SUMMARY TIME ORIENTED RECORD (STOR) -- A NODE IN A LOCAL AREA NETWORK

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Abstract

The STOR ambulatory record system remains committed to its original principles of prioritization of information, time orientation, and interphysician communication. It has been expanded to provide a sophisticated user help system, to provide extensive interactive access to its database to augment its hardcopy output, and to function in an interface to the UCSF distributed hospital information system. The complex and difficult application level issues of effectively using a distributed database accessed through a local area network are being dealt with. In a limited context, the major question of whether physicians would accept the change STOR imposes on the way they record and display clinical data has been answered.

Introduction

Descriptions of Summary Time Oriented Record (STOR) were reported in the Fourth and Fifth Annual Symposia on Computer applications in Medical Care. The purpose of this paper is to provide an update of the progress and experience with STOR.

Description of STOR

STOR has been designed as a potential replacement for the medical record in ambulatory care. It consists of hardcopy and online components. The STOR system is being interfaced to the fiberoptic local area network which has been implemented at UCSF. This gives the STOR users access to the critically important patient identification data, as well as a radiology reporting and management system, the clinical laboratory computer, pharmacy computer, pathology reporting system, and medical record management system, with others to become available soon. STOR has been operating in the Rheumatic Diseases Clinic and the Arthritis Clinics at UCSF since November 1979. There are 1107 patients in the database. It is presently implemented on a Data General S/250 and is written in the MIIS programming language (a variant of MUMPS).

The two hardcopy components have been described previously (1,2). They are generated immediately prior to a scheduled patient visit to an outpatient clinic. Part A is a one page document that contains patient and clinic specific information displayed in a flowsheet format. Data columns contain data of visits to the current clinic or summaries of data occurring between clinic visits or at other clinics. Other columns include those for problem or therapy descriptors, units of observation, date of onset, and route of drug administration. The left most data column is always blank and represents the current visit. It is in this area that the physician updates observations regarding the various data rows. The rows consist of three types of information: problems and their manifestations, therapies, and laboratory tests. The specific items in the rows are under the control of the physician in each clinic. Problem and therapy names are entered initially as free text by the physician or, optionally, as coded problem or therapy lists. Manifestations can be nested under the problem or diagnosis to which they pertain. The laboratory test results which the physician expects to follow serially are also displayed on Part A at the physician’s option. Physician updates are entered into the STOR computer interactively by trained data entry personnel.

Contained on Part B of the hardcopy display are problems and therapies deemed inactive or of less importance by the physician and stipulated to appear on Part B. Part B also contains free text summaries from each clinic visit, and shortly will contain impression section of radiology reports, pathology reports, and other reports from other clinical systems.

There are three major types of online display available through the STOR software that permit physicians to access data on demand that is not displayed in the hardcopy Parts A and B. SHOW displays a wide variety of patient specific information usually in a reverse chronological format unless otherwise requested. Thus, clinical physicians can request a summary of a patient’s problem or therapy list, recent activity in other clinics,
radiology reports, pathology reports, and/or clinical laboratory data. The FLOW program allows providers to stipulate up to six items to be flowsheeted indefinitely in reverse chronological order. The items may be any combination of problems/manifestations, therapies, or laboratory tests in the patient's database. For example, if a patient had hypertension and renal insufficiency, one might choose to create a flowsheet whose columns consisted of blood pressure measurements, hypertensive medication doses, and serum creatinine values. The GRAPH program allows providers to stipulate up to three items whose numerical data values will be represented as bar graphs displayed along side of one another for comparison. This requires that the free text therapy doses be converted to a normal form (amount per day). The machine is able to do this making errors of omission in 1% of therapy doses and errors of commission in 0.1% of therapy doses. The function of the SHOW, FLOW, and GRAPH displays is to allow providers to customize requests of the database and to access data further back in time than the Part A and B display permits. A great deal of effort has been expended in making these programs easy for untrained physicians to use. Every prompt in the STOR system is supplied with user help which is pyramided and interactive. The system makes extensive use of default options so that typing the simplest command will request the most commonly needed data. For example, the command "SHOW LAB" results in a display of all the patient's laboratory data in reverse chronological order.

