Review

Gaining the competitive advantage in eHealth interoperability solutions

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Managing information systems today requires more than just having stand alone information systems - which are efficient in themselves. It requires that the information being managed is readily available to other departments within an institution as well as other institutions within the same domain or economic sector. Health Institutions across the globe make use of some Hospital Information System / Electronic Health Record system or the other which can only be maximized if there is some level of interoperability between them. This paper presents a SWOT analysis of interoperability solutions that have been implemented or are being used in the health sector – with a focus on highlighting actual problem(s) addressed by the researcher/developer, the implementation strategy and methodology adopted, as well as pros and cons of the solution. Considerable recommendations were made for the development of eHealth Interoperability solutions that can help gain competitive advantage in the healthcare interoperability solutions market.

Keywords: Electronic health record (EHR), health information systems (HIS), interoperability, health information exchange (HIE), competitive advantage.

INTRODUCTION

Information Systems in health institutions are made up of distributed, heterogeneous and autonomous hardware and software systems – thereby creating diversity in the requirements for information processing as well as the computing devices used. As a result, most Health Information Systems exist as “stand-alones” with little or no ability to interact effectively. (Obal and Lin, 2005) Furthermore, proprietary standards are often used for the implementation of the various Healthcare Information Systems, hereby making them operate in a highly defined way (Begoyan, 2007).

One of the pressing priorities of research in Healthcare Information Systems is the rising concern about the Interoperability need. There are different viewpoints to the problem of interoperability in Health Information Systems: problems exist in the interoperability of the diverse database systems (e.g. Oracle, Microsoft Access or Microsoft SQL Server database systems, etc), diverse implementation/programming languages (e.g. C++, C#, VB, Java, PHP, XML, etc), diverse system-platform (e.g. Operating Systems such as Microsoft Windows, Linux, etc, or internet browsers such as Firefox, Internet Explorer, Chrome etc for the web applications) (Kuziemsky et al., 2009).

This paper explores available solutions to interoperability that is not just documentations of recommendations, but that have being implemented and/or in use in various health institutions across the globe. An analysis of the mode of operation, strengths, and limitations of the selected solutions was carried out for possible hybrid solution as a contribution to the interoperability gap.

Hence, we present a SWOT Analysis carried out on interoperability solutions implemented in healthcare systems. The term SWOT analysis refers to a careful highlight of the Strength, Weakness, Opportunity, and Threat of a particular entity. The healthcare interoperability solutions analyzed were selected based on availability through internet search. The analysis led to a set of recommendations that can be considered by developers of eHealth Interoperability solutions in order

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to gain competitive advantage in the healthcare interoperability solutions market.

**Electronic healthcare (eHealth)**

The World Health Organisation (WHO) defines eHealth as “the use, in the health sector, of digital data - transmitted, stored and retrieved electronically - in support of health care, both at the local site and at a distance.” Electronic Health Records (EHRs) are a form of eHealth that enable online access to a person’s health record from many separate, compatible systems within a network. Real access to EHRs provides the best of patient care, especially to those who have need to consult multiple healthcare providers.

In view of the definition of EHRs stated earlier (defined as a form of eHealth that enables online access to a person’s health record from many separate, compatible systems within a network), one may infer that any system referred to as an EHR is not exactly an EHR until separate systems within a network can gain access to a patient’s health record when need be (Interoperability). In other words, if it not interoperable, then it is not an EHR. A key advantage of EHRs is that all the patient information will be brought together in one place and will be easily accessible by all providers irrespective of their location.

**Interoperability in healthcare systems**

Interoperability is broadly defined as the ability of two or more systems to exchange and use information. (Lopez-Gutierrez, 2009) The Oxford dictionary defines interoperability as the ability of a computer system or software to “exchange and make use of information”. Interoperability of EHRs as defined in ISO (ISO TC 215, ISO/TR 20514, 2005) is “the ability of two or more applications being able to communicate in an effective manner without compromising the content of the transmitted EHR”.

The International Organisation for Standardisation (ISO) argue that it is important to develop national and international standards for EHR interoperability to enable patient health information sharing between health professionals in a multidisciplinary shared-care environment and to also enable the sharing of patient health information between health institutions locally/regionally/nationally, as well as to enable exchange between EHRs from different vendors (Begoyan, 2007).

Existing solutions that attempt to achieve some level of interoperability are mainly web-based, and as such require contiguous access to the internet. In developed countries, access to the internet is n, but in many under-developed and some developing countries, internet access can be a luxury at times.

