Design and Implementation of a SOA-based in Co-allocation Medical Grids Platform

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Abstract

21st century health care industry is different from the face of the old century. With the advanced medical technology, medical treatment arising from personal medical information also showed explosive growth. And more scattered in between the different medical units, the various medical units have health care database must be open at the same time maintain stability, as well as common information.

In order to satisfy the hospital information system to the heterogeneity, interoperability, information sharing, and information integration, a kind of new software system architecture to came with the tide of fashion -- Service-Oriented Architecture (SOA) [3, 4, 8]. Our research take the SOA technology, combined with the grid based of the hospital for back-end platform—Co-allocation [15, 16, 17] MedicalGrid [5, 9, 20, 21], provides a powerful computing capabilities, and fit with a Cross Grid Information Service (CGIS) [5] that enables Resource Brokers [11, 12, 13, 14] to get information from cross grid environments for other components.

Keywords: Information Technology, Service Oriented Architecture, Cross grid, Resource Broker.

1. Introduction

The introduction of the National Health Insurance has gradually increased the competition in the medical market. Taiwan people for medical treatment financial may be the greatly progressive enhancement. But the distribution of medical resources there is a significant imbalance [7]. Many people in country sides need have a longer time to take their medical treatments, thus delays the time for treatment.

Face in the quality of medical care services more and more better and cost considerations, complete patient care and enhance the quality of medical be taken seriously. In order to achieve personalized health management and maintenance the rights of the people to know. This thesis develops a grid-based medical resources sharing platform, which provide medical services to the populace. Aims at separately by the home viewpoint (patients) and the hospital viewpoint (doctors) provides the different service.

To the home point of view, provide a standard platform (middleware) to integrate the health care services when the patient being out of hospital, to help patients take the follow-up treatment. In order to achieves the goal of health management. To the hospital point of view, this thesis use SOA technology to integrate Grid & Medical (MedicalGrid) systems, to provide physicians and patients interactive with each other. The health care services which can provide originally the hospital extended to individuals and families. In the process, we discuss with a number of attending physicians, nurses and related medical experts many times. The collection of clinical practice and views on professional advice, to sum up the views of staff to the general public demand for health services management as a major research direction will be produced after the system prototype design and development system.
In view of this, this study was the use of Service Oriented Architecture (SOA) and grid technologies come to develop a basic Healthcare Service Grid Infrastructure, contains one of the main Grid Resource Management and Information Service, service platform and the entrance of health information user interface (Service Portal and GUI), HL7 [1, 2, 6, 19] Data Management System, Health Services API, and Data Replica and Parallel Download Management parts.

2. Background

2.1. HL7

Since a variety of time and space factors, the general public may be at different hospitals for treatment, and various medical institutions to use the hospital information system (HIS) is not necessarily the same as a result of patient medical information cannot be at each inter-hospital transfer, often creating the need for patients to check the duplicate, or duplicate medical acts, resulting in unnecessary waste of medical resources. By the HL7 Organization for medical information exchange standards, the role of medical information is structured, standardized so that they can through the network, at different medical institutions between the transmissions, to achieve the purpose of information sharing.

Health Level Seven (HL7) [1, 2, 6, 19] is one of several American National Standards Institute (ANSI) -accredited Standards Developing Organizations (SDOs) operating in the healthcare arena. Most SDOs produce standards (sometimes called specifications or protocols) for a particular healthcare domain such as pharmacy, medical devices, imaging or insurance (claims processing) transactions.

HL7 protocol brings together different vendors application software used to design the interface between a standard formats, which allows the various medical institutions of different application systems, carry out some important information to communicate. Protocol design while retaining a considerable degree of flexibility, making some information on the specific needs of a deal to maintain compatibility. HL7 Organization reference to ISO (International Standards Organizations, ISO), the use of open systems architecture (Open System Interconnection, OSI) communications model as shown in Figure 1. The HL7 is satisfied for the highest level, that is, the application layer. It provides norms such as: the relevance of the classification, the emergence of an effective inspection, the structural mechanism for the exchange of information and consultation functions.

Taiwan health information exchange agreements seventh layer Association (HL7 Taiwan) was established in 2001, and at the Department of Health under the guidance of continuing education to organize various activities such as training and seminar, and actively promote the HL7 standards in the domestic [2].

