Design and Implementation of a Bedside Clinical Information System for Inpatients

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Abstract

Recently, more patients' participation in decision making in health-care is becoming very important, and their demands for sharing and/or disclosure of their own clinical information with health-care providers is getting very common. To satisfy these patients' demands, we developed a bedside clinical information system which provides the access to the clinical information for inpatients. With this system, patients can check their own clinical data and related information on the Web browser using their bedside information terminal. The system was developed as a Web-based application in Java Language, and uses various open, distributed technologies and standard message formats such as HL7. At present , the system is under test phase. In this paper, we describe the design and the implementation of the bedside clinical information system for inpatients in the University of Tokyo Hospital.

Keywords:
Patient-centered clinical information system, Bedside Information Terminal, Computerized Patient Record, HL7, CORBA, XML

Introduction

Recently, patient plays very important role on decision making in healthcare, and their demands for sharing and/or disclosure of their own clinical information with health-care providers is getting very common in Japan.

Also, advances of information technology provide high performance computers and high-speed networks to our healthcare environment. As the results of these advances, the Hospital Information System (HIS) and electronic medical record system were introduced in many hospitals, and in such environments, the service for patients that provides an access to their own medical records via computer network became possible. Previous researches showed that these systems provide patients' satisfaction and improvement of the patients' understanding about their conditions, which affect to the Patient-Physician relationships [1-3].

The University of Tokyo Hospital (UTH) has been providing a clinical information service for inpatient using a bedside terminal since September 2001. Currently the inpatients can access the general hospital information and general medical topics with the bedside terminal [4]. However, the patients have no access to their own clinical information via the terminal so far. We have developed a Web-based clinical information system for the inpatients. Using this system, the inpatients can browse and check their own clinical data and the related medical information.

In this paper, we describe the design and the implementation of a newly developed bedside clinical information system.

Figure 1. Bedside Information Terminal.

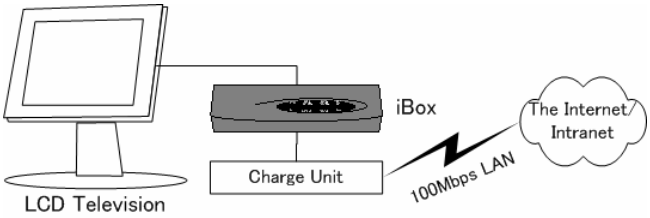

Figure 2. Block diagram of Bedside Information Terminal.

Materials and methods

Present System

At present, our hospital has bedside information system for all the inpatients [4]. The client terminal of this system is the LCD (Liquid Crystal Display)-television with iBox from Japan Computer Corporation (set top box-style network computer) [5] that has internal Web browser. All the client terminals are connected to the intranet with 100Mbps Ethernet cable.

The patients have free access to the general information about the hospital on the intranet; however, access to the Internet is the pay service. The bedside information system is shown in Figure 1 and 2.

System Design
The bedside clinical information system is designed as an additional component of the present one.
This system has two components; one is a gateway system (GW) and the other is a patient-dedicated Web server (PWS). The system diagram is shown in Figure 3.

Functional Requirements
Due to the functional limitation of the client terminal, this system is designed as a Web-based application. The system includes functions below:

1) Display of laboratory test results and their reference values on the terminal.
2) Displays of medical image results of endoscopic, radiologic examinations, and so on.
3) Providing correct user authentication reflected by the information about the patients' admission, discharge and transfer (ADT).
4) Logging all operations of users and providing the statistical data of the system usage for system administrator.

Patients-dedicated Web server
The patients-dedicated Web server (PWS) stores all clinical information in the database and generates Web pages. Laboratory test results are stored as a record of the relational database. Endoscopic images are stored as separate files on the PWS's hard disk and the database holds the pathname of the file for each images.
When a patient accesses the PWS, the server checks the client terminal's IP-address and asks the patient to enter the password for authentication. The reference information table between patient's ID and the IP-address is updated every 15 minutes from the ADT database in the HIS.
The example screenshots generated by the PWS are shown in Figure 4, and 5, and screen of administrative function is shown in Figure 6.

