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National Electronic Health Record Models

Nation and Region Wide Electronic Health Records are currently deployed or are being deployed in several countries around the world to enable sharing of care records within an organization and between different organizations. This sharing of health records would enable the patient's medical history and other details to be available at the point of care and would enable effective treatment of patients.

In this paper, we discuss the origin and need for Electronic Health Records (EHR) and describe the key design principles for EHR. In addition, we outline two of the most-commonly used architectural models of EHR. We also outline the importance of standards and strategies for effective usage of standards in successful deployment of EHR.

About the Author

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Ananda Mohan has been associated with Tata Consultancy Services (TCS) since 1998. He holds a Master of Technology degree in Opto-Electronics and a Master of Philosophy in Physics. He has worked on different healthcare projects ranging from design, development to deployment. His current focus is on healthcare interoperability solutions while working on the largest healthcare IT project in Europe.

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Introduction

Healthcare providers have been providing assessments, procedures, and therapies for patient care. There are several administrative processes that need to be coordinated, which result in delays in providing patient care. Healthcare providers have realised the importance of automating these administrative processes to provide appropriate care to patients in time. To automate these administrative processes, several systems have been procured from external vendors or built in-house. This automation has led to the process of capturing information related to patient care and storing them electronically. The electronic clinical record of patients helps clinicians to treat patients more effectively by providing the required information at the required time.

However, these systems catered to specialist departments and are usually best-in-class systems for the specific department, but not across an enterprise. This created a huge challenge in presenting the data in these disparate systems as a single unit. The introduction of the Integrated Healthcare Delivery Networks and moving beyond the single episode of care in a single enterprise to the entire continuum of care in multiple enterprises generated the need for availability of information as a single entity.

Economies world-wide have also started to realise the burgeoning costs of providing healthcare to its population. Several studies support the fact that the availability of correct data at the point of care reduces the patient's costs to a large extent. Real-time messaging between clinical systems did solve the problem of data being available at the right time to some extent but it did not solve the problem of presenting data available in disparate systems as a single unit. The model of allowing clinical data to be presented as a single entity and sharing care records within an organization and between different organizations led to the birth of Electronic Health Records (EHR).

The ability to share clinical data helped decrease spiralling costs of providing healthcare. This was possible by preventing duplicate laboratory tests and by providing quick and effective treatment through easy access of the patient's clinical history. The models of sharing data to provide integrated healthcare have been envisioned by different national organisations in development and deployment of data repositories at provincial or national level depending on the size of the country to which the organization caters.

The Committee for European Normalisation provides the following definition for EHR.

"A repository of information in a computer readable format regarding the health of a subject of care "

The Australian National EHR Taskforce, which is one of the front-runners in providing a nation-wide EHR (along with NPfIT of England and Infoway of Canada), through its Health Connect Programme, defines EHR as:

"an electronic longitudinal collection of personal health information based on an individual or family and entered or accepted by healthcare professionals. It can be distributed over a number of sites or aggregated at a particular source including a hand held device. The information is organised primarily to support continuing, efficient, and quality healthcare."

EHR Design Principles

This section discusses the key design principles or elements for successful development and deployment of a national electronic health record.

In our view, the key capability of an Electronic Health Record system is its ability to generate a single patient-centric view of electronic health information showing a lifetime record. The records need to be retrieved from multiple organisations that are part of the patient's healthcare continuum. The information can vary from historical to current care data associated with the patient. The retrieved information should be presented in a consistent user interface to authorized users. The EHR should not only provide required information but also support decision making - that helps enhance the quality, safety of patient care, and support delivery of healthcare effectively, without hindering the routine of the clinicians, whose main job is to provide care and not to record care information.

Figure 1 shows a summary of the architectural principles that need to be followed while designing the EHR and the systems that feed the EHR.

