Medical Informatics

Final Paper

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EPRs For The Digital Hospital

Problem Statement

Health Information systems have nationalities [1]. All the HIS in the world have a common goal: to support healthcare professionals in improving overall efficiency, cost-effectiveness and ultimately the quality of patient care. However, they differ widely in the implementation. The growing trend towards shared care requires that these systems be able to share their data. The objective of this project is to propose a generic system that will provide integrated access to all the information and knowledge necessary to treat patients.

The technologies which will be integrated include the Electronic Patient Record (EPR), simulation tools, case-based reasoning, Decision Support Systems (DSS) and generic patient management software. These technologies have been applied, but in a fragmented manner, reducing their effectiveness. Central to these technologies is the EPR. Traditional EPRs exist in a variety of heterogeneous information systems and have been used as archives. In contrast, this EPR will be a multimedia report eventually incorporating genomic data, which will then be integrated with the DSS, triggering alarms when necessary. The EPR will serve different people like medical staff, researchers and insurers, each of which have different data requirements. This project will address these and other issues like security, privacy and confidentiality. [6]

Features

The universal features that EPRs should have are lifelong records for every person, online access to patient records for practitioners and genuinely seamless care resulting from the above two features.

- Integrates information from many sources; from blood pressure monitors to complex imaging systems
- Provides a single access point for relevant, concise, accurate and active data about a patient to authorized users in different locations. These records may be available for:
    1. Patient care
    2. Administration
    3. Clinical Audit
    4. Financial Audit
    5. Research
    6. Education
- The UI features are easily configurable to meet the varying demands of each medical practitioner.

Evaluation

Six steps are used to plan evaluation: Agree why an evaluation is needed, agree when to evaluate, agree what to evaluate, agree how to evaluate, analyze and report, assess recommendations and decide on actions. [3][16]

We outline an evaluation framework that addresses structure, processes and outcomes, along five dimensions (strategy, operational, human, financial and technical). For each dimension some example evaluation questions can be given. Data can be collected by using questionnaires, focus groups and tool-kits like the balanced score card. [17]

The primary importance should be low delay. The practitioner should not waste time between two successive operations on the terminal. The system should be intuitive enough for the users. The screen layout should be simple, important data should be highlighted. We should be able to test how secure the data of the patients is.

We test the time required for the databases to spit out the relevant information under heavy load. The DSS systems should be evaluated by highly experienced users. Users should be trained that the DSS is present for suggesting options, not as an 'auto-pilot'. We should check whether multimedia is consistent over the multiple platforms that will no doubt exist. Audits should be done to see if the system has enough information to ensure traceability.

We try and to answer the following questions while evaluating our system:

- Will the evaluation provide a comprehensive and objective assessment of the achievement of goals? Will it form the basis for continued improvement in the application and use of information?
- Will the evaluation be realistic?
- Will the findings of the evaluation be accurate? Will it convey technically adequate information about the features that determine the worth or merit of the system being evaluated?

Design

Traditional approaches to HIS are ad-hoc, domain specific and are generally not scaleable or customizable. We can address these limitations by linking the EPR directly to the computer simulation with the end goal of delivering support to clinicians on their desktops. Also case-based reasoning systems and guidelines for clinical practices that have been developed independently can be incorporated. Figure 1 shows an overview of the Information Architecture of the system.

Decision-support tools are not integrated with patient-specific information. In the design of the system, there are three fundamental challenges to be met:

- To develop a generic approach to integrate the various components to provide decision support, using the existing health information systems, imaging systems, case bases, clinical guidelines and protocols, and modeling and simulation tools
- To do this in a manner that enables a clinician to dynamically adapt and customize it
- To provide feedback mechanisms to optimize the modeling and simulation, to update the case bases, to improve the evidence base, and refine the clinical guidelines based on actual clinical outcomes

