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Toward Clinical End-user Computing: Programmable Order Protocols for Efficient Human Computer Interaction

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Abstract

We have developed and implemented an efficient method of managing routine patient care information as a programmable group order protocol. The purpose of protocol is to minimize a labor-intensive manual computer interaction by grouping clinically related routine orders as a single entity, thus to greatly speed up the time taken for manual entry such as keyboard stroke and/or mouse clicking. User programmability is added to facilitate insertion, deletion and update of order items to be a locally independent operation. A sequence of menu screen is also programmable when a change of standard operation is needed. Department specific order protocols are classified into four categories to improve user convenience. The degree of efficiency is measured by a number of key strokes and entry time. In most cases the time to enter order protocol with correction is found to take less than one minute with less than five key strokes. The method of order protocol entry clearly demonstrates end-user computing capability so that department specific requirements are resolved without resorting to computer department personnel. Flexibility of managing individual physician specific protocols is also beneficial enough to enhance the morale toward a hospital information system currently in use.

Keyword

End-User Computing; Human Computer Interaction; Order Entry; Graphic User Interface; HIS; HCI; EMR;

Introduction

Over the decades, information processing in a clinical environment has been of great interest because information system plays a key role in patient care and quality assurance [1,2]. However, data collection and interpretation of health data on patients are still left to a team of healthcare professionals regardless of sophisticated information system. These healthcare data include chief complaint, past history, family and social information, physical examination, laboratory, radiology studies and so on. Apart from other sources of clinical data such as nursing observation and therapeutic intervention, clinical information need to be gathered by physicians to be a relevant medical record. Due to rapid advances of computer technology, it is now common to see hospital information system (HIS) in many institutions. HIS allows paper based medical record to migrate toward electronic medical record (EMR). Although many problems remain unsolved, computerized EMR exhibits many promises for the healthcare professionals [3,4,5].

The objectives of all HIS are almost the same. The primary purpose of HIS is to integrate clinical support, patient administration, medical research and hospital management. In general, HIS is initiated by clinical data, or order entered by physicians. Data is entered into the computer and information is then extracted for further processing. Once patient information and clinical data is entered, then such information will be available on-line indefinitely unless archived on external storage devices. If order entry is not properly executed, no further information processing is possible. The timely and accurate transfer of patient information into the computer is found to be the most important yet laborious and time-consuming job in HIS management [6,7].

Convenient and efficient order entry into computer is also a significant problem in Korea. Due to poor healthcare policy and management a number of hospitals has to face with incessant flow of outpatients. This means that nearly all clinicians have to see as many patients as possible. It is so-called "3-hour wait and 3-minute treat" of clinical reality in Korea. In many cases information system is expected to improve healthcare productivity and overcome such overloading of a physician; however, clinicians are reluctant to work with computer because of inconvenient data entry. To alleviate such inconvenience, data entry specialist or group order entry method was introduced but has not been successful because both methods created another problems such as input error or inflexibility of group order structures.

Also because developers tend to overlook this problem of data entry, end-users do not really welcome HIS. It is obvious that a major resistance to a new information system is due to the task of order entry. Entering prescription data into the computer is often a formidable task for healthcare professionals. Order entry is inherently a manual processing which appears to be impractical. In reality a worst example was reported that a physician, poorly trained for computer system, struggled to enter a single patient data for two hours. We concluded that the problem is not because of poor system performance but because of poorly designed human computer interaction . It could be said that if a

convenient, efficient and flexible way is given to a user, then the user could be more comfortable to use and communicate with computer system. User flexibility can play an affirmative role in using HIS [8].

Materials and Method

Ajou University Medical Center (AUMC) installed a hospital information system, ATOM (Ajou TOtal Medical), which has been operational since 1994. ATOM implemented open distributed client-server technology in order to establish a sophisticated order communication system (OCS) for clinical environment [9].

The system hardware consists of 20 Unisys servers (4 U6000/65, 16 U6000/85), approximately 130 workstations (SUN SparcClassic), 480 PCs (250 386s, 60 486s, 170 Pentiums), and 280 printers. The network is configured with FDDI backbone managed by TCP/IP. The DBMS is M, previously known as MUMPS, migrated from Ingres v 6.4, running on UNIX SVR4 operating system. The implemented software applications include OCS for all clinical orders, ADT (Admission, Discharge, Transfer), patient administration, pathology, laboratory, pharmacy, radiology, dietetics, account receivables, billing, nursing package, and so on. A simplified ATOM is shown in the following diagram.