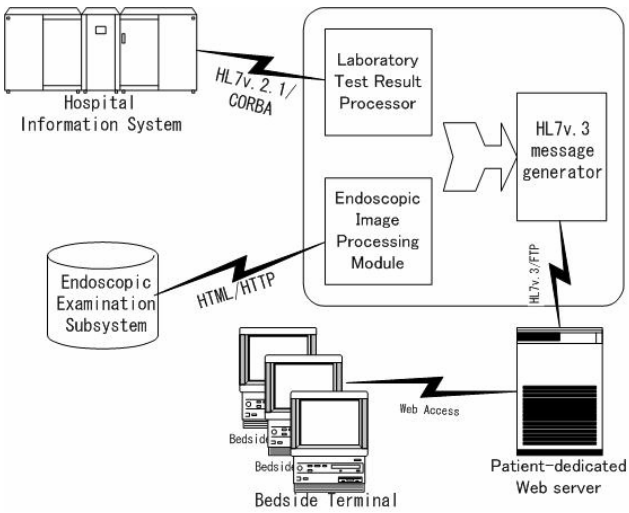

Figure 3. System Diagram of the Bedside Clinical Information System.

Gateway System
The gateway system (GW) has four sub-components. All four sub-components are tightly connected and work as a single program. Each sub-component is described as follows.

1) Laboratory Test Results Processing
The component for laboratory test results processing fetches the necessary information from the hospital information system (HIS). The HIS provides CORBA interface to make an access to clinical information stored in the database [6,7]. The component receives clinical information in HL7v.2.1 format, which was developed in 1995 [8]. Then, the component parses the HL7 messages and gets the required information such as patient-ID and diagnostic results. After the parse stage, it calls the HL7v.3 Generator component to transfer the information to the PWS.

2) Endoscopic Examination Image Processing
Endoscopic examination images are fetched from the endoscopic examination subsystem of the HIS via its Web interface.
In this process, patient-ID, image file names and image file bodies are fetched. Then the GW generates HL7v.3 messages and transfers them to the PWS. The contents of the endoscopic images are transferred separately.

3) Latest inpatient List Processing
The gateway also generates the latest inpatient list and transfers it to the PWS every 30 minutes. This list is required to update the authentication-information table stored on the PWS.

4) HL7-Message Generator
The component of HL7-message generator creates HL7 version 3 compliant XML- messages and transfers them to the PWS. The message schema is "Observation Event Completed" defined in the Laboratory Domain of HL7 version 3 3rd ballot packages [9]. Sample message is shown in Figure 7.

Figure 4. Screenshot of the Patient Medical Information Browser with Laboratory Test Results.

Security issues
To prevent inappropriate access to other patient's clinical information, every patient must access to one's own clinical information from the bedside terminal, which is placed just beside one's bed. In addition, the patient is required to enter his/her personal password.

Each patient must set his/her own personal password with medical staffs' assistance before using the system.

Implementation

All systems were developed with SUN's JAVA2-SDK (version 1.3.1 or higher) on Linux Operating System. Due to the limitation of HIS's CORBA interface, the gateway system required specific CORBA-Orb module included in Fujitsu's Interstage Application Server Package (Version 5.0-L1). Patient-dedicated Web server was developed as Java Servlet/JSP, and it runs on Jakarta-Tomcat Servlet Runtime Environment (version 4.1) and PostgreSQL SQL Database Management System (version 7.2) for its backend.

To process the HTML documents retrieved from the HIS's endoscopic examination subsystem, we transformed the original HTML documents generated by the subsystem into well-formed xhtml documents to correct the lack of some tag elements in the original documents [10]. After the transformation, the component analyses the xhtml documents with an xml parser and gets all of the required information. To select the information in the xhtml document, we used the Xpath technology available from the W3C consortium [11].

Because the HIS already has CORBA interface gateway and IDL documents that describe the programming interface, no additional work was needed in order to access the clinical information repository.