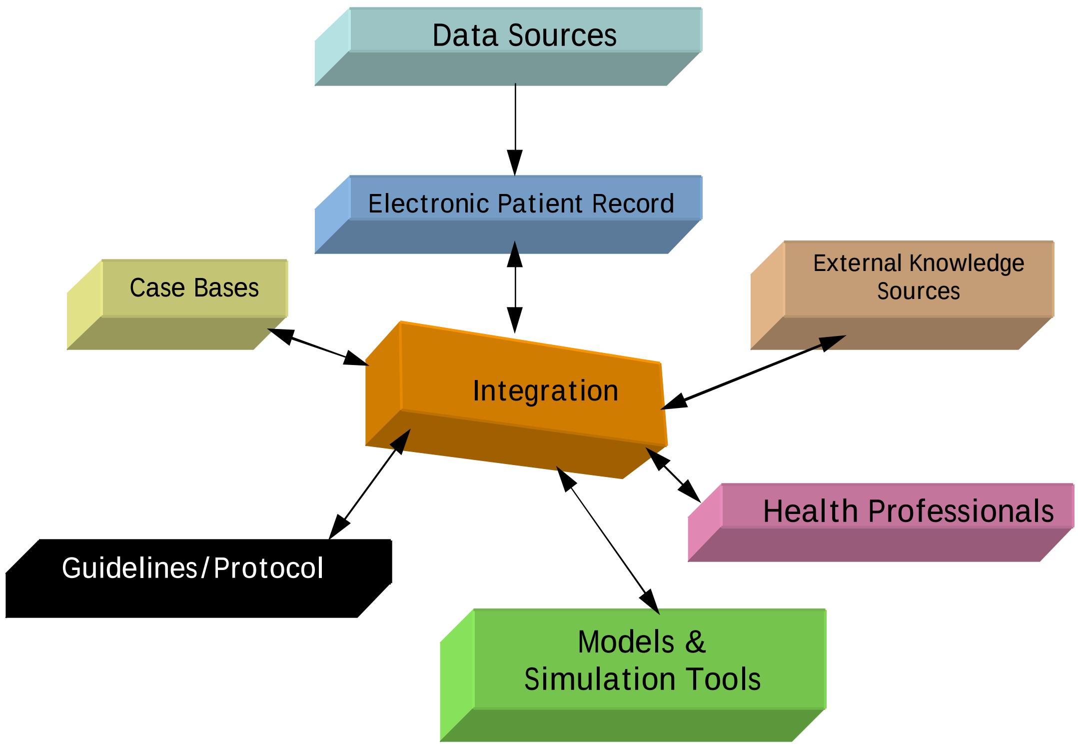

Figure 1 – System Architecture

Surprisingly, the most important design considerations are the human factors [6]. However, the front-end is not of interest in this project. We seek to make sure that the parts fit into the jigsaw puzzle properly. There are various implementations of the UI and they can be developed further by getting the staff of the institute into the feedback cycle. The best designed system will always be a work in progress as it has to be continuously updated to provide the best service.

Experts working in the various medical sub-domains can chose the appropriate methods by which their knowledge can be expressed. Therefore the concept of EPR is vitally important. The patient records have to be populated before we apply methods to develop knowledge.

The problem with the EPR is that it is not homogenous [18]. It is taken from a multitude of sources. The data which feeds or populates the EPR already resides in a variety of highly heterogeneous and autonomous information systems and simply integrating this data does not necessarily result in a valid EPR. Clinical data may be entered using a multiplicity of methods such as keyboard, voice recognition software, touch screens, scanners or from medical instrumentation such as blood pressure monitors, ECG machines, laboratory analyzers or imaging devices. We will have to develop a middle-ware client-server component-based approach, acting as an intermediary.

