

An Application Research on the Workflow-based Large-scale Hospital Information System Integration

Yang Guojun

School of Computer, Neijiang Normal University, Neijiang, China;
Ygj_8383@163.com

Zheng Ying and Wang Gang

Department of Information Engineering, Neijiang Vocational & Technical College, Neijiang, China
Information Center, The First Neijiang People's Hospital, Neijiang, China
Zying_0005@163.com, 404510815@qq.com

Abstract— At present large-scale hospital information system has more than nodes, independent, extended strong and informative and so on, and it is difficult for the system to achieve a unified integration issues. In view of this, the article proposed a large-scale hospital information system integration solutions, which use the workflow-based mechanism for MIS development tools as the integration platform, customize and control the main line flow to achieve strong connection to the node and work independently as a loosely coupled business systems interface.

Index Terms—Workflow; Hospital Information System; Integration Platform; Process control; Integrated program

I. INTRODUCTION

The construction and development of the hospital information system is an important indicator of the development of large hospitals under the information age.

With the expanding of hospital scale, increasing of the business, and the gradually increasing of the expert system and the increasing of the flow of information ,it's the most urgent problem for all sorts systems of hospitals to implement system integration. On the other hand, the traditional point to point, message-based integration, component-based integration or middleware-based integration scheme seem powerless to the current hospital information systems which exist multiple heterogeneous systems, data structure, message format, communication protocol inconsistencies and other issues. So, we need a solutions Considering all aspects and Using a variety of integrated approach combination.

To solve the above issue, the author use the idea of workflow technology as the main line to play process customization and process control advantages, proposed a new mechanism based on workflow development tools

for MIS integration platform to meet the hospital internal system process control, data exchange and seamless sharing, which can achieve the effective control of the hospital system processes, and achieve seamless integration of hospital information system.

II. BACKGROUND SYSTEM

This article bases on the Research projects in " the research and development of a new type of MIS development tools based on workflow mechanism " and takes the First Neijiang People's Hospital Information System as the research background .The hospital proposes to establish a unified integration platform .And with the process of customization and process control for the line, the existing software system of the hospital can be fully integrated. It's complicated to realize this large system whose goal is integration, digitization, patient-centered, with the openness, scalability and maintainability, and which can realize the process customization and control of hospital business. The reasons as follow:

First ,large-scale multi-hospital system has many subsystems, such as HIS (Hospital Information System), LIS (Laboratory Information System), RIS (Radiation Information System), PACS (Picture Archiving and Communication System) and so on;

Second, the general hospital has a number of legacy applications and general medical equipment has its own unique software systems, but these systems do not have source code except some interface available to them

Third, a variety of data formats is involved in hospital, for example ,common data, graphics and images and so on.

Fourth, with the realization of electronic medical records. A good information exchange can be achieved among Hospitals (for example, when the patient transfers). We must abide the international standards and norms about the existing medical system , such as the

HL7 standard, DICOM standards, IHE norms. Although the various criteria of the interaction between various systems need to pass the message format, they do not include the realization technology. So integrating the various business systems is technically difficult.

Fifth, the hospital's business processes is complex and changing. Many of the existing systems are eliminated because they can't adapt to the changing of the hospital's business processes.

Although the Existing large-scale hospital software systems achieve the integration of various subsystems, most just put together a simple subsystems and The connections between them are achieved only by using peer-to-peer mode (Message-Oriented Middleware, or direct access database, etc.). So not only the development and maintenance are very difficult, but also the degree integration are not high and the support of the hospital's business processes are inadequate. There are many inconveniences to Doctors of information sharing and management of hospital management .And the hospital's needing of new business processes usually lead to large-scale changing to source code and make the maintenance price high. In addition, they support only part of the international standard.

This paper presents a workflow-based mechanism as the new development tool of MIS integration platform for large hospital system integration program, which is not only easy to achieve integration in the development and maintenance, easy to support the international standards, but also allows hospitals to comply with the Business Process IHE norms. Besides, the doctor can get more comprehensive information of patients .And the implementation of doctor's advice will be even more automation and smooth. Therefore, this program is not only for the convenience of doctors, but also is conducive to the patient. And it realizes the unity of the process design and management, even when the process changes, as long as the managers simply re-design the workflow and do a small number of changes in the application will be ok .So it has a lot of help for managers. Therefore, the integration which based on workflow mechanism as the development tool of MIS is a feasible option to optimize.

III. SYSTEM ANALYSIS AND DESIGN

A. Hospital System

Large-scale hospital information system as a whole system of vast, has complex structure, and has strong independence of the system, and mainly has the following categories:

Hospital Information System (HIS) is to achieve the hospital's core business system, which includes the registered subsystems, doctors' workstations, reproductive center management system, health-check management system, blood transfusion management system, surgery, anesthesia management systems, sub-clinical experts system, drug management system, economic management system, integrated management and statistical analysis systems and data security management systems

Laboratory and central laboratory information system (LIS) is mainly responsible for dealing with the inspection of report and the management of the laboratory information business.

Picture archiving and communication system (PACS) is mainly responsible for image acquisition, transmission, storage, processing, display and print management. In addition, the current Full PACS systems typically including a radiology information system (Radiation Information System, RIS), is responsible for a variety of radiation treatment equipment inspection reports, as well as the association with PACS systems for images access and in accordance with HL7 standards and the external system (For example, HIS) to interact.