2.2. Web Service

Web Services [2] is a software component, which through Web protocols and data formats open standards (such as HTTP, XML and SOAP, etc.) for other applications to provide services. There are two key points: first, it is a component of services provided. Second, it is Web-based on open standards. Provide services as components, it can be used to construct distributed systems architecture, distributed architecture achieve dynamic integration and balance the burden of the advantages of upgrading unit.

- **SOAP (Simple Object Access Protocol)**
  SOAP is a means available to Web Services with XML produced by the protocol, as are phone calls through telephone lines or wireless base stations, etc. The purpose is to allow applications and applications can communicate with each other, but it does not need to know each other's platform is what kind of homework or their respective implementation details such as how information.

- **WSDL (Web Services Description Language)**
  WSDL description of Web Services are the major concepts, but also the use of XML format language, Web Services allow applications to a standard method to describe what they have the ability to allow interaction more easily than before. So you want to know Web Services, the first step is to try to understand the WSDL definition.

- **UDDI (Universal Description, Discovery and Integration)**
  UDDI refers to a directory on the Web Services Registration Service, and its architecture is also
based on XML-based document, its main purpose is a provider of Web Services through UDDI provider to the other person has to provide Web Services, therefore the function of UDDI also similar to a telephone directory, or known as Yellow Pages, the purpose is to quickly inform service users can use him there is what the Web Services.

2.3. Service Oriented Architecture (SOA)

A Service-Oriented Architecture (SOA) [3, 4, 8, 22] is a group of services that communicate with each other. The process of communication involves either simple data-passing between a service provider and service consumers, or a more complicated system of two or more service providers. Intercommunication implies the need for some means of connecting two or more services to each other.

SOAs build applications out of software services. Services comprise intrinsically unassociated, loosely coupled units of functionality that have no calls to each other embedded in them. Each service implements one action, such as filling out an online application for an account, viewing an online bank-statements, or placing an online booking or airline ticket order. Instead of services embedding calls to each other in their source code, they use defined protocols that describe how one or more services can “talk” to each other.

A software developer, software engineer, or business process expert associates individual SOA objects by using orchestration. In the process of orchestration, a software engineer or process engineer associates relatively large chunks of software functionality (services) in a non-hierarchical arrangement (in contrast to a class hierarchy) by using a special software tool that contains an exhaustive list of all of the services, their characteristics, and a means to record the designer's choices that the designer can manage and the software system can consume and use at run-time. The new generation of IT architecture should provide the platform to set up with the following characteristics of application services: (1) loosely coupled; (2) location transparency; (3) Agreement independent.

In response to such change in the trend of IT architecture, SOA are from Gartner's IT architecture was first put forward the concept of an enterprise IT infrastructure must be flexible enough to response to business needs with flexibility, such as the telecommunications industry may at any time for various services, adjust billing methods. As in recent years, an emerging model of software architecture, SOA concepts are the main business needs for a hospital or a combination of a group of software components. Combination of elements typically include: software components, services and flow, show in Figure 2. When the hospital or enterprises face an external request, the external flow is responsible for the definition of the requirements of treatment steps; Services of specific steps, including all program components and software components are responsible for the implementation of programs. SOA has become a modern software development technology, through the SOA allows easy integration of heterogeneous systems, the program also increased the degree of re-use. Do not have to own or have all the program components, developers can be required depending on the best combination of network services. Not limited to specific vendor product functionality or platforms, to achieve genuine openness. From the distributed component architecture to the SOA concept, SOA, as object-oriented software components, such as software technology in general, the use of smaller components into applications. However, SOA is how to emphasize the relations between the loose application system components on the network distribution, composition and use.

**Figure 2 The key elements of the SOA paradigm.**

Service Oriented architecture (SOA) software to change the traditional pattern of development, through the SOA and Web Service, makes the user is no longer confined to a single operating platform, be able to achieve more effective cross-platform operating environment, as well as efficient methods of service integration are future development goals.

3. System Design

3.1. Co-allocation Model

The architecture proposed [15, 16, 17] consists of three main components: an information service, a broker/co-allocator, and local storage systems. Figure 3 shows co-allocation of Grid Data transfers, which is an extension of the basic template for resource management provided by the Globus Toolkit. Applications specify the characteristics of desired data and pass attribute descriptions to a broker. The broker searches for available resources, and gets replica
locations from the Information Service and Replica Management Service and replica selection; then, obtains the lists of physical file locations.