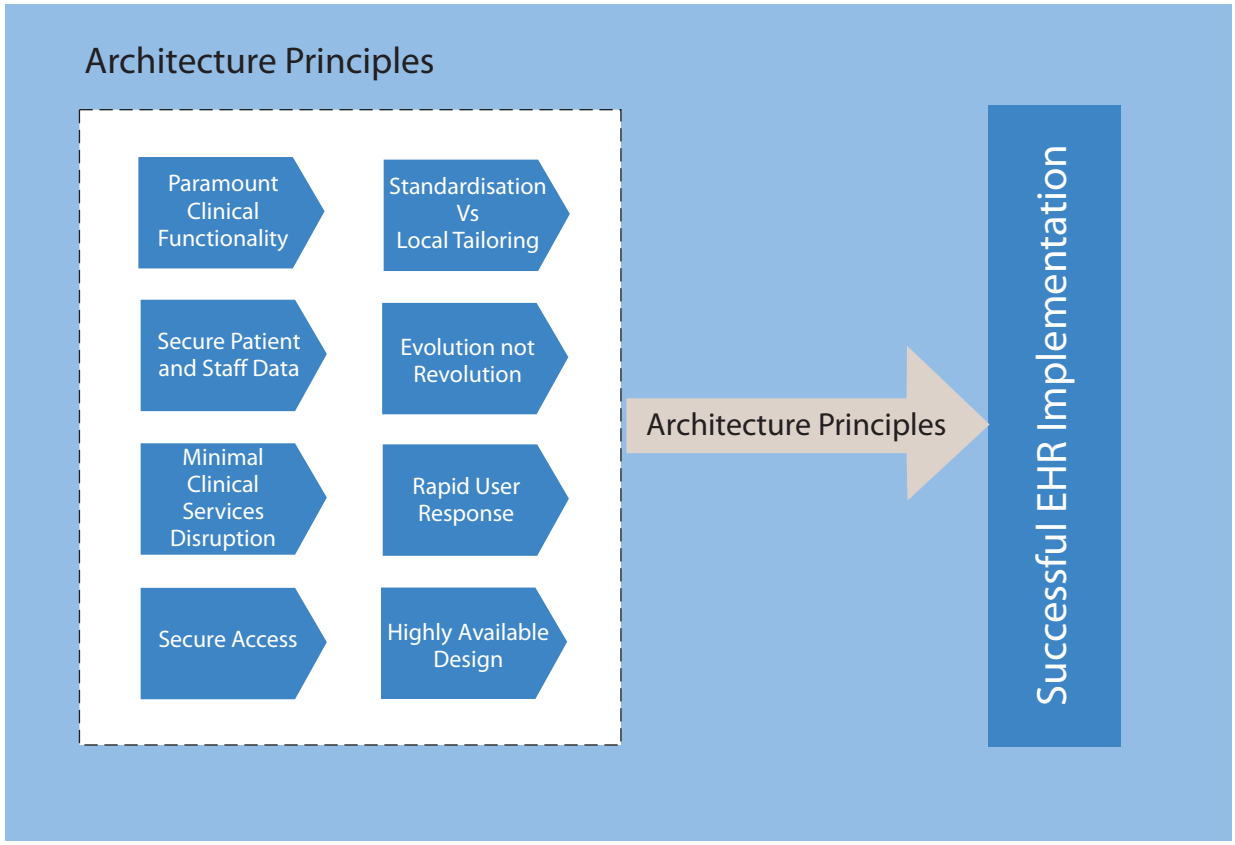

Figure 1: EHR Design Principles

- Clinical Functionality – The main principle that drives the success of EHR is the ability to identify the required clinical functionality within the EHR, which is required for the clinicians to enhance user acceptance of the system. User acceptance and extensive usage of the EHR depends on the importance of clinical functionality and the information maintained using that functionality. Besides this, the key requirement of EHR is to enable interoperability between EHR and the local systems used by the clinicians, which can be achieved either through interfacing (messaging) or integration.

- Information Governance – A key requirement of EHR is to deliver robust controls and mechanisms to ensure that the shared information of patients and staff is properly protected. This requirement translates into providing application and infrastructure level security, ensuring data integrity, and having a security policy design and enforcement team.

- Regulatory Compliance – It is important that an external regulatory body functions as an accreditation agency and audits existing and future solutions that accommodate the short-term and long-term requirements of the EHR vision. This includes minimizing the duplication of services and information between different solutions which support EHR and which are a part of an EHR implementation. The regulatory body also needs to ensure that the products that feed the EHR also have a strategic long-term position in the EHR roadmap.

- Disruption – Safeguarding and improving existing operational clinical care in a clinical setting with the introduction of EHR and not disrupting the existing services is a major driver. This can be achieved through seamless implementation of fully tested services and systems.

