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A Hospital Information System based on Common Object Request Broker Architecture(CORBA) for Exchanging Distributed Medical Objects – an approach to future environment of sharing healthcare information–

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Abstract

Tightly related subsystems in a HIS have to exchange medical data flexibly by the data object rather than by the battery of the data. We developed a CPR subsystem based on Common Object Request Broker Architecture(CORBA) that retrieves and stores clinical information in the object-oriented database via Internet Intra-ORB Protocol(IIOP). The system is hybridized with the legacy HIS applications on the client terminals. We believe that our solution and the experiences will contribute to the future CORBA-based environment in which computerized patient information is shared among hospitals, clinics, and tightly related systems.

Keywords

Hospital Information System; Computerized Patient Record; Object-Oriented System; CORBA; Distributed Database

Introduction

Legacy Hospital Information Systems(HISs) have been based on centralized computing architecture composed of a few powerful host-computers and hundreds of their dedicated terminals[1], although the roles of the terminals are enlarging from the point of providing better man-machine interface to the users. In these several years, however, a technology for distributed database has been introduced in innovative HISs. It is suggested that the main reasons are 1)distributed database systems can reduce the work-loads of each server computers and give the better response to 2)the departmental databases located in their own dedicated servers are highly independent from each other, so it is easier to maintain the system and to modify the structures, 3)each server computer might be a powerful and inexpensive PC instead of a giant mainframe computer, and as the result the total cost of the maintenance could reduce.the users

On the other hand, new issues to be discussed have been brought up from introducing distributed database architecture; e.g., how to communicate between servers so that the consistency of the distributed databases might be guaranteed, how to standardize the communication protocol that is independent from the venders of the database management systems(DBMSs), how to indicate a particular field of a particular record independently from the database structures, and so on. Thus, even if an HIS is composed of several distributed databases, same DBMSs from a single vender are often adopted in all the databases because it is reliable for the administrators to maintain the databases.

In recent years, Common Object Request Broker Architecture(CORBA) for exchanging information objects has been introduced by the Object Management Groups (OMG)[2,3] and Internet Inter Object Request Broker Protocol (IIOP) was proposed as a standard communication protocol under a CORBA environment. Under a CORBA environment, every information object (e.g., a patient's name, a laboratory test result, a chest X-ray image, etc. in medical domain) has the content and the interface through which the object can provide its services to other objects. The content of an object can be retrieved and updated only by the dedicated service-interfaces via Object Request Broker(ORB), and IIOP is the general protocol for exchanging objects between ORBs. Further, IIOP is independent from the programming language in which the communicating systems are implemented. So using IIOP, each database server based on CORBA from a different vender can communicate and exchange medical objects even if it is implemented on different platform.

In the University of Tokyo Hospital, the author had an experience of developing an HIS based on distributed database systems using both HL7 protocol and HTTP to communicate between servers, and between clients and the server. Since the upgrading stage in 1997, the HIS is under reconstruction aiming a new information infrastructure based on object-oriented database and CORBA. In this paper, this new approach of the HIS using object-oriented technology will be introduced and a method to harmonize a legacy system with this new architecture will be discussed.

Legacy sever-client HIS and the problem about the communication protocols

In July of 1994, the University of Tokyo Hospital introduced an integrated HIS composed of physicians' direct order entry system including most of the examinations, ADT, prescription, booking of next visits, etc. as well as a system for browsing the results and the reports of examinations. In this HIS, a vender-

proprietary, ready-made software packages for an order entry system was adopted as the clinical server system, and the communicating software for HL7 were newly developed as the wrapping modules to communicate with other systems. Through this wrapping modules, the clinical server can be accessed from the clients terminals and the other departmental servers via HL7 messages[4]. To satisfy the end-user's demand on availability of the HIS, we also developed World Wide Web interface to browse clinical data of patients. Although the availability and the usefulness of the HIS has been highly accepted by the users, the complexity of the architecture about the communications causes us, administrators, the difficulty in expanding the system for the future comprehensive computerized patient record system that includes the records of patient's interviews, clinical summary, nursing records, voice memos etc.

The difficulty is derived from the features of the communication protocol used between servers or between applications. The HL7 protocol defines a battery of closely related fields as a segment and sends a package of segments as a message. This way is really useful for the communication between loosely connected databases, i.e.; between auxiliary systems or between hospitals. However, because tightly related systems within a HIS or within a client computer need to retrieve and update any data field of another system according to the clinical context, the predefined battery of fields causes redundant accesses as well as the slow response time. From this reason, we need the alternative protocol in which a system can make an access to any data object on a server by the object rather than by the battery.

A solution using object-oriented database and CORBA

As described in the introduction, CORBA is suggested to be a key technology to solve the problem mentioned above. Since CORBA is an architecture in which a client can request a particular object to serve a certain predefined function, it is strongly suggested that the database on the server should be constructed using object-oriented database management system(OODBMS). However, because we have little experience of constructing large-scale clinical database systems using OODBMS and the task to move a current HIS toward such an inexperienced system let us hesitate, we adopted a hybrid configuration of the legacy, yet reliable systems and the new object-oriented system in the first transition stage (from 1997 to 1998).

