Semantic Interoperability in the Context of e-Health

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ABSTRACT

Within the context of Europe's e-Health strategy, interoperability is the only sustainable way to help partners acting in various locations, with different expertise, perspectives, agendas and status, even cultures and languages, and using distinct information systems from different vendors, to collaborate harmoniously to deliver quality healthcare.

Furthermore, to meet the technical demands for the successful support of complex healthcare processes, modern healthcare enterprise architectures must achieve and implement interoperability in all the healthcare domains. Interoperability, which may be expressed using functional, syntactic, or semantic methods, it is necessary to provide information dissemination for all areas in healthcare.

Semantic interoperability, which defines the ability for information shared by systems to be understood at the level of formally defined domain concepts, so that the information is computer processable by the receiving systems, it is essential for the development of automatic computer processing healthcare applications and decision support systems.

This paper provides an overview of the terminology and definitions needed to understand the implications of interoperability in the context e-Health as well as the influence that semantic interoperability could have for achieving seamless interoperability between several healthcare domains.

General Terms

Semantic interoperability, system integration, healthcare architecture.

Keywords

Interoperability, e-Health, healthcare, integration, interface, semantics.

1. INTRODUCTION

1.1 The framework for e-Health in Europe

In Europe the demand for quality and quantity of patient care is growing while the resources remain limited. Europe needs to improve and refine the supporting processes of healthcare to gain resources for future demand [14]. In this regard, e-Health[1] has the potential to improve the quality and effectiveness of healthcare services.

Many European countries are increasing their attention on the use of ICT (Information and Communications Technology) in the healthcare domain. Some have a declared national or regional policy and others have adopted ambitious strategies for the next five to ten years [5].

1.2 The bits vs atoms analogy

This distinction so clearly outlined by Nicholas Negroponte[2] is central to any discussion on the role of digital information in modern societies [8]. One interesting aspect of this observation is that is ten years old and that compared to other observations in technology, this observation remains valid.

> *"The world is divided into bits and atoms. Atoms occupy a large proportion of area in space, they cost money to move around, they cost money to duplicate and store. Essentially, we are not moving, duplicating, or doing anything with them that we didn't do two thousand years ago i.e jets are faster than horses but they are not that much faster. As opposed to this, bits, which occupy less disproportionately area in space, cost replication is infinitesimal related to the general number of replications, and transport times are often constant regardless of how far you have to transport them. The reason why telecommunication companies are having such as hard time is that their whole business model prior to digital was based on time and distance, and of course time and distance fall apart when you move into bits ..."*

Hence, the question that remains is, what does this observation has to do with healthcare? The usefulness of this observation has to do with the fact that for years, the healthcare industry has traditionally used atoms to move bits e.g. it has used paper to move information, and that traditionally, people involved in healthcare are so deeply tied to that view, that it is easy to get confused on what is the information and what is the moving vehicle.

1.3 Process vs Implementation

The notion of process versus implementation outlines the fact that, in healthcare, paper has been extensively used as an implementation by healthcare professionals for so long

[1]e-Health (also written eHealth) is a relatively recent term for healthcare practice which is supported by electronic processes and communication.

[2]Founder and director of MIT's Media Lab.

that it is perceived as part of the process[3], and this in turn reveals another interesting fact: "healthcare professionals spend most of their time dealing with large amounts of paper-based information which causes inefficiencies to the delivery of healthcare".

It is important to keep in mind that there is no need to replicate the paper implementation, what is needed is to understand the essence of the process more firmly and use technology to implement the process in the most efficient manner.

1.4 The Complexity of Healthcare

From a software architecture point of view, an entire healthcare system can be modelled as a complex system[4], and by definition, a complex system is "a system that is organised in multiple levels of vertical organisations, and has horizontal processes that have to cross these vertical boundaries in order to succeed, which makes the system unpredictable over time".

In healthcare, all these vertical organisations are organised by discipline, by knowledge, by financial entities, by people and location, etc. However, the essence of delivering care to patients is an horizontal process, which makes the task of collaboration, development, and implementation of systems in healthcare extremely difficult [11].

2. INTEROPERABILITY IN HEALTHCARE

2.1 Definitions and Terminology

The main purpose of standarising healthcare information systems is to make interoperability and integration possible. Therefore, the distinction between interfacing, integration and interoperability is extremely important to understand.

> **Interface**: a boundary at which interaction occurs between two systems or processes [1]. In computer science terminology, there are three types of interfaces: user, hardware, and software interfaces. For instance, a software interface according to Webopedia, defines "the languages and codes that the applications use to communicate with each other" [13].
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> **Integration**: a combination of diverse application entities into a relationship which functions as a whole i.e. the joint collaboration of several system components to form a single system.
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> **Interoperability**: a state which exists between two application entities when, with regard to a specific task, one application entity can accept and understand data from the other and perform that task in an appropriate and satisfactory manner without the need for extra operator intervention.