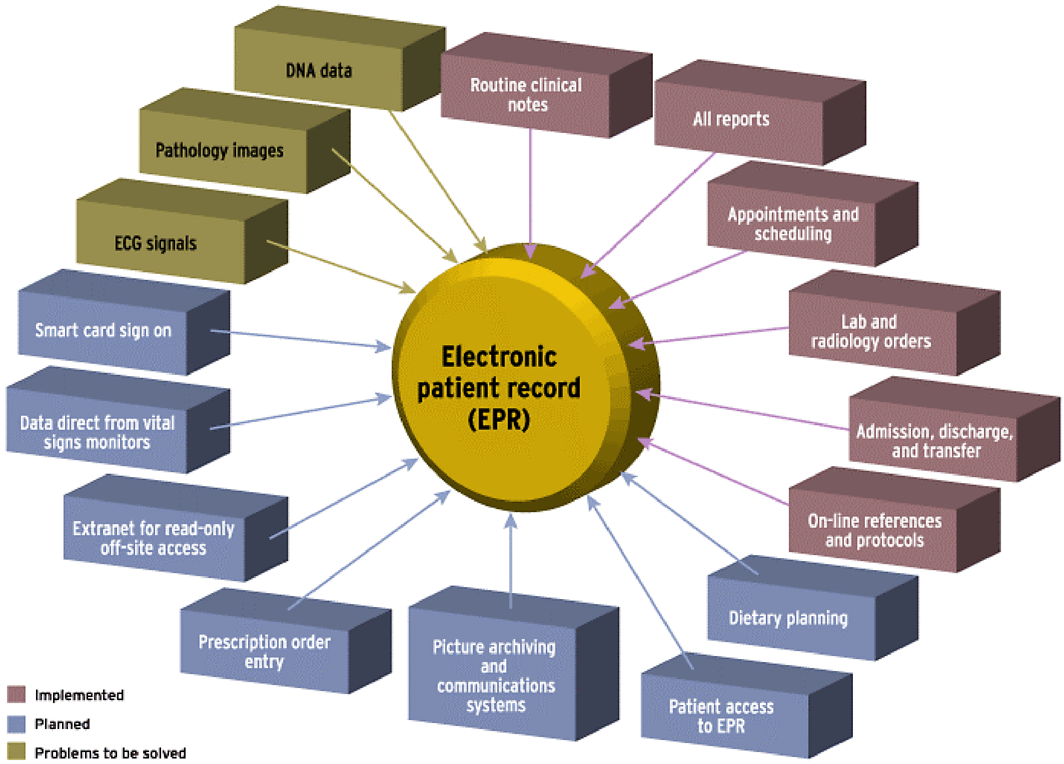

Figure 2 – EPR with functions that have been incorporated and those that have not in the current crop of HIS. [6]

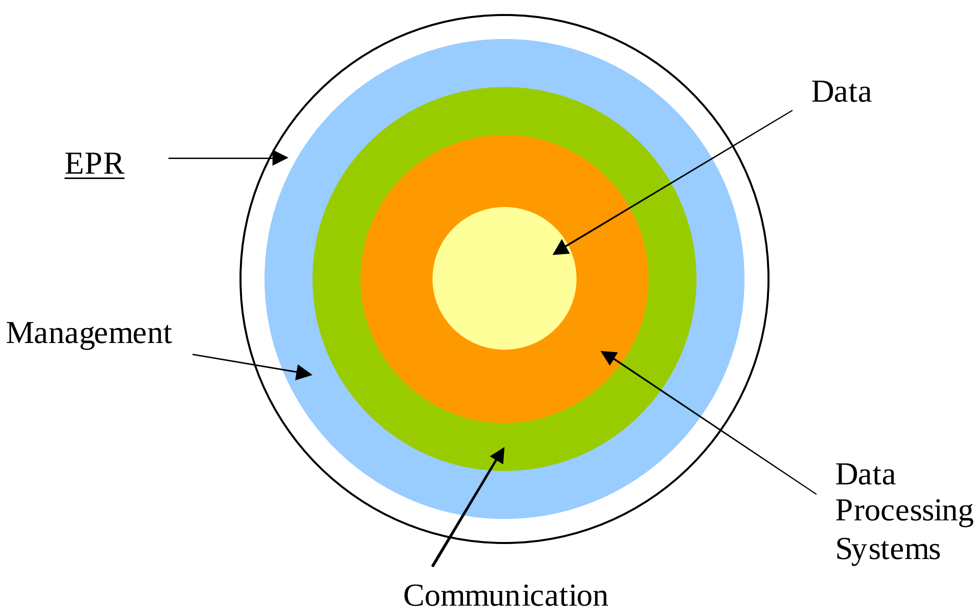

Figure 3 – Another view of an EPR

From the variety of knowledge-based approaches to decision support, case-based reasoning is the most promising approaches for complex data rich domains such as health. CBR involves matching the current problem against ones that have already been encountered in the past and applying the solutions of the past problems in the current context. This basic philosophy has been applied in two quite different ways. The obvious strategy is to accumulate cases as they occur and add them to the case-base - in this way the case-base comprises a history and competence increases over time.

The alternative strategy is to manually build a case-base of hand-crafted cases that will provide good problem coverage. This second approach is the more popular because it is easier to implement. However, it loses the potential of CBR to accumulate experience and improve over time.