- User Access – Providing user authentication and authorisation systems would enable them to access the EHR and local systems securely through a common point of entry using a standard user interface such as a portal.

- High Availability and Fault Tolerance – The EHR needs to support the retrieval and presentation of information in geographically dispersed clinical systems. This requires highly resilient infrastructure and strong business continuity processes. Besides this, it might require services hosted in a managed services environment, such as, Data Centers that can be managed by groups of consortia led by healthcare vendors, infrastructure vendors, and system integrators.

- Fast Responses – Users need to quickly access EHR to enable fast and efficient treatment of patients. Therefore, it is very important that the EHR system provides fast responses to the user.

- Flexibility to Adapt – It is crucial to provide a modular system for different clinical domains within the EHR system as advances in a particular branch of medicine can be easily and rapidly adapted to meet the changing requirements.

- Revo-evolutionary Approach - This approach will combine the innovation of revolutionary development with the controlled development of evolutionary design to develop the solution, without the need for major change, towards delivering the EHR requirements.

- Standardisation vs. Local Tailoring – In complex system environments, those solutions that form the building blocks of EHR should address the balance between rich standardised functionality and local tailorability for organisations and provinces in conjunction with local user focus groups.

- Conformance to National and International Standards – The EHR should not only meet the standards defined by regulatory agencies but should also meet the requirements mandated by international organizations such as the World Health Organization (WHO).

The above-mentioned design principles are important for the successful implementation of EHR. But, developers and deployers of EHR should be aware that the existing healthcare applications that form the basis for EHR by interfacing or integrating might not be built on the above principles. In such a scenario, the products which might be suitable to form the building blocks of EHR need to be embraced while those that are not suitable need to be replaced through the double R architectural policy of Reuse and Replace.

Reuse - Existing clinical systems that will endure, which are accepted by the health communities but need minor modification in the clinical functionality, and will be able to adopt new standards should be allowed to become building block of EHR. These systems should be accredited in accordance with standards defined by the regulatory agencies (e.g. NPfIT in UK), which is responsible for the deployment of EHR.

Replace - Existing clinical systems that will not endure, which are not accepted by the health communities, cannot provide required healthcare functionality, and cannot be modified to adopt standards defined by regulatory agencies should be phased out and replaced by newer solutions.

EHR Models

In this section, we describe the architectural patterns of the two most popular EHR models.

Central Repository Model

The centre of EHR model will be the repository, which will be fed by the existing applications in different care locations such as hospitals, clinics, and family physician practices. The feed from these applications will be messaging based on the pre-agreed data set. The messaging needs to be based on HL7 Reference Information Model (RIM) for which XML is used as the recommended Implementation Technology Specification (ITS). We observed that regulatory agencies of several countries are taking an active role in speeding up the balloting process of HL7 V3.0 so that an open system messaging standard is available. Figure 2 shows a graphical representation of the central repository model.