This previous definition of interoperability, in relation to a specific task, clearly distinguishes interoperability from integration. This definition it is also aligned with definitions given by the IEEE [7] and the ISO [2] organisations, which conclude that interoperability is namely "the ability of two or more systems to exchange data, and to mutually use the information that has been exchanged".

2.1.1 Interfacing and Integration

Interfacing is the most basic method of enabling two systems to work together. However, when the number of systems increases, the task becomes difficult or even impossible . This raises practical issues and represents a significant economic challenge to the development of healthcare information systems [9]. When dealing with integration in hospitals, healthcare system developers are increasingly concerned about the tremendous increase in expenses devoted to performing systems interfacing, as compared with their acquisition. Unfortunately, in the last few years these interfacing costs have increased from 20 to 30 percent, thus, a possible solution to reduce this trend is to provide better interoperability in their developed products.

Similarly, when a user or developer wants a variety of software components to work together in a seamless way, to emulate a single system, integration techniques have to be used extensively [4]. These techniques sometimes appear to provide certain levels of success in bringing together several complex subsystems, however, the integration of these subsystems may still theoretically rely on interfacing a system step by step usually using a defined software methodology. In this context it can be clearly identified that the use of fully interoperable components could greatly facilitate the integration process.

2.1.2 The impact of interoperability

It is critical to recognise the complexity of the processes that surround healthcare when aiming towards interoperability of healthcare information, in which various categories of players are directly or indirectly involved:

> **healthcare companies**: this includes vendors of clinical systems, administrative IT systems, and medical devices e.g. imaging, ultrasound, laboratory, etc. This category usually involves large multinational companies with global objectives, to companies of small and medium size, focusing on a market in a small geographic area, or narrow scope.
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> **healthcare providers**: this category includes health professionals, belonging to a variety of professions e.g. physicians, nurses, technicians, etc. Unfortunately, very few have all the necessary and appropriate skills in computer science and technology; or the necessary time to dedicate resources to tackle interoperability problems or participate actively in standardisation of health informatics and standards.
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> **IT and administrative staff**: they both play key roles in large healthcare providing institutions, but are often absent in small healthcare facilities. In addition, very few are active in standards development organisations or technology integration.
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> **health authorities and governments**: this are the related bodies that supervise or manage the health system at the national level. With evolving technologies and standards, usually, governments and authorities enforce interoperability through national standards, and in most cases this has proven to be effective.

[3]This issue has caused the slow adoption and use of computerised medical records.

[4]Complex systems exhibit very complex, discoordinated behaviours, in which it is very hard to predict what an element will do over time.

Therefore, when driving towards interoperability and in order to support e-Health strategies successfully, the needs of a variety of players have to be taken into account.

This includes in particular healthcare professionals, whose work environment will be directly impacted by the way standards and technologies are used to support the workflow in their daily practice. It is recommended that before considering mandating the use of a particular technology or standards through any official body, their consent has to be achieved through a collaboration process.

3. SEMANTIC INTEROPERABILITY

Interoperability is the only sustainable way to help partners acting in various locations, with different expertise, perspectives, statuses and agendas, possibly cultures and languages, and using distinct information systems from different vendors, to collaborate harmoniously to deliver quality healthcare. At the very top of an "interoperability scale" are three levels, each one subdivided as : functional, syntactic, and semantic [10].

Extensive sharing and exchange of information requires that at least two levels of interoperability are reached [3]:

1. **functional and syntactic interoperability**: the ability of two or more systems to exchange information through functionality and defined message structures so that this information is human readable by the receivers[5].

2. **semantic interoperability**: the ability for information shared by systems to be understood at the level of formally defined domain concepts[6] so that the information is computer processable by the receiving systems [12].

However, semantic interoperability is not an "all or nothing" concept. The degree of semantic interoperability depends on the level of agreement between sender and receiver regarding the terminology, and the content of archetypes and ontologies to be used [6].

Semantic interoperability is essential for automatic computer processing which will enable the implementation of advanced clinical applications such as EHR (Electronic Health Records), laboratory systems, and intelligent decision support systems. In fact, healthcare delivery deals predominantly with information and knowledge management, and in terms of clinical information dissemination, the aim here is not only exchanging data and information but reuse and process that data more intelligently.

4. CONCLUSIONS

The development and implementation of e-Health throughout Europe, within and between the member states, requires well tailored standards and systems aimed at facilitating interoperability between local, regional, and national healthcare information systems, and the availability of "plug-and-play" systems. However, in a number of healthcare domains, it is extremely difficult to find the right systems or standards that can be used in part or in whole, without further integration, interfacing, and development.

In this context, semantic interoperability will be necessary as there is a shift from integration services to interoperability, and for the successful introduction of Europe's value added healthcare applications such as electronic health records, care planning systems, and decision support systems. In Europe, there is already a roadmap for interoperability in e-Health with special emphasis on semantic interoperability e.g. RIDE project, which aims to promote and undertake interoperability issues in healthcare organisations at the European level.

[5]For example, the DICOM and the HL7 v2.x standards.

[6]As in the case of the HL7 v3 using the Reference Implementation Model (RIM).

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