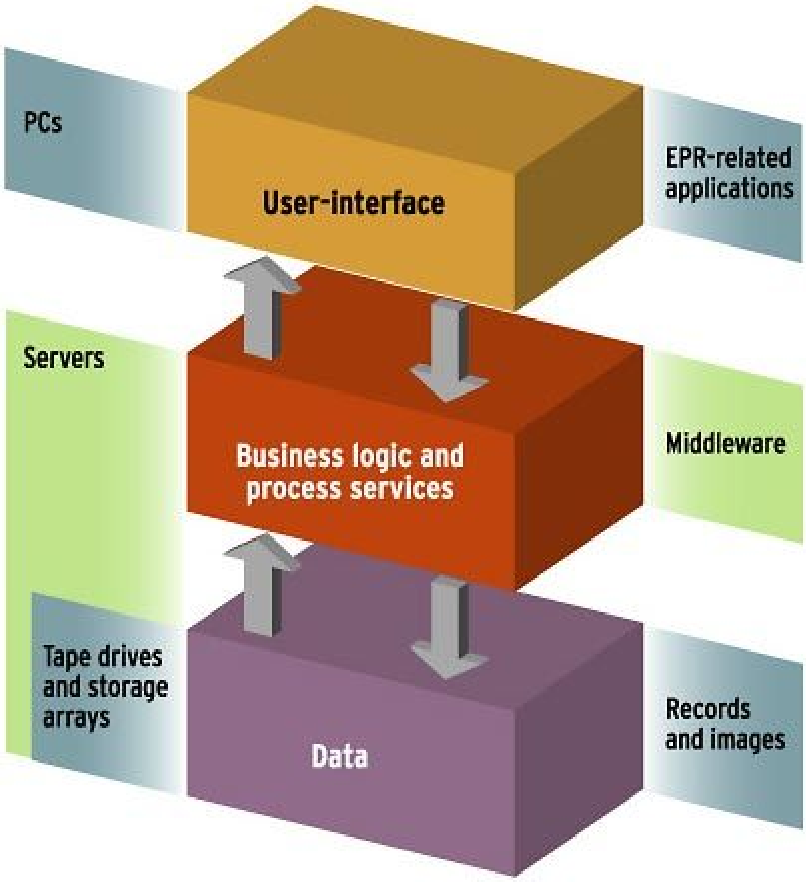

Figure 4 – Application Architecture [6]

Implementation

The computing system has to be so designed that it retrieves all the information related to a patient, whatever be its source of origin, and make it all available at the point of care. It can also be mirrored so that it is available online to any practitioner in the world. The EPR is stored in record form and is a multimedia report which includes digitized images, video and eventually genomic data.

This will be integrated with a DSS and methods for setting alarm will be present. To setup the infrastructure, we can use the 3 tier architecture shown in Figure 4. Data is at the bottom, a flexible UI at the top (allowing customization) and the services in the middle-ware. The data and files can be distributed on either Unix or Windows servers. The essential quality is that they should be distributed. Very little software, other than the UI software, should be present on the client terminal. Thin clients can be used to access the servers.

The middle-ware glues the applications together. It includes various distributed components for security of data. The middle-ware will use a web-interface. The connection between servers can be maintained over an ATM network. Local terminals can be networked by LANs or WLANs.

Accountability is a major concern. Anybody with the right username and password can get through. This falls into the domain of Information Security. [10] suggests an accountability model which can be realized using secure hardware.

Consideration of Standards

Developing an integrated EPR implies dealing with a lot of standards. These include communication standards, data-exchange standards, vocabulary standards, and security standards. HL7 (health language 7), is a data-exchange standard for sharing information within and between healthcare institutions [7].

The data elements themselves have to be standardized. Regenstrief Institute in Indianapolis, Ind., has created LOINC [8] (Logical Observations Identifiers Names and Codes), a database that provides a set of universal names and codes for identifying laboratory tests. A complementary standard called SNOMED (Systematized Nomenclature of Human and Veterinary Medicine) provides codes for the results of those tests. In the middle-ware, CORBA (Common Object Request Broker Architecture) can be used.