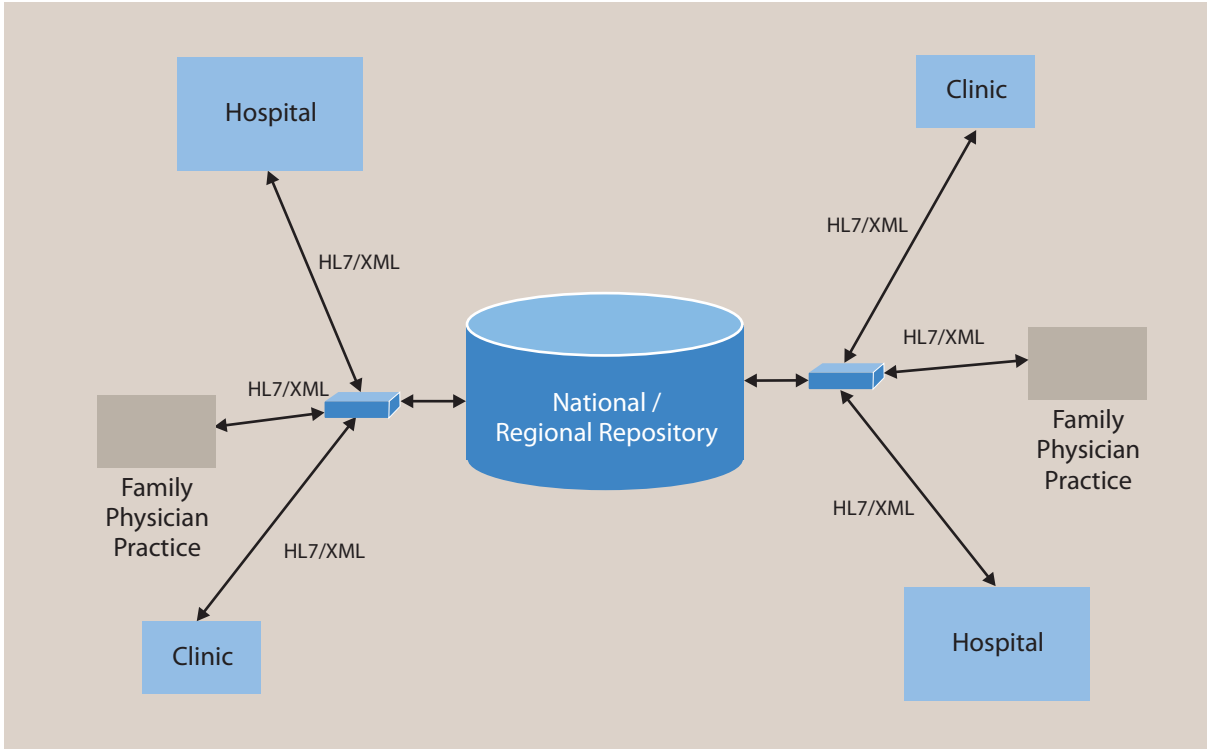

Figure 2: Repository Model

The technical feasibility of this solution depends on designing a repository, which can be populated based on the messages generated across the care continuum. Integration hubs need to be provided in different regions to receive the messages and route to the repository, where data will be stored for future retrieval and usage. The data will be retrieved using the XML queries. The Integration hubs need to perform validation and verification of messages sent by different applications and perform further rule-based processing. The messages need to be sent over secure channels of communication through a high speed dedicated network or alternatively through secure encryption and decryption mechanisms to the repository.

The event-driven messages that need to be sent and stored in the repository will essentially be event-based summaries as shown in Figure 3. The event-based summaries stored in the repository can be queried and retrieved

by different clinicians who are treating the patients in different scenarios and by different clinical settings where the patient's previous clinical data and history does not exist. The retrieval and access of data from the repository is subject to establishing that the clinicians are legitimately accessing the data for treating only those patients who are in their care. The retrieval is done through messaging, which can be done either through synchronous or asynchronous messages depending on the urgency, complexity, and importance of the data that is being retrieved. The technologies used for messaging can be SOAP Web services and ebXML as dictated by HL7 transport specifications for V3.0.