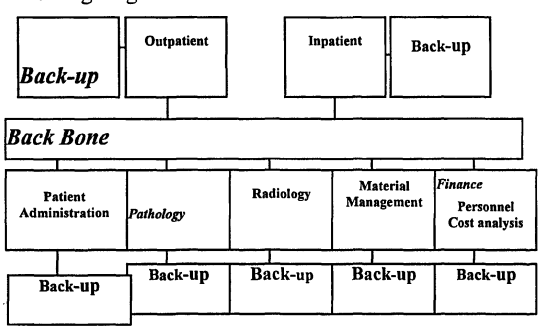

Figure 3 - System configuration

Programmable protocol management system (PPMS) is developed by standard M language and Visual Basic 4.0, supported by inpatient and outpatient servers with M DBMS.

Results

In order to resolve inefficient human computer interaction (HCI) we need to provide an efficient order entry method to support routine clinical computer processing for end-users. The initial intent of PPMS to ease the inflexibility usually present in conventional group order formation. In fact, there were frequent requests to insert/delete/update usually performed by the responsible personnel in the computer department, which usually takes time to accomplish. For example, many clinical end-users wish to have the privilege to modify the menu contents as well as screen format. Group order protocol only covers 60-80% of frequent clinical requirements and prescriptions used by departments and individuals, and the remaining orders need to

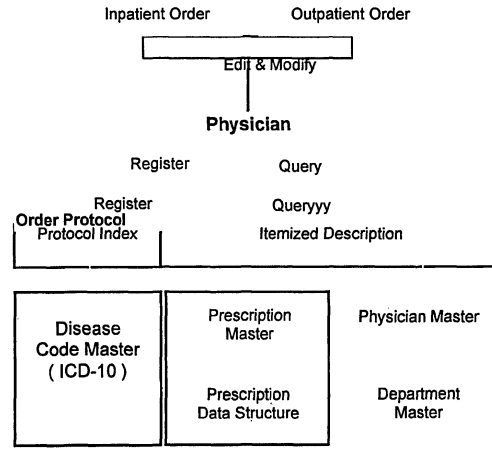

Figure 4 - Structure of PPMS

be covered by supportive functions. Not only medication oriented orders, but also textual message orders can be registered as a frequent request using Remark/Message.For each clinical department, a set of protocols is developed and managed independently for insertion, deletion, and update of order data items. Departmental standard operation may change, thus PPMS is used to modify the sequence of menu screens as well. Department specific protocols consist of common and individual orders according to functional categories. A series of protocol screens are prioritized by the frequency of use. The protocols are arranged hierarchically into a 4-level directory structure as follows:

department

- common/individual division
- grouping category
- order protocols

ICD-10 coding system is used to simplify insurance reimbursement and information management for medical record, and department specific disease codes are also supported by PPMS.

Frequently used orders are clustered and given by a group code to maintain lexicographic sequence as follow: numeric < uppercase < lowercase < Hangul (i.e., 1<A<a<Hangul). Hangul naming convention follows the Korean standard character code, and Unicode conversion is under preparation. Each protocol consists of 5-20, 10 in average, prescription items. Most common protocols fall into the following four categories and a few examples are given:

- Routine: admission, discharge, pre-op, post-op
- Disease and status: bleeding, fever, pain
- Procedure: NAB, ERCP, SPINAL TAB, Amniocentesis
- Frequent yet independent: chest AP, CBC panel, DITI, EKG

Order protocols also allow an expression such as "abdomen shield" for department specific protocols to maximize user convenience. Four examples of protocols from the department of obstetrics and gynecology are presented in the following:

- IPD1: ADMISSION(GYN), PREOP(GYN), POSTOP(GYN)
- IPD3: SERUM HCG, X-RAY, SONO, CULTURE
- IPD5: BOWEL PREP #3, PRE IVP
- DR-2: PIH SERVER, POST BARIUM BLEEDING

PPMS also provides the following functions.

- **Message protocol** - Some order contents are compact enough to be an order protocol. The remaining contents of orders are usually presented as textual messages. However, if a message is so frequently used, such message can be regarded as an order to be included in the protocol by registration. For example, "In case of chest pain, notify doctor." or "Keep observation." kind of messages can be used as protocols.
- **Minor protocol** – Major protocols cover approximately 60-80% of the contents of prescriptions. Only the most frequently used orders, not every prescription, are included. Because the rest of the prescriptions still play an important role in patient care, PPMS must be able to support clinicians. The second most frequently used order items are organized in such a way that at any given time they are ready to be used as a minor protocol. The remaining clinical orders are usually presented as textual messages.
- **Medical certificates** - In many cases medical documents are required and its terminology, sentence structures and output formats are standardized so that it can easily be computerized. A set of standard print forms is registered as a template in order to reduce significant amount of manual typing.
- **Operation note** - Every surgical procedure produces operation record, which contains information regarding procedure and findings. PPMS supports functionality to query operation related information from computer in a most convenient way.
- **Composite medication** - The major part of order protocol is medication, which allows various combination of medication for every clinical department. PPMS supports such departmental and clinical varieties by registering various combination of medication in advance with great simplicity.