Critique

The most important question to be answered is, “Whose record is it?” The United States has limited privacy legislation and this leads us to a grey area. There is always a tradeoff between security and sharing. Also, such a system *may* not be very successful if we put it into different contexts. For example, some hospitals follow a holistic method of treatment whereas others follow the interventionist method. The healthcare philosophy also differs from institution to another. If we decide to use a similar system in the US and Canada, once again, it *may* not be as successful as envisioned. Therefore, this system has to be aware of cultural specificity and subtle differences that may have significant effects.

More questions arise. Should nursing information be included in EPRs [2]? Should nurses be allowed into the DSS cycle? It can be argued that this sort of a system has too many points of failure. Capturing, storing and making readily available huge amounts of clinical data is difficult and costly. Organizations are generally suspicious of change. Limited understanding, politics and concerns about privacy are definite hurdles. To develop and maintain such a system would indeed require tremendous amount of effort, but is by no means impossible.

References

[1] **Do Information Systems have Nationalities? “De-scribing” electronic patient record systems**
Matthew Jones
University of Cambridge, Judge Institute of Management. Oslo 2002
<http://www.jims.cam.ac.uk/research/seminar/slides/oslo2002_jones.pdf>

[2] **Nursing Information in Electronic Patient Records: Criteria established in a Delphi study.**
Goossen, Epping, Dassen
<http://www.nur.utexas.edu/0305/jkang/JKweb/Nurse/SYSTEM.pdf>

[3] **PROBE: Project Review and Objective Evaluation for Electronic Patient and Health Record Projects**
Prepared by the UK Institute of Health Informatics for the NHS Information Authority, March 2001. Document reference no. 2001-IA-611
<http://www.nhsia.nhs.uk/erdip/pages/publications/probe_020701.pdf>

[4] **Glossary of terms**
Health Level 7
<http://www.hl7.org/ehr/documents/public/documents/Glossary of terms.pdf>

[5] **HER: The collaborative development of a standard**
Fred Stark
HL7 EHR SIG, Sept. 2003.
<http://www.hl7.org/ehr/documents/public/presentations/Basic Definitions 0_4.ppt>

[6] **Welcome To The (Almost) Digital Hospital**
Giselle Weiss, Contributing Editor
IEEE Spectrum Online
<http://www.spectrum.ieee.org/spectrum/mar02/features/digh.html>

[7] **HL7**
<http://www.hl7.org/EHR/>

[8] **LOINC**
<http://www.loinc.org/>

[9] **SNOMED**
<http://www.snomed.com/>

[10] **Towards Accountability for Electronic Patient Records** p. 189.
16th IEEE Symposium on Computer-Based Medical Systems (CBMS'03)

Ana Ferreira, Simon Shiu, Adrian Baldwin , HP Labs Bristol
June 26 - 27, 2003, New York

[11] **Handbook of Medical Informatics**
J.H. van Bemmel, Erasmus University, Rotterdam
M.A. Musen, Stanford University, Stanford
<http://www.mihandbook.stanford.edu/handbook/home.htm>

[12] **Data Standards in Health Care**
Clement J. McDonald, Gunther Schadow, Jeff Suico and J. Marc Overhage
Annals of Emergency Medicine, September 2001, Vol. 38, pp. 303310.

[13] **The Computerbased Patient Record:An Essential Technology for Health Care**
Richard S. Dick, Elaine B. Steen, and Don E. Detmer
Institute of Medicine (National Academy Press, Washington, D.C., 1997)
<http://www.nap.edu/catalog/5306.html>

[14] **Doctors' Use of Electronic Medical Records Systems in Hospitals: Cross Sectional Survey**
Hallvard Lærum et. al.
British Journal of Medicine, 2001, No. 323, pp. 13441348
<http://bmj.com/cgi/content/full/323/7325/1344>

[15] **Managing your Clinical Information**
Session 8: The Electronic Patient / Healthcare Record
Robin Beaumont
< http://www.robinbt2.free-online.co.uk/virtualclassroom/chap5/s8/epr1.htm>

[16] **Evaluating information technology in health care: barriers and challenges.**
Heathfield HA, Pitty D, Hanka R.
BMJ 1998; 316: 1959-1961

[17] **Explosive growth in CPRs: evaluation criteria needed.**
Dick R, Andrew W.
Healthcare Informatics 1995; 12: 110
PMID: 10140917

[18] **Department of Clinical Health Informatics**
CS Department, Trinity College Dublin
<http://www.cs.tcd.ie/CHI/>