Office Automation System (OAS) is mainly responsible for a number of routine office functions.

External system mainly refers to the banking system, medical insurance system, drug supply systems. Because a large hospital system can not be a closed system, its interaction with the outside world is inevitable, but also is the future development trend.

B. Design Principles

The contents of a large hospital system involves in many demanding system integration. In the design of the system would have to consider the feasibility, flexibility, robustness and scalability, and maintenance which are the basic design principles of the system integration.

Feasibility .Because the system is a real system used in large 3 B hospital , the feasibility of the technical and time becomes a problem that needs to be considered first.

Business processes of large hospital system are not only complex and changeable, so flexibility is a question need to focus on the design of the system. Whether the hospital can adapt to the complex processes of existing and future process changes, and whether the procedure can be changed as little as possible when demand changes is a manifestation of system flexibility.

Robustness. To the hospitals using this system of, their average daily outpatient amount is nearly 2,500, and their average annual outpatient amount is approximately 65 million. So, whether the system is able to withstand the high load, high flow, that is, the system robustness is also the problem of the design of the system needing to focus on .

Maintainability .The maintenance cost of the System take up a large part of the whole cost of the system. So, the maintainability of the system is also crucial.

Scalability. After referring to system integration, a with the hospital system continue to increase and expand, the business continues to expand and the external system becomes more and more standardized , the system provides an extension interface.

C. Technical Difficulties

The realization of a large hospital system integration need to consider and resolve many technical difficulties that were described in the following.:

Multi-subsystem .Because of the many subsystems included in the hospital system , the independence among the subsystems ,and the interaction between subsystems

more, if using the traditional methods to achieve point-to-point interconnection, it will form a network structure. But that will make the system almost not scalable. Because, if the system adds a subsystem, other subsystems and its all connected will need to be added, so that was the poor maintenance caused by.

Data format conversion. The realization of this system is not only the realization of the connection of its own subsystem simply by sharing the database with the Internet, but also bring other hospital system suppliers' products (such as: PACS) integrated into the hospital system. But directly accessing the database of other vendors products is unsafe and not feasible. Because relating to a specific data structure may have a product of a dependent, and runs counter to the interaction standard defined by the medical profession between the system. In short, in order to reach the Internet, we need to address different suppliers in different systems of the unification of data formats.

Changing business processes. The business processes of hospital are complex and changing. For example, to fill the orders of doctors belonging to the original task, but it may be fill out the task to the nurses because the change of process. For another example, the year-end assessment of the indicators of medical personnel, may be different as time changing, may also add new content. To adapt to changes in the process is all along the most intractable problems in the system been running.

IV. DESIGN OF THE WORKFLOW-BASED NEW MIS DEVELOPMENT TOOL

As enterprises of information technology, many local enterprises establish an MIS system to improve efficiency and reduce costs. However, the existing MIS development tools for sector-specific functions adopt object-oriented development model, and it does not support the customization and control of MIS in the process of implementation. Most of the MIS system is only a simple integration of features that enterprises need, and business process has been solidified in the system, any small changes may force the system to modify or re-developed, resulting in a lot of system maintenance overhead. At the same time, enterprises in order to improve market competitiveness, must constantly modify their business processes to adapt to market changes. Clearly, for the MIS system to better serve the enterprise, from enterprise reality, it is necessary to give full advantage of existing features (ERP systems), and also achieve process customization and control. According to the above problems, this paper presents a new type of MIS development tools based on workflow mechanism to meet the flexibility to customize and

control the process, supporting features of the platform. It has far-reaching significance to integration of heterogeneously information systems of enterprise or hospital.

A. *workflow teconology*

Workflow: (Workflow Management Coalition Workflow Management Coalition, SFMC defined) workflow is a business processes which is defined, implemented and monitored by computer software, that is a workflow system, which is different from the general working process, and need to rely on computer software, and fully under the control of the software system to complete.

Workflow system: A complete workflow system includes workflow management systems, process models and applications. Workflow management system is a workflow system infrastructure, which is responsible for storage, interpretation and implementation of process models;

process model establish service through the flow customization tool to describe and definite the control and data dependence among a variety of business processes; applications are specific operational processing activities, and the implementation of an application corresponds to a task, and a number of interrelated tasks form a process.

Workflow management system based on process model to create and start the process, and choose process routing according to the implementation of the task in process; application are tightly integrated with workflow system, and execute the schedule according to the results of the implementation of the routing process, after implementation completed, it will return results to the implementation workflow management system as basis for its process route.

B. *WFS framework*

According to its features WF-MIS make workflow mechanism embed MIS found process to set up a structure platform for the men who develop the software, thus they concentrate to developing transactional logical and active MIS of process control. The generated MIS support rebuilding-up of enterprise transactional and support recompiling construction and software's reusing in Distributed heterogeneous environment, and it supports system scale's expanding. In a word, it is a RRS(Reconfigurable Reusable Scalable)system[1], which optimizes enterprise transactional process especially key process and strengthens enterprise works' cooperation and communication. The system adopts bottom framework of CORBA communication mechanism system and is shown as Figure 1. [2]

