# "HIS-Treck -- The Next Generation": An Introduction to Future Hospital Information Systems

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## Abstract

*The shift by health care organizations to integrated care with an outpatient emphasis requires the development of a new generation of multifaceted electronic medical record systems to coordinate these services. This paper introduces the context of present day health care computing to set the stage for Dr. Essin's paper on our proposed paradigm shift from record processing to document processing, using mark up language technologies. We believe that such document oriented systems can be designed to be both distributed and secure with respect to patient and institutional confidentiality.*

## 1: Introduction

In order to understand health care computer systems and why a paradigm shift in the underlying systems architecture is necessary for their continuing evolution [1], one must first look back at the changes in health care itself since 1950, at the succession of systems that have been brought to bear on the healthcare environment after 1970, and what they have been unable to accomplish.

### 1.1: The evolution of health facilities

We can identify three recent stages in hospital institutions, here presented in a light parody:

#### 1.1.1: 1950 -- Dear old St. Everywheres...

Surgical Suites, Labor and Delivery Rooms
Semi-Private Accommodations
Room rates: $25.00 per day
Long stays...

Most of us recognize this environment. We were born in such hospitals, and some of us trained there. At that time or before, there was little need for information systems, because the clinical chart served well to coordinate and document the focused tasks at hand. Apart from anatomical pathology, and a simple X-ray department there were few support services to coordinate. The modest amount of clinical laboratory work was often done by the physicians themselves. Physicians' offices were dispersed around the town, but their records and those of the hospital were not related.

#### 1.1.2: 1970 -- The BIG BLUE Medical Center

With additional Services such as:
Emergency Room, Radiation Therapy,
Hemodialysis Unit, Surgical Intensive Care Unit (ICU),
Medical ICU, Neonatal ICU
... and an adjacent Doctor's Office Building

These additional diagnostic and therapeutic services had already begun to include expensive and sophisticated technologies, so that doctor's offices had begun to cluster around the hospital in order to share them conveniently. Some were already information intensive, such as the ICU's, with an increasing amount of electronic monitoring. Most reimbursement was by third party insurance payors, and the largest was destined to become Medicare. Complicated bills had to be submitted and justified and clinically, data had begun to pile up. Early information systems in the hospital concentrated on posting of bills for every small item used, down to cotton balls, sometimes taking these data from electronic orders entered on the clinical floors. Clinical laboratories introduced systems for their own internal data management, intensive care environments had begun to use monitoring systems; and outpatient clinics developed scheduling systems.

#### 1.1.3: 1990 -- HUMONGOUS Health Center Inc.

(A Division of OmniCare Ltd.):
With outreach facilities on campus including:
Surgicenter Inc.; CAT scans + MRIs
Women's Wellness Center; Cardiac Center;
Drug Rehab Center; etc.

The hospital system, now a cog in an industrial complex, began testing the hypotheses that merger and competition would hold prices down. (They didn't.) In the process, these new entities extended their reach to whole campuses of facilities. For hospital information systems, navigating patients through these numerous services, and matching patients to physicians, became major issues, with new information requirements to be both integrative and decentralized. However, in attempting to extend old systems to new uses, these requirements were seldom met.

### 1.1.4: J AN 17 1994 -- Northridge EARTHQUAKE

Representative and symbolic of the "tectonic shifts" in health care today:

At ST. JOHN'S, Santa Monica:
All 501 beds were closed due to damage
1,500 personnel were laid off...
The Sister Administrator announced:
"We will reopen in the fall at 150 beds maximum"

SEPULVEDA VA (Veterans Administration) Hospital
All beds are to remain closed
It will reopen as an outpatient facility...
Using Wadsworth VA in Westwood for inpatients.

### 1.2: The lesson learned

The fundamental lesson cannot be ignored. The earth has shifted... and there is *no going back*.... and so too with the medical paradigm -- which has moved from inpatient to outpatient care. The information systems and their support structures must also shift to meet the increased importance of this new distributed outpatient service environment. Moreover, these systems must bring the clinical charts on line, and do so while retaining the necessary privacy and confidentiality of these records in much more difficult circumstances. At the same time, this shift of emphasis outside the hospital must not leave the hospital behind. In fact, the new system design must serve all stakeholders: physicians, nurses, administrators; and analysts, and must fit the work priorities of all clinical venues: office, outpatient centers, nursing floors, and ICUs. One need hardly reiterate that today's hospital information systems are too parochial to meet this challenge. While the best of today's systems may address the problems of one set of stakeholders well, all leave issues important to others either unanswered, or only awkwardly addressed. There are reasons why this is so.