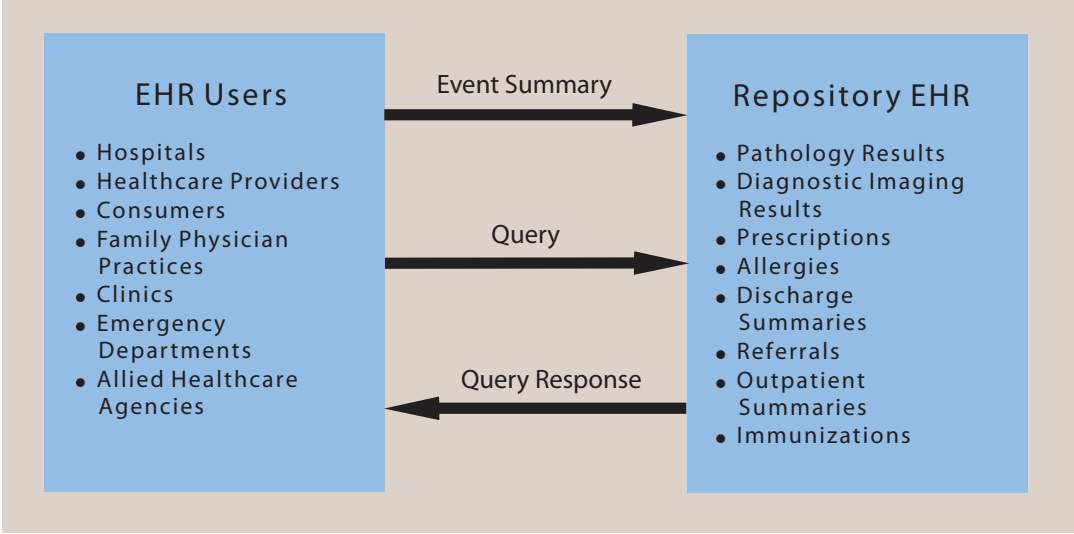

Figure 3: EHR Message Events

The query for the patient's data from the repository can be initiated from point of care applications used in the clinical settings. This is done after completing the authentication and authorisation process, which is performed through security services provided as part of the repository. The security services can be provided through products such as Netegrity's SiteMinder, which is a security middleware product for managing presentation of user credentials held in a central directory server hosted as part of the repository. For quick access, the user credentials from this central directory can be cached in a local Lightweight Development Application Protocol (LDAP) services directory. A user management product can be deployed directly into applications to manage the provisioning of user accounts from the LDAP (where direct integration with LDAP is not supported) so that user account creation and removal is automated and auditable. Figure 4 shows the architecture to support this approach.

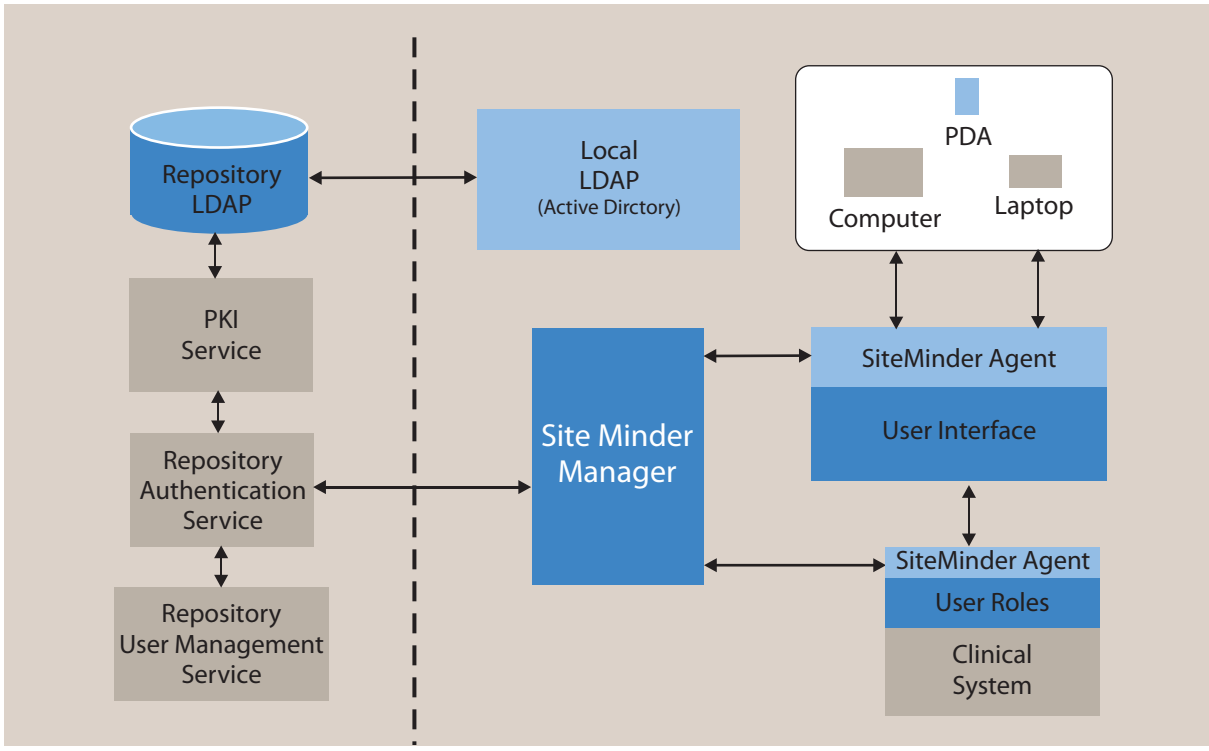

Figure 4: Controlled User Access

Applications can also be built around the repository so that sites without any IT infrastructure can access the data from the repository and enter data directly into the repository by using a user interface provided by these built applications.