As Fig.1 shows, not only legacy applications for order entries run on a client terminal using HL7 as a communication protocol , but also a new applications for CPR subsystems are available on the same terminal, which CORBA-IIOP is used to make accesses to the server's object-oriented database. The OODB is implemented by the Objectivity/DB (Object Technology Inc.) and the CORBA-IIOP is realized by the VisiBroker (Visigenic Software, Inc.). Most of the new client programs were coded in Java language, in contrast to the legacy ones in C++, because we would like to run them on a variety of platforms like Windows NT, Macintosh, UNIX and so on. On the other hand, the programs running on the server in combination with the OODB were written in C++ language, because we need short responses on the server machine. Thus, the language-independent feature of CORBA-IIOP allowed us to use any language as we needed.

Object-oriented modeling of CPR

To adopt CORBA-based HIS successfully, the sophisticated object modeling for the target domain is necessary. We analyzed the paper-based patient charts using OMT method[5] and depict the class definitions using Rose/C++ tools (Rational Software Inc.). Through the process, we referred the reference information model of HL7 version3 [6]. After the modeling, the classes were implemented in C++ language and the persistent objects were stored in the object-oriented database.

A WWW-based clinical environment

Adopting the above solution gives us a new paradigm of Web-based clinical environment. So far, dedicated gateway programs, or CGI modules, had to be developed in order to provide Web-based services to end-users[7], and the tasks to maintain and expand the functions of the gateway programs in accordance with the original client applications was rather time-consuming, Since the client applications are written in Java language in our solution, they can run on a WWW browser as *applets* on any user's platform without modifying the programs. Further, because a certain WWW browser like Netscape Navigator is announced that it is possible to make an access to an OODB server directly via CORBA-IIOP, WWW browser might become one of the client platforms without developing the dedicated gateway programs for the WWW browser under CORBA environment.

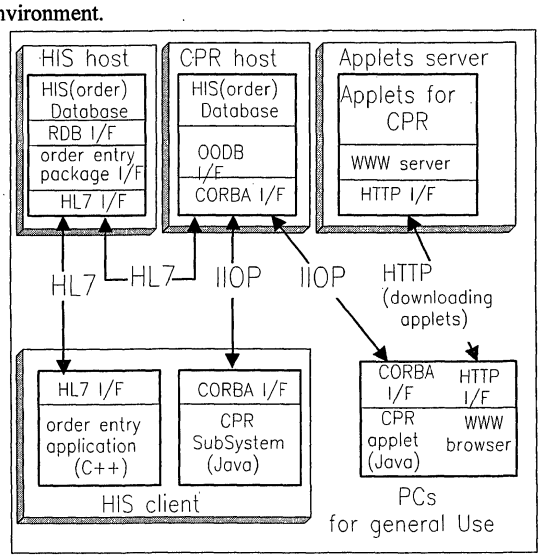

Figure 1 - CORBA-based CPR subsystems.

Discussion

An Object-oriented technology gave a variety of new paradigms to healthcare information systems. First, we acquire a analytical method, or object-oriented analysis, to make a model of knowledge, a structure of database, and flows of process in the medical domain[8]. Secondly, it gave software developers a new method to develop large systems composed of highly reusable, component modules according to the results of object-oriented analyses and the modeling. Thirdly, the technology produced an object-oriented database architecture that can store data as objects and make an access to every object directly with the object-ID instead of using relational field in relational database systems. Lastly, CORBA and IIOP are the very important architecture to exchange every data object between systems via a network.

So far and even now, most of HIS have been constructed based on a centralized computing architecture and their main databases are usually implemented using relational database management system that can be retrieved via SQL language. In that system, SQL, HL7, Web-based protocol, and other protocols have been used depending on the combination of the communicating systems, and the dedicated gateway functions have been necessary for implementing such environment[9].

Thus, our HIS is moving from the chaotic communicating architecture to CORBA-based systems. Although in the transition stage it is rather complicated from the point of architecture, the movement gave us several advantages as follows; 1) Constructing object-oriented database let us make a sophisticated model of clinical database using object-oriented analysis, 2) Flexible retrieval and storage services could be provided independently from the data-types of the information, and 3) The developers and the programs did not have to know where the required object existed, thanks to the powerful naming service of CORBA, and so on.

In near future, many hospitals and clinics have to share a patient's healthcare information for the purpose of providing better healthcare to the patient, and to share medical information objects via the Internet we need a standard communication protocol in consistent with the protocol used in the *intranet* within a hospital. From the experiences in our HIS, we believe that one of the hopeful solution is CORBA and the IIOP and our experiences will contribute to the future CORBA-based environment in which computerized patient information is shared among hospitals, clinics, and tightly related systems.

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