Technology Architecture describes how the infrastructure underlying the business, application, and information architectures is organized.
7. Data Architecture includes: Data model, Meta data dictionary, Classification.
8. Application Architecture includes: Software applications, Interfaces, User.
   Application Architecture describes the architecture for enterprise applications, information systems, and automation processes that support the business architecture.

9. Technology/Equipment Architecture include the convergence of medical equipment based on new technology insight and IT systems. Medical devices no longer operate independently within the healthcare environment. They provide critical patient care information to clinical and physician staff and must be compatible to achieve optimal efficiencies, not only within departments, but facility and system-wide.
   Accommodating advanced technology solutions directly impacts on operational efficiency, quality of care and patient satisfaction.
10. Knowledge—is accepted widely that we moved into knowledge era. Since the paradigm shift was realized, it is mandatory to manage knowledge more effectively. The knowledge "is a fluid mix of framed experiences, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of the people that hold the knowledge. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices and norms [23]. In this context, knowledge is supporting layer for e-health framework in order to enhance the value of stakeholders' personal capital solely by deployment of systems, processes and technologies.
11. Educational/Research/Training and Research/Innovation/Creation are important steps to support and continue the improvement and changes of e-Healthcare system.

Especially for Health, which has a holistic approach in the System, it is demanded to share and coordinate expertise for better and more efficient solution and health services to be meet.

4 Conclusions

In order to meet Healthcare Informational objectives of a society it is important as first step to establish an Enterprise Architecture for e-Healthcare Framework. We proposed a representation which integrates components tailored to implementation of e-Health strategies in a holistic view. This framework can be applied to meet both general and specific objectives such as the Romania Healthcare framework for Rare Diseases.

Future development of Electronic Health File Patient Rare Disease and integration in actual National Integrated Informational System would make possible to streamline the health information exchange between actors. Aggregated digital patient rare disease information based on legal requirements and health standards would essentially solve the problem of delays and breakpoints in releasing files for cross border treatment and facilitate cross network's communication.

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