## 2: The clinical stakeholders

The different stakeholders have quite different interests and work requirements. If we concentrate on the clinical practice of medicine, there are three quite different venues: 1) the in-hospital critical care environment; 2) the in hospital nursing service; and 3) the outpatient service. These differ as to who is in charge, what the dominant task is, where the focus of attention lies, and what information formats and processes are most useful.

### 2.1: In hospital critical care

In surgery or in intensive care, the physician (or on occasion the intensive care nurse) is in charge. The dominant task is hands on intervention, with the focus of attention on the present physiological status of the patient. The information requirements are rather similar to those of a pilot in a cockpit, and require an easy recognition of trends. Thus spreadsheets, graphs, images, and diagrams dominate as data formats.

### 2.2: The hospital nursing service

On the inpatient floors, the nurses are in charge. The physicians write the orders, but the nursing service sees that these orders are carried out. The nurses extend these direct activities with their own care plans. The focus of attention is on continuity of care, and the balancing and brokering of service priorities among the patients in the hospital. The primary information formats are order sheets, checklists, and schedules; while nursing unit status and census may be presented on convenient spreadsheets.

### 2.3: Outpatient services

In the ever increasing outpatient world, the patients are in charge! The visits to their physician are folded into their own lives, and they take or ignore advice at their option. Thus the dominant task of the physician is a rapid assessment of patient status for illness, and health related context, with a particular emphasis on past compliance. Significantly, although the doctor writes orders, as in the hospital, the loops remain open. For outpatients these only have the force of requests, for which the patient must take the responsibility. Information is formalized on encounter forms, check lists, directories, and prescription pads.

### 2.4: The resultant territoriality

These differences may appear obvious when described, but, given present architectures, they have proven very hard to bring together in a balanced, information system package. As a consequence, when overarching computer systems to manage the hospital and health center are proposed, they almost always engender bitter, territorial infighting -- on the rational, if parochial, grounds that each set of stakeholders seeks the best system for themselves.

## 3: The patient chart

In order to understand and review this situation, we have returned to the basic information source for clinical medicine: the patient chart. A great deal has been said in computer circles about the chart, largely in the negative. However, it is equally important to understand what the chart does right, and why.

### 3.1: Positive features

On the positive side, we observe that: 1) A chart is a collection of diverse documents, designed for admission, discharge, lab results, images, doctor's orders, description of the patient's history and physical exam, etc. 2) Each of these documents is loosely structured; each following its own general outline, but with contents that differ radically in detail from patient to patient. 3) This forgiving format has long proved very effective; indeed, one reason the chart is so hard to find is because it is so much in demand. 4) The paper chart is handy because it is portable, permanent, and relatively easy to navigate by paging through it. 5) The diversity of information in the chart need not be sacrificed to the requirements of HIS data fields -- paper allows marginal notes, even on forms, and a whole essay may be included if need be. 6) Also of importance, the chart is reasonably secure because it is in only one place at a given time, either in the record room or under the eyes of the staff, and the usage is visible.

### 3.2: Negative features

The negatives are all too real: 1) The chart is difficult to find, because it is often needed by separate users in separate places at the same time. 2) It is fragmented -- most particularly the images (which are of ever increasing importance) are located in separate files with only interpretive reports in the chart. 3) It is insufficiently indexed, and, being on paper, allows only a single ordering which is not satisfactory for all purposes. 4) Because portions are hand written by physicians, it can be messy and difficult to read. 5) Being a loose leaf notebook to which much must be added, it is fragile. 6) Most importantly, it cannot support rapid, shared access or large-scale extraction and aggregation of data.

## 4: The new EMRS architecture

The problem is thus posed: How should we design an Electronic Medical Record so as to retain the advantages of paper while incorporating the new capabilities of computer automation? The answer is compelling: we should process documents, not data, because documents are the natural units of an EMRS. Moreover, there is now a powerful means to do so: SGML or the Standard Generalized Markup Language [2].

### 4.1: Document processing using SGML

In the new paradigm, the EMRS will consist of a patient oriented data base that is a collection of loosely structured documents, not a data base of structured records. The novelty here is to take a set of SGML conventions that have been applied to printing format and generalize their use to medical content. Such documents have much in common with formatted word processing documents (including embedded images or pointers to images), but are also tagged, following the conventions of SGML, with tags that represent medical content. In assembling or searching a record, patient documents will be navigated and processed by applications that can use these tags by first referencing an appropriate document definition table (DDT). We have prototyped an architecture which anticipates the processing of such documents, and which has many implications.