We have implemented the following eight co-allocation schemes: Brute-Force (Brute), History-based (History), Conservative Load Balancing (Conservative), Aggressive Load Balancing (Aggressive), Dynamic Co-allocation with Duplicate Assignments (DCDA), Recursively-Adjusting Mechanism (RAM), Dynamic Adjustment Strategy (DAS), and Anticipative Recursively-Adjusting Mechanism (ARAM).

Our design for the Co-allocation grid is as shown in Figure 4 and developed a user-friendly GUI for Cyber Agent Transformer to help users unfamiliar with downloading and managing files in data grid environments as shown in Figure 5 user tools. Every Client node access point uses Cyber Agent to enter the Co-allocation data grid and manage queries and image retrievals, as with the Web-based Enquiries PACS. Overall, the greatest benefit of our method is that it speeds up query accesses and image retrievals. It also provides security for queries and image retrievals in the data grid environment.

3.2 MedicalGrid

We use grid and peer-to-peer technology, as well as a huge resource sharing future ability to establish from individuals, families, hospital physicians to complete medical service mechanism, in order to improve the current general hospital of Chinese medicine and healthcare system is not adequate. Those data form a data warehouse to support the data mining techniques that extract valuable information for medical decision support and future research.

This study focused on developing a system to facilitate the application of the general users remote access to grid resources systems. To our grid-based computing platforms, the system will be built on the grid platform, apart from the development of basic interactive interface, provides users with the optional job order requirements, but also the development of available resources control systems to automate the way, let the system self-demand according to different distribution of appropriate resources, will be much complicated management process to be hidden, so as to simplify the user's hard to level up in order to achieve universal access to grid computing purposes.

Nowadays the application of grid computing instrument, and did not have a set of comprehensive use of a mechanism for users to more easy way, just in their own computer to install the public on the widespread use of the software, you can network through the Internet on the specific scope of Grid resources to carry out access, efficient computing and control platform. First of all, we want to develop the Resource Broker will make use of Globus Toolkit [18] as the future of the Grid software agent. The main objective of this program is to develop a Grid Monitor, used to monitor the computing platforms on all available computing resources of the current status, such as machine load on CPU, Memory size available, the node between the current instantaneous frequency wide, and the network flows in each node shown in Figure 6 - Figure 7. This Grid Monitor is NWS (Network Weather Service) as the main core, by the NWS is responsible to retrieve the information (bandwidth, flow rate, CPU load, etc.), and then use
RRD Tool with MRTG to carry out mapping to produce page, supply users browser and Jane transaction. Figure 6. show the Ganglia snapshot from grid nodes. Then, a set of questions future prediction model at the grid on the network flow and execution time for job applications.

Figure 6. show the status of grid nodes.

Figure 7. show the Ganglia snapshot from grid nodes.

3.2. Resource Broker

We implemented a Resource Broker for Computational Grids. It discovers and evaluates Grid resources, and makes job submission decisions by comparing job requirements with Grid resources. The Resource Broker system architecture and the relationships among components are shown in Figure 8. Each rectangle represents a discrete system component.

The Resource Broker’s primary task is to compare user requests and resource information provided by the Information Service. After an appropriate assignment scheme is chosen, Grid resources are assigned and the Scheduler submits the job for execution. The results are then collected and returned to the Resource Broker, which records them in the Information Center database via the Information Service Agent. Users can view the results through the Grid portal.

3.3. Architecture

The system software stack includes three layers constructed using a bottom-up methodology as shown in Figure 9. The layers are described below:

- **Bottom Layer:** principally consists of Nodes. The layer contains two main blocks, the Information Provider, which uses Ganglia to gather machine information on Nodes, such as number of processors/cores, processor loading, total/free memory, and disk usage, and NWS, which gathers essential network information such as bandwidth and latency. The second block contains Grid Middleware, used to join Grid Nodes together, and the MPICH-G2 required for running parallel applications on the Grid.

- **Middle Layer:** we use SOA technology to build middleware, combined with Resource Broker, MedicalGrid and P2P network. User can invoke services and resources that MedicalGrid and P2P network provided.