For patients not previously in the STOR system the SHOW and FLOW programs function to access other databases on the fiberoptic network, and thereby, act as a general purpose conduit for information available in other computers on the network.

Conceptual Basis

Prioritization of data.

STOR is a summary. This is the case because of our conviction that the presence of more data often means less, rather than more, information. Summarization implies two processes: data prioritization and data reduction. It is accomplished by the de-emphasis of older data through the structure of the STOR displays and by physician effort on input that is motivated by the one page limitation on the Part A display and the limited text allowed in the free text portions of STOR.

Time orientation.

The flowsheet type of format makes accessible several types of information virtually inaccessible in the traditional medical record format. Thus, information relating changes in various problems, therapies, and laboratory results to each other and to changes over time is readily appreciated. This becomes increasingly important as ambulatory care concentrates more and more effort on the care of patients with multiple, chronic and often interrelated problems.

Inter-clinic and inter-physician communication.

Although most of the STOR output is clinic specific and physicians can tailor their own problem and therapy lists, there remains a core of common information that is displayed by default: the master problem and therapy lists and recent free text originating in other locations. The STOR design reflects the current trend toward multiple care providers for a single patient.

Major Issues in the STOR Implementation

The Distributed Database Problem.

As is apparent from the preceding description, STOR is intended to functionally integrate clinical data residing on several distinct distributed heterogeneous processors. A description of the UCSF network and its underlying concepts have been published elsewhere(3,4,5). We have implemented or are now in the process of designing and implementing the application level network interfaces from STOR to the following distributed applications, and others are expected in the near future.

- A radiology reporting system operating on a Data General S/250 (not the STOR computer) and running the M1S operating system.
- A pathology reporting system operating on the same computer as the radiology system.
- A clinical laboratory system operating on a Modcom Classic and running a proprietary operating system with applications written in Fortran.
- A patient identification and registration system operating on a Data General S/230 and running the Data General AOS operating system with applications written in Fortran.
- A centralized transcription system operating on the STOR computer, giving access to discharge summaries, operative notes, and clinic letters.

The issues associated with this kind of effort are complex and as yet not resolved in general. The local area network handles the problem of establishing and guaranteeing the integrity of communications, but leaves untouched several questions of application and data level integration. First, if the STOR software is to access data in any of N applications, then N programs must be written in STOR and at least one in each of the applications to be accessed must also be written. This is an onerous process. In STOR, we have attempted to minimize this problem by modularizing and standardizing queries to and responses from the various distributed databases. This is made possible by taking advantage of the fact that at least so far as the STOR interfaces are concerned the data
structures can be viewed as being keyed by a relatively uniform set of data elements: patient number, service location, a data procedure code, date and time. Thus, the application level integration within the distributed hospital information system has been greatly simplified by the inherent structure in patient related clinical data.

A related set of difficulties are presented by the dual problems of distributed database synchronization, and network based access versus redundant local storage. At the extremes, there are two choices if one is to be able to use the data of the distributed database. One could store locally (that is in STOR) none of the data captured in the other clinical computers, and access it as needed through the network. This approach has the disabling disadvantages of putting a large data volume load on the network, and at the same time, a severe processing load on the distributed host computers responding to the multiple requests. There is an important risk of data unavailability because one of the computers or the network might be inoperative at the time the data are needed. In addition, the level of sophistication and complexity of the data processing and retrieval would be markedly limited by the round trip query/response time through the network and two host computers (currently 5 to 20 seconds).

The advantage of this approach is that there is no problem of synchronization of redundantly stored data. The converse extreme approach is to store all clinical patient data redundantly in the STOR computer by automatically sending it to STOR via the network as it becomes available in the distributed applications. This presents serious problems in maintaining synchronization of the redundant data bases, and it requires STOR to store large amounts of data which may never be accessed. Both extremes imply a level of intrusion into the software of the distributed nodes on the network that would essentially destroy the concept of independent modular sub-systems as an approach to a hospital information system (S).