### 4.2: The MARC library catalog example

Our approach has antecedents in on-line library cataloging where entries may be organized using in the MARC (MAchine Readable Cataloging) conventions. Here the library card is a loosely structured document, and once again the purpose of the system is to retrieve material based on content and content categories such as author, title, subject, etc. MELVYL, the system designed by the University of California, is particularly flexible and forgiving in this regard.

**MARC coding**

```
100 10 Shapiro, Norman Zalmon, $d 1932-
 <LC,IG,LAG,BG>
245 10 Toward an ethics and etiquette for electronic mail
/ $c Norman Z. Shapiro, Robert H. Anderson.
 <LC,IG,LAG,BG>
260 0  Santa Monica, CA : $b Rand, $c 1985. <LC,IG,BG>
260 0  Santa Monica, CA : $b Rand, $c [1985]  <LAG>
300    vii, 35 p. ; $c 23 cm.  <LC,IG,LAG,BG>
440 0 Rand report ; $v R-3283.  <BG>
650 0  Electronic mail systems  <LC,IG,LAG,BG>
650 0  Ethics  <LC,IG,LAG,BG>
```

### 4.3: Other text processing examples

Other easily recognized examples of similar technologies include 1) RTF, the Rich Text Format for record interchange between PC Word 6.0 and Mac Word 5.1 and between WordPerfect™ and Word™, and 2) LEX and TROFF to print formatted text files on UNIX. A particular program, LECTOR, is a SGML markup for publishing dictionaries. One of the most convincing uses of this general approach is the html language used by MOSAIC, the database indexing and navigation tool now widely used on the Internet.

**RTF coding**

```
{\info{\title RTF EXAMPLE}{\subject MLA1994}
{\author Tom Lincoln}{\*\verscomm Slides} {\keywords
Tagging}}\margl1152\margr1152\margt1152\margb1152\ft
nbj\ftnstart0 \sectd \linemod0\cols1 \pard\plain \qc \f34
{\b\f21\fs48 OTHER FORMS OF\par AG PROCESSING
\par }\pard {\b\f21\fs32 \par RTF  (RECORD
INTERCHANGE FORMAT)\par } {\b\f23 \tab \'b7
}{\b\f21\fs32 Between PC Word 6.0 and Mac Word 5.1\par
```

These examples both illustrate clearly the large amount of tagging that must accompany the actual text when this approach is used. Until recently, this presented issues of data storage and memory that were previously too large for medical files.

### 4.4: Advantages of SGML

The advantages of the SGML approach include: 1) Loosely structured documents can be accommodated easily. 2) It is an ISO Standard. 3) It has already been adapted for hypermedia as in HyTime™[3]. 4) It simplifies the conventions needed to deal with heterogeneeous data bases [4]. and 5) Tagging conventions fit well with established means of denoting confidential data, extending rule based procedures for security into a domestic area with quite different requirements from the government [5].

## 5: The prototype system

In a practical case study as a prototype for a broader EMRS project, we have applied rudimentary SGML conventions to the history and physical examination records of the newborn nursery of the LAC+USC Medical Center. The ease of use of such a system is further augmented by the appearance of pen based portable devices which bring the convenience of a light pen to a broader set of gesture based applications on a more flexible platform.

The particulars of our approach will be presented by Dr. Essin in the accompanying paper "Healthcare Information Architecture: Elements of a New Paradigm."

References:


1. Lincoln, TL, Essin DJ, and Ware, WH: "The Electronic Medical Record: A Challenge for Computer Science to Develop Clinically and Socially Relevant Computer Systems to Coordinate Information for Patient Care and Analysis." The Information Society, Vol 9, (Spring 1993); 157-188.
2. Goldfarb CF The SGML Handbook, Oxford, Clarendon Press, 1990
3. Krishnamurthy R, Litwin W, Kent W "Language Features for Interoperability of Databases with Schematic Discrepancies," Proc. of ACM-SIGMOD Conf. SIGMOD Record, 20, 2, (June 1991); 40-49.
4. Newcomb S, Kipp N, and Newcomb V "The 'HyTime' Hypermedia/Time-based Document Structuring Language," Commun. ACM, 24, 11, (Nov. 1991); 67-83.
5. Lincoln, TL: "The Computer Based Medical Record: Issues of Organization, Security, and Confidentiality," in Data Base Security V, Status and Prospects, CE Landwehr and S Jajodia, eds. Amsterdam, North Holland, 1-19, 1992