Managed Services Model

The managed services model is based on hosting applications for different care providers and care settings in a data centre by a consortium, which may consist of group of infrastructure providers, system integrators, and application providers. The hosted applications can be used to provide an effective EHR by building a common repository using a shared database or by providing a common user interface to all hosted applications and extracting data from these systems using a portal whose authentication and authorisation mechanism can also be controlled at the data centre level as shown in Figure 5.

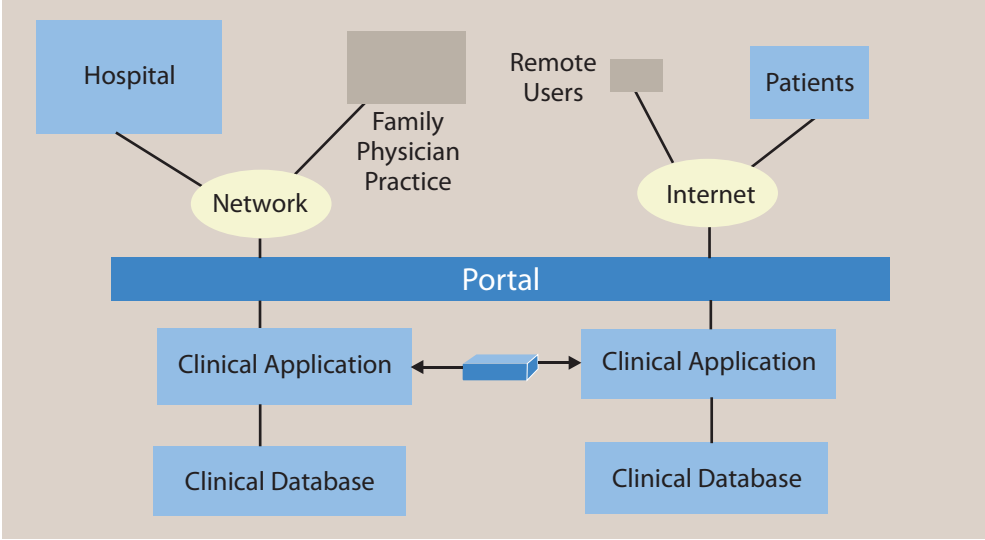

Figure 5: Shared Services Model

This model will help hospitals to forget about their everyday IT needs and allow them to share the records effectively in different regions. The effective consolidation of applications for different care providers for a region in a single place will allow other regions with a similar model to quickly access the required data about a patient. This can be done by providing access to the patient's data through the portal over the Internet or by allowing some sort of integration between different regional managed centers. The information governance issues associated with this model can be sorted out using the authentication and authorisation model suggested in the central repository model. The managed services model will provide access to detailed records that are not supported by the central repository model as it can provide access to only the summary records of the patient.

Service Oriented Architecture's Enterprise Service Bus approach allows these different regional managed centers to be accessed through a portal on the Internet, or even through programmatic access using protocols such as Web services as shown in the Figure 6.

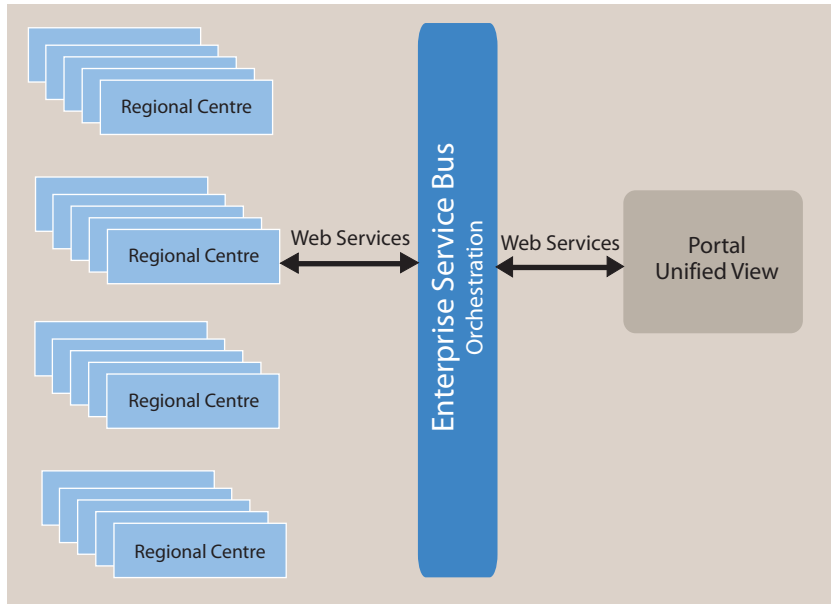

Figure 6: ESB Approach

Standards

Information and communication technologies are increasingly becoming integral part of inpatient, outpatient, and administrative areas of healthcare. The speed of technological advances stands in contrast to the requirement for a reliable, long-term, and easy access of clinical data. EHR provides easy access of clinical data. However, successful deployment of EHR depends on maturity of standards used.