Results

Evaluation

The System is currently under test phase, and evaluation by the users was not available at the time of writing this paper. Currently, we are planning to examine the usability, understandability and effects to the Patient-Physician relationship by using questionnaire or other methods.

Figure 5. Screenshot of the Patient Medical Information Browser with Endoscopic Images.

Performance

Test environments; Gateway: Pentium4 2.4GHz with 1GB RAM, Patient Server: Dual Pentium3 1.13GHz with 1GB RAM.

The gateway processes all the available messages on the HIS at one time. We set the gateway to process all the messages emerged between June 1st and July 15th from 43 patients, and the total number of the message processed was 643.

The duration of the processing time was 40 minutes for fetching from HIS and 2 hours for transferring all messages to the PWS.

Estimation time for processing was about 4 seconds for fetching a message from the HIS, and 30 seconds for transferring it to the PWS. Updating the patients' authentication-information table took about 90 seconds to fetch a patient list from the HIS and 11 seconds for transferring it to the PWS.

Discussion and Conclusion

Since this system is currently under test phase, we cannot discuss about its usability, the effects to the patient's understanding to their condition and evaluation of the usability by the actual users yet. Previous researches pointed out that this kind of system would affect to the Physician - Patient relationship in the US and other countries. However there are few researches for the effect of computer system to the Physician - Patient relationships in Japan, and further investigation is needed.

Technically, since this system uses internationally standard message formats such as HL7v.2.1 and HL7v.3.0, our bedside clinical information system can be introduced into other hospitals without large modification to their HISs that have a HL7 message interface.

As similar system has reported its effectiveness of enhancing patients' understanding of their conditions and supporting patients to manage themselves, we expect our system to increase the quality of stay in our hospital.

We are going to improve this system, and planning to extend the support to outpatients of our hospital.

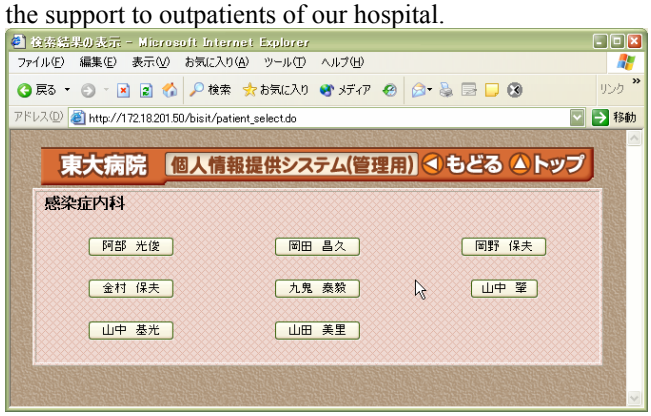

Figure 6. Administrative screen of the PWS.

```
<?xml version="1.0" encoding="Shift_JIS"?>
<!DOCTYPE ObservationEvent SYSTEM "../testResult.dtd">
<ObservationEvent>
    <class_cd code="OBS"/>
    <mood_cd code="EVN"/>
    <id assigningAuthorityName=
      "The University of Tokyo Hospital"
      extension="2003071542959612" root=""/>
    <cd code="E981" displayName=
        "Emaergency Biochemistry Test"/>
    <activity_time value="20030717000000"/>
    <patient>
        <type_cd code="PAT"/>
        <patient>
            <class_cd code="PAT"/>
            <id assigningAuthorityName=
              "The University of Tokyo Hospital"
              extension="000000000" root=""/>
        </patient>
    </patient>
    <component>
        <type_cd code="COMP"/>
        <sequence_nbr value="1"/>
        <ObservationEvent>
            <class_cd code="OBS"/>
            <mood_cd code="EVN"/>
            <cd code="000000" displayName="RBC"/>
            <value unit="" value="520" xsi:type="dt:PQ"/>
        </ObservationEvent>
    </component>
</ObservationEvent>
```

Figure 7. Sample message of the HL7 version 3 (with some modifications)

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