- **Top Layer:** when user connected to SOA web portal, they can find the services as the follow:
  1. **Resource Status:** The main function is to provide users view the machines status when user create job. They can choose the correct machines.
  2. **Job Creation:** users can program through the SOA middleware into the Workflow Engine, will be cut into sub-program code, and then through the resource broker (RB) will be allocated to the grid sub-program environment for computing machines.
  3. **P2P Network Distributed and Selected:** each peer in the P2P network provided services each other. They cooperative composition in the space of services for discovering and composing some services.
that solve the problem. Each node in the network contributes to discover the peers that can originate useful compositions. According to the P2P model, peers become a crucial part of the architecture, since with this model the network lacks of structural components for discovery and composition. Each peer is responsible of receiving requests from other nodes (goals), and fulfilling them (i) by relying on service operations or lower level features available on each peer or (ii) by forwarding the request to other known peers. All services can register on our SOA web portal. SOA web portal will list all WSDL of services. User connected to our web portal to find services they wanted. The P2P nodes communicate each other to complete the job.

4. TMT/CDA Convert: the general public of the personal health record information, because of differences in medical situations may be scattered in a variety of medical institutions; to make the information on to the network for the exchange and integration, we need the same information in a standard format will be edited. We use international standards as the Health Level 7 as the exchange of information integration.

Figure 9. System Architecture

3.4. SOA Technology Combination Resource Broker

SOA combination of elements typically include: software components, services and flow. When the hospital or enterprises face an external request, the external flow is responsible for the definition of the requirements of treatment steps; Services of specific steps, including all program components and software components are responsible for the implementation of programs. We use the characteristics of SOA, and resource brokers (Resource Broker) for the combination of resource brokers go through the medical access grid (Medicare Grid) system. High-level interactions between various entities, components, resources, and human participants and the channels of control (shown in Figure 10.) are described below:

Figure 10. the flow chart of SOA operation

1. SOA components will be imported from time to time updates on web services, the service’s Web Services Description Language (WSDL) to release to be published on the portal for users to search.
2. On the user portal, the search for suitable services.
3. Service users to have access to the WSDL.
4. WSDL of the service allows users to be connected to the Internet through the SOA components, and will invoke service.
5. Through the SOA technology, combined with the Resource Broker, MedicalGrid and P2P network. SOA component will take submission of tasks to resource broker.
6. Resource broker submitted the tasks to MedicalGrid or P2P network in order to achieve the goal.
7-9. Result.

3.5. SOA Web Portal

We add access right control mechanism into our portal to provide user more secure way to utilize our healthcare system. Unauthorized user is only capable of seeing the resource monitoring pages without job related operation, as shown in Figure 11.

While user login to web portal, the user account and password are verified by our account database. Each account has different privilege which is pre-defined in database. Now we provide 3 kinds of privileges, administrator, authorized user and unauthorized user. All these privileges can be altered any time using administrator account. Unauthorized user is only capable of browsing and using the
services. Authorized user also can browse private dates (ex: patient records), using the services (ex: submit job by making workflow, monitor grid node information and modify own account information). Administrator user can use all functions of authorized user (but can not browse private dates of patients) and alter all user privileges. The additional function of administrator is cleaning of job records and image files.

![User login and Single Sign-On Model](image)

**Figure 11. User login and Single Sign-On Model**

### 4. System Implement

Our development tools using open source: NetBeans IDE 6.5 shown in Figure 12. NetBeans is set up the open-source software development tools by Sun Microsystems, the framework is an open, extensible development platform, can be used in Java, C language / C + + such as the development itself is a development platform, you can extend the plug-ins to extend functionality.

![Development tool](image)

**Figure 12. Development tool**

This subsection describes experimental results of our web portal. The SOA web portal to register many services as shown in Figure 13 and Figure 14. Figure 15. shows the return of the machine status which in the grids.

![The services on the web portal.](image)

**Figure 13. The services on the web portal.**

![The job submit service.](image)

**Figure 14 The job submit service.**

![The return of machine status.](image)

**Figure 15. The return of machine status.**

### 5. Conclusion

In this thesis, we use SOA technology to integrate with the Co-allocation MedicalGrid. Let Co-allocation MedicalGrid of the computing resources or other services through the standard interface provided the user to use.
We design and implementation a SOA web portal. The web portal provides the services that combine resource broker. The resource broker enables users to submit job, monitoring grid nodes and viewing patient records, etc. via a SOA web portal. So, user will be able to take care of their own will be more convenient.

Reference