The healthcare sector is distributed and unstructured. Therefore, the standardization of interfaces from the conceptional level down to the technical levels is of great importance. The interoperability standards that form the basis of an Electronic Health Record must support the secure storage and exchange of useful and clearly understandable health information with appropriate secure access by authorised people. The most important standards that are of relevance to EHR are related to messaging, data dictionaries, and clinical terminology. The following sections suggest ways to address the concerns while using these standards.

Messaging

A number of organisations in the healthcare sector have clinical messaging for interoperability of clinical applications in their individual settings. However, the sites that were planning or had implemented clinical messaging within the organisation had no national standards and had defined their own message sets. If this continues in future, then it will not be possible for us to attain interoperability across organisations and between EHR components. Therefore, it is important that we standardise clinical messaging of all the necessary message types.

Message definition proposals should come from existing suppliers as well as from the existing regulatory organisations. At the moment, suppliers have no route to influencing what standards are put in place (and when) to fill gaps that are present. Involvement of suppliers in defining the message standards along with regulatory organisations responsible for deployment of EHR will allow the suppliers to fill in the gaps in their applications. Organisations that have some message standards have some advantages over organisations that do not. If some message standards are subsequently found to be incomplete or incorrect, they can be revised over a period of time. Accreditation is a way to ensure that systems comply with the required set of message standards.

We have identified that HL7 v2.x is used in a number of sites for interfacing between source systems. But, due to difficulties with HL7v2.x, it was identified that it cannot be used for integrating source systems with EHR. HL7 v3 can be used as a strategic messaging standard for interfacing source systems with EHR and it is gaining greater support from suppliers worldwide (as seen from NPfIT of England). Some stability and standardisation issues have arisen with the use of HL7 v3, but it is recommended to consider it as a mechanism for interfacing source systems with EHR. The use of HL7 v3 to interface source systems with EHR need not preclude the use of other messaging standards in interfacing of EHR if a national messaging standard (e.g. HL7 CDA) is already in place.

Data Dictionaries

Many organisations use different data dictionaries which are more oriented towards base data types and administrative information and does not meet the needs for clinical data standards, message sets, or existing national dataset definitions. Many sites have created their own standards. Implementations of national datasets are important for creating a mechanism that will help to deliver the national plan of an EHR.

There are a variety of dictionaries existing today, mainly standard drug dictionaries used across different care settings in addition to locally defined formularies. We need to improve methods of representing medications within EHR to cope with this variance. A common representation for medications should be one of the important goals of implementation of an EHR.

Clinical Coding

The regulatory agency as part of EHR compliance should ensure that initial EHR information requirements are grounded in what is possible with current coding schemes. Currently different clinical settings have widespread usage of local codes and different existing coding mechanisms such as OPCS-4, ICD etc. The use of different coding mechanisms make it difficult to perform grouping operations on clinical events and show a summary of the health record of the patient, which is the main goal of EHR.

Standards such as SNOMED, are too ambitious in their scope and actually difficult to implement and map to the realities of the domain. Standard terminology and nomenclature, standard message sets, sets of valid values, reference masters, and standard ways of expressing schemas or a subset of it need to be defined by the involved regulatory for use by multiple providers in multiple heterogeneous systems to bring uniformity in recording and presenting data.

Although, there are no easy readymade solutions to overcome this variance in coding mechanism, we should have accreditation standards that progressively "raise the bar" on what suppliers must achieve, year-by-year. As it might be counter-productive to insist on a mandatory support of an existing standard such as SNOMED CT, consideration must be given to have a phased implementation of standard coding mechanism for only procedures and diagnosis in initial stages.

Summary

EHR plays a huge role in providing a single longitudinal view of patient record. Sound architectural principles and usage of uniform standards through regulatory agencies will ensure successful deployment of EHR.

Acknowledgements

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