The level of acceptance is found to be satisfactory due mainly to end-user computing capabilities, which allow both individual and department specific prescriptions with greater flexibility. The number of keystroke required for order entry can measure a figure of merit. Frequently ordered itemized prescriptions are selected from the clinical database and classified as a single unit significantly enhances efficiency during the patient consultation. As a result, numerous data items are searched, corrected and directly entered by only a few, usually one to three key strokes. A comparison of the time required for order entry with correction between a trained data entry specialist directly entering data items and a user manipulating order protocol is shown as follows.

The time required to manage order protocol is not directly proportional to the number of data items because of the convenient handling of grouped items. Conversely, simple itemized data entry is directly proportional to the number of data items. Therefore, direct entry of itemized prescriptions must be prohibited clinically because of its long entry time.

Table 1 - A comparison of entry time

Number of items	Protocol entry	Itemized entry
5	20 seconds	85 seconds (1' 25)
10	37 seconds	140 seconds (2' 20)
15	41 seconds	223 seconds (3' 43)
20	48 seconds	307 seconds (5' 07)

In the department of dermatology, for example, faculty and staffs jointly developed and arranged a series of protocols in descending order to minimize the search time for retrieval. A physician in the department of pediatrics identified order patterns and developed approximately 300 protocols to minimize the number of corrections needed. The following is an example of protocol used in the department of cardiology. (Data items are updated and no longer in use.)

Table 2 - An example protocol

Department: CAMD	Group code: CAMD
Sequence number: 4	Protocol name: ANGINA PECTORIS, STABLE
Lab	1. *Y Lipase by WB
Lab	2. *Y Fibrinogen be CB
Special func lab	3. *Y Treadmill Test
Oral med	4. *Y Nitroglycerine Tab. 0.6mg 10 TAB 1000 Sig. PO 30min. after meal X 1 days <prep>
Message	5. <MSG> IF CHEST PAIN: NTG 1T SUBLINGUAL
Oral med	6. *Y Baby aspirin 100mg 200 MG #1 2000 sig. PO 30min. after meal X 1 days <RMK> DAILY
Oral med	7. *Y Halcion Tab. 0.25mg 1 TAB #1 1000 Sig. PO 30min. h.s. X 1 days

For each department, common order patterns are extracted from protocols to share with department physicians, which allows individual varieties with less redundancy and error. Due to the complexity of insurance claims policy, it was extremely difficult for clinicians to find out at the time of order entry. PPMS is a tool to give a warning or advice at the time of prescription which is payable or not. As a result, PPMS helps reduce the amount of dropout for claims and track down the causes of dropout. Because clinicians proactively participate in insurance review process, the amount of reimbursement is significantly increased.

Discussion

Like many institutions ATOM experienced a series of beginner's trials since the opening: resistance to computer technol-

ogy, slow response time, redundant hardware resources and so on. These difficulties were resolved with constant user training, process reengineering, software upgrade, and database migration to M. ATOM also incorporates graphic user interface (GUI) in order to draw attention from user. As far as computer interaction is concerned, however, user-friendly interface was not much of help.

Computer department in general, usually run by either expert programmers or hospital personnel manages nearly all computer related requests. Computer jobs were scheduled and prioritized centrally but processing feedback was usually a bottleneck and sometimes not supported at all because of its low priority. Also, specifications of user request were sometimes misunderstood thus improperly corrected or supported to cause another problem. It has been said that some clinical requests could be much better handled by end-users. The implemented PPMS is programmable in such ways that an end-user best utilizes the flexibility for insertion, deletion, modification of ever-changing clinical updates, and also be able to program the sequence of menu screen at one's convenience. Individual and departmental security levels are allowed and managed. Individual protocols are correctable by individual only and department protocols are modified either by unanimous agreement or by authorized personnel of the department. Therefore, the amount of global administration tasks for the computer department is greatly diminished.

Conclusion

Because both inpatient and outpatient clinicians found protocol management convenient and efficient to use, implementation is rapidly spread throughout the hospital. At present, 100% of outpatients and 95% of inpatients are supported by the information system due mainly to managed protocol entry. PPMS also results in flexibility of managing individual physician specific protocols, which helps enhance the morale toward an information system. Increasing use of PPMS based on efficient HCI will make it possible for a to settle in a clinical setting. The method of programmable protocol management clearly demonstrates end-user computing capability so that department specific requirements are resolved within clinical boundaries.

Now that HIS provides diagnosis, lab results, patient history, admission notes, operation notes, progress note, nursing reports, discharge summary, and multimedia information such as PACS (Picture Archiving and Communication System) is under consideration, EMR (Electronic Medical Record) will be facilitated with much ease.

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