**Interoperability classifications in healthcare systems**

Interoperability is classified at different levels of exchange, these include: functional (or technical) interoperability, semantic interoperability and process (or social) interoperability. The ability to interchange health information is known as functional interoperability, whereas the ability to use the interchanged health information through the provision of a common capacity of understanding is referred to as semantic interoperability. Process interoperability on the other hand is an emerging concept that has been identified as a requirement for successful system implementation into actual work settings (Gibbons et al, 2007).

The focus of technical interoperability is mainly on the conveyance of data, not on the meaning or interpretability of the conveyed data, semantic interoperability focus on clear understanding or interpretation of conveyed data, and process interoperability focus on methods for the optimal integration of EHRs into actual work settings.

“Interoperability goes beyond technical issues. Rather we must look at interoperability as the infrastructure for the entire healthcare system that includes technical, clinical, workflow and human aspects” (Kuziemsy et al, 2009).

**Identified implementations of interoperability solutions**

The analysed implementations of an interoperability solution are described in this section:

**The direct Project**

The Direct Project is a low cost practical mechanism for exchanging health information over the internet. The health information exchanged includes communication of summary care records, referrals, discharge summaries and other clinical documents in support of continuity of care and medication reconciliation, and communication of laboratory results to providers. Technically, a product or service that supports the Direct Project is responsible for packaging the content of messages, securing it, and transporting it from a sender to a recipient (as shown in figure 1 below).

**iConnect enterprise clinical platform**

The iConnect Enterprise Clinical Platform delivers integrated suite of solutions to healthcare enterprises so as to enable diagnostic content and results sharing, with a focus on lowering costs and assisting patient care –
providing a valuable patient-centric view of all diagnostic images. This was done by leveraging on a standards-based approach alongside web-based technologies. This vendor-neutral platform merges, standardizes and archives images and data from diverse picture archiving systems, sites, etc., and gives a consolidated view of all diagnostic images to clinicians. The iConnect Enterprise Clinical Platform also provides the flexibility to add or replace storage systems when the need arise. The iConnect Enterprise Clinical Platform is a 3-in-1 package which includes the iConnect Access (a zero-download DICOM image and XDS server), iConnect Share (an Internet-based gateway for image sharing between enterprises) and iConnect Enterprise Archive (which serves as the crux of the enterprise imaging strategy).

The Multi-Database System

The system being developed consists of a collection of databases accessible through a common graphical user interface. In this system, various users have different customized interfaces to the system, and as such are able to see different views of the stored data. The
Implementable features of eHealth interoperability solutions

From the SWOT analysis we see unique features that have been useful to healthcare providers and have provided them some level of interoperability. Here we highlight valuable features that developers of eHealth Interoperability solutions should endeavour to implement, as well as lapses that should be avoided so as to ensure efficient use and to gain competitive advantage in the healthcare solutions market. Recommendations are given below on implementable features for competitive advantage in development and sale of Interoperability Solutions in the healthcare systems market. In no particular order, the features include:

Ability to leverage on existing ICT infrastructure

Decision makers in any health institutions are often concerned about the cost implication of interoperability solutions. Even though it is clear that the use of these solutions will reduce expenditures on the long run, the initial cost of installation should be at the barest minimal. One key contributor to a reasonable reduction in installation budget for healthcare interoperability solutions is if the client institutions are able to still make use of their existing ICT resource. This may also require some level of consideration on vendor-neutrality. The ability of an EHR interoperability solution to leverage on existing ICT infrastructure / technologies will not only help health institutions to save cost, it will also enhance the acceptance of the product by the consumer health institutions.

Ability to match received messages with patients’ information

On delivering messages to the requesting information system, an additional value that may serve as a key-seller is an automated matching of the received message with the information existing on the receiving system, rather than having the practitioner manually search and match received messages with concerned patient’s information.

Exchange protocol that guarantees message delivery

The fact that information was sent by a host information system on request does not necessarily imply that the message was delivered to the requesting information system. The exchange protocol used for the development of the software determines confirmation of message delivery. Developers (individuals’ organisations) should consider the use of exchange protocols such as: AMQP (Advanced Message Queuing Protocol), FIX (Financial Information exchange) protocol, TFTP (Trivial File Transfer Protocol) may be used only on private local area networks because of security concerns. The use of UDP as exchange protocol is discouraged for it does not retransmit any lost packets and it has no inherent congestion control. SMTP (Simple Mail Transfer Protocol) is often used by emailing information exchange application, but SMTP does not guarantee message delivery. Rather than use SMTP, developers may consider the using ODMR (On-Demand Mail Relay) which is an extension of SMTP that allows an intermittently-connected SMTP server to receive email queued for it when it is connected. The downside of the ODMR is that it can only be used with Internet service providers that support ODMR. Ensuring message delivery and secure data transfer can be challenging as protocols such as FTP (File Transfer Protocol) that guarantee message delivery are sometimes exposed to eavesdropping at the network layer. SFTP (Secure File Transfer Protocol) could be used instead of FTP.

Foundation for exchange - A unified interface

For different systems to integrate a patient’s information there is a need to transfer the patient’s information from one system to another. This transfer is generally performed through adapted and customized interfaces. (Mannai and Bugrara, 1993) In order to effectively gain access to the heterogeneous database systems various EHRs, using a unified interface is advised. This allows a user to query different databases simultaneously through a single interface. Databases differ in content type, form, design, software (DBMS – Database Management Systems), and run on different platforms, and as such require some unification of interface requirements in order to enhance efficient interoperability.
Table 1. Summary Description of Selected Interoperability Solutions (Actual Implementation)

<table>
<thead>
<tr>
<th>Interoperability</th>
<th>The Direct Project</th>
<th>iConnect Enterprise Clinical Platform</th>
<th>The Multi-Database System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem Addressed</strong></td>
<td>State Health Information Exchange focusing on having a low cost health information exchange over the cloud (internet) via emails</td>
<td>Enterprise sharing of diagnostic content and results by enabling the viewing, sharing and archiving of any type of image, anywhere, any time. IConnect works with existing applications, leveraging widely-used web and healthcare technology standards, to provide a vendor-neutral interoperable environment.</td>
<td>Aiding the way data is accessed, retrieved, analyzed, and combined with other data using a multidisciplinary minimum data set.</td>
</tr>
<tr>
<td><strong>Development Strategy / Implementation Platform</strong></td>
<td>Independent of specific operating system or programming language frameworks. ¬ Multipurpose Internet Mail Extensions (MIME) for packaging message content ¬ S/MIME encryption and signatures used for integrity and confidentiality of messages. ¬ X.509 digital signatures to authenticate message sender and receiver ¬ SMTP for routing messages</td>
<td>¬ Standalone vendor neutral archive, giving room for third-party integration ¬ Images (of any type) are easily archived, and accessible at the point of care ¬ Real-time access to any image and full image history on any web-enabled device</td>
<td>The multidisciplinary minimum data set that serves as the common platform for data exchange among the various medical databases. This was used as the basis for providing inter-operability.</td>
</tr>
<tr>
<td><strong>Strength</strong></td>
<td>¬ Does not ensure semantic interoperability ¬ Does not address complex scenarios such as emergency situations</td>
<td>¬ Its modular approach allows institutions to leverage on existing ICT resource, this enables easy integration</td>
<td>¬ Access to multiple heterogeneous databases through a unified interface. ¬ Freedom of association and controlled access. ¬ Participating organizations can join the multi-database federation (by putting their database online for access)</td>
</tr>
<tr>
<td><strong>Weakness</strong></td>
<td>¬ Has a common transport layer: an important foundational element of exchange</td>
<td>¬ SMTP does not promise message delivery ¬ Matching of received messages with patient information is not automatic</td>
<td>¬ A possible foundation for future systems with high degrees of dynamic data interchange and interconnectivity</td>
</tr>
<tr>
<td><strong>Opportunity</strong></td>
<td>¬ Highly web-based, this might be a threat in regions with poor internet resource</td>
<td>¬ Participating organizations can join the multi-database federation (by putting their database online for access)</td>
<td>¬ Putting database online so as to participate may give room for information breach</td>
</tr>
<tr>
<td><strong>Threat</strong></td>
<td>¬ Highly web-based, this might be a threat in regions with poor internet resource</td>
<td></td>
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**Imaging Capability**

This goes in-line with the Stage 2 Meaningful Use (MU) requirement of healthcare systems, which requires that healthcare information exchange products should attempt to incorporate imaging capabilities. Imaging capabilities will not only help comply with MU stage 2 requirements, it will provide additional benefits such as increased productivity, optimized operational efficiency, improved patient safety, enhanced quality of care and reduced costs (especially in avoiding repeated radiology scans). For optimal throughput, health institutions will need to be able to distribute imaging results securely and allow referring physicians to view images directly from their certified EHRs.

**Patient’s Consent**

For any patient’s information to be communicated, best practice conduct requires that the patient is aware of this and is in agreement with the
exchange. This can be done through various means; such consent or authorization from the concerned patient may be gotten off-band (e.g. via phone communication), or consent can be taken before hand at the point-of-care, on referrals or at the time of creating the patient’s health information account. Developer should consider how to incorporate this functionality in the EHR. Emailing technology may be considered in developed countries where text messaging can be used in developing countries where there is unreliable access to the internet. This will also ensure that the patient’s authorization details can be stored electronically and can be retrieved in future if any legal issue comes up. A study was carried out by EKOS in 2003 to determine major HER privacy concerns among Canadians, the top 3 concern were: the ability to find out who accessed the record and when – 71%; make it a serious criminal offence for unauthorized access – 64%; a clear and accessible privacy policy – 61% (Canada Health Infoway, 2006).