In STOR we are taking an intermediate approach. STOR maintains in its local database a subset of the patients' total data. The exact subset is determined by a system of data prioritization similar to that used in formatting the Parts A and B output. When a user inquires about a patient resident in the STOR data base, or when Parts A and B are about to be formatted, the STOR software generates the queries to the network necessary to bring the database up to date for that patient. Thus, STOR only requests information that has been created or changed since the last update of the STOR database. This compromise dramatically reduces the network loading and database synchronization problems inherent in the extreme approaches, but it still has the disadvantage of requiring STOR to redundantly store a substantial amount of patient data.

In addition, this approach implies that each responding computer must be able to access data according to the time it was created or modified in its database, not according to its time of acquisition from the patient (e.g. time of blood drawing in the case of clinical laboratory, or time a radiograph was taken in the case of radiology data). This is a fundamental distinction from the route of access needed for data which intended for display only.

If the query regards a patient who is not resident in the STOR system, then a "display only" query is generated to the appropriate distributed module in the network. For example, suppose radiologists' x-ray reports are needed. Then a "display only" query is sent to the radiology computer which responds by sending data formatted for direct display in reverse chronological order according to the dates the radiographs were actually taken. In this case the STOR data base is not updated. In the radiology reporting system computer, it has been necessary to modify the database structure slightly in order to accommodate efficient access to radiograph reports by either method. On the other hand in the clinical laboratory system, the data are organized by time of data completion in the data base, and it is necessary to reorganize the data when it is being accessed for display only.

The Physician Acceptance Problem.

There is little doubt that the success limiting factor for ambulatory record systems is often physician acceptance. Although it is a problem even for automated systems which largely attempt to reduplicate the informational structure of the traditional paper record, physician acceptance becomes the overriding consideration when the system attempts to restructure the way clinical data are captured, processed and displayed, as is the case with STOR. Yet it is readily apparent from the preceding discussion that many of the unique capabilities and potential of STOR are critically dependent on the structure of the captured data, and therefore, on the willingness of physicians to restructure to some extent the way they record patient information.

A formal survey of provider attitudes of STOR users has been completed in the Rheumatic Diseases and Arthritis Clinics. They include a nurse practitioner, 7 rheumatology fellows, 4 UCSF staff physicians, and 3 consulting physicians. The survey was done in two parts. The first was a questionnaire that was filled out by the physicians anonymously. The second was a detailed structured interview of each clinic provider. Physician’s reaction to the system is quite positive despite STOR’s imposition of a substantial degree of structure on data capture and display. Ten (67%) physicians said they always used STOR while none stated they never did. Fourteen physicians (93%) stated they would prefer to use STOR with option for the paper chart on special request as opposed to one physician who stated he would prefer to receive the paper chart. Fourteen (93%) providers said they would recommend STOR to another physician, and thirteen (87%) said they would use a computerized record system in their private
practice if given the opportunity. Somewhat surprisingly, the physicians found the Part A flowsheet (especially the laboratory section) more useful by a ratio of 14 to 1 than Part B, which contains the 320 character free text visit summaries. (It should be noted that the display of radiology and pathology reports was not implemented during the period of time to which this survey pertains. Similarly, only the physician's own clinic notes would have appeared since just two clinics were using the system at the time.) Physicians found STOR less time consuming, but felt it was more likely to contain critical errors. It is clear that there was substantial user learning time since there were only seven providers whose initial overall reaction was positive with 8 negative, whereas later (after at least 6 months of use) 14 had overall positive reactions with only 1 negative. Situations in which the providers preferred STOR to the medical chart were when seeing a familiar patient or a relatively simple unfamiliar patient, when consulting by telephone, and when checking laboratory results. Situations in which the medical chart was preferred were when seeing a complex and unfamiliar patient, preparing a conference presentation, and dictating a letter to an outside physician. For the STOR summary to contain this type of detailed information would require an unusually assiduous physician in maintaining the historical portions of the summary.

Whether these results are generalizable to clinics with an informational model different from that of the Rheumatic Diseases and Arthritis clinics, or to other summary automated records requires confirmation. Nonetheless, it is evident that the imposition of substantial degrees of change in the way clinical data are captured and displayed does not in itself imply that the system will be rejected by its physician users.

REFERENCES