Security / controlled access

It is pertinent to consider security alongside solving the interoperability challenge. In as much as, the industry is eager to have individual healthcare systems “talking to each other”; health information communication exchange must be done securely so as to avoid information breach or violation of privacy policies or regulations. Some of the questions to be asked at design stage are: “Can the data be adequately protected and confidentiality maintained? Will the quality of the data remain reliable without unauthorized modifications? Can the availability of needed information be assured? Can those accessing data be verified? Will changes to data be associated with the user making those changes? Finally, does the data structure support an audit trail for forensic purposes? The answers can be used to properly formulate the appropriate level of security controls for the information in electronic health records” (Conklin and McLeod, 2009). Access controls beyond the application level are now vital to aiding maximized benefits of data consolidation and the likes. “While encryption and access control are key components to protecting data, even the best security systems are not complete without a monitoring system in place.” (Oracle Inc., 2011) A form of Audit Service may also be provided by the EHR. Audit Service basically refers to provision of information access history usually in the form of summary logs. Even if a physician obtained access to a record that he or she had no need to access, the Audit Service would log the access.

Simplicity and Scalability

Simplicity enables easier comprehension and usability of the developed solution, while Scalability enables easier upgrading or downgrading of the solution before or after installation of the developed solution. In other words, scalability refers to the ability to accommodate changes, if need be. Simplicity and Scalability can mainly be achieved by paying careful attention to the architectural design phase of the SDLC (Software Development Life Cycle). In terms of actual implementation current industry standards for portable, extensible software include both the NET platform and Java.

Standardization

Many researchers across the globe have argued that the only way forward on the issue of interoperability is standardization. “Without unified and authoritative hospital standardization data dictionaries, it will be difficult for software systems within the healthcare domain to interoperate.” (Gambo et al, 2011) Hence, standards are often defined to enable semantic interoperability (i.e. information exchange whereby the sender’s intention is correctly interpreted by the receiver). Information exchange between different health systems requires unification of titles, concepts and classifications – which are defined in health information vocabularies. Standards are defined nationally and internationally, they establish definitions for data elements in an EHR system and their specifications are contained in data dictionaries. Examples of standards that define components of an EHR and complement interoperability include HL7 Communication Standard (Version 2 and 3), National Council for Prescription Drug Programs (NCPDP), Digital Imaging and Communications in Medicine (DICOM), NCPDP Batch Transaction Standard, NCPDP Billing Unit Standard, IEEE 1073 Point of Care Medical Device Communication, amongst other. To facilitate the organisation, storage and retrieval of healthcare data, there are vocabularies, terminologies and classification systems that have been put in place. They include Alternative Billing Concepts (ABC) codes, Clinical Care Classification (CCC), Current Dental Terminology (CDT), Current Procedural Terminology (CPT), International Classification of Primary Care (ICPC), Logical Observation Identifiers, Names and Codes (LOINC), Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT), amongst many others. (AHIMA, 2007) However, one major concern with these vocabularies is that words are often misused, or may assume two or three mutually exclusive meanings, as the receiver may be thinking of a different interpretation from the sender’s intended meaning (Gibbons et al, 2007).
CONCLUSION

The whole essence of interoperability is to enable access to relevant information (such as consultation notes, health history, radiography images, etc) when the need be (e.g. during referral consultation sessions, emergency situations with unconscious patients, etc). Hence, this does not necessarily mean that the information must be persistently stored on individual EHRs; the key concern is for the information to be always available on demand, because the demand for specific patient information varies from one patient to another.

Although most healthcare interoperability research often focus on terminology standards (definition, comprehension and clarification of healthcare information communication standards), there is a need to note that the Critical Success Factors for thriving in the healthcare interoperability solutions market requires more than just complying with standards. It is important to consider other factors described in the implementable features discussed in the body of this paper.

Furthermore, the developing country scenario may require a careful implementation strategy given their known challenges of unreliable electricity, poor access to internet, limited health-IT expertise, un-even spread of national globalization, amongst others. On the other hand, the mobile phone platform can be leveraged on (especially where communication with patients is required - informing patients and receiving responses/feedback from them), given that there is an increasing mobile penetration as the years roll by. Research has it that there are ten times as many mobile phones as landlines in sub-Saharan Africa, and that about 60% of the population has mobile phone coverage (ITU, 2009). Also, while Europe recorded an annual 17% increase in mobile phone subscription between 2002 and 2007, the sub-Saharan sect recorded an annual 49% increase, hereby bringing new opportunities to the continent even as it concerns health information (Aker and Mbiti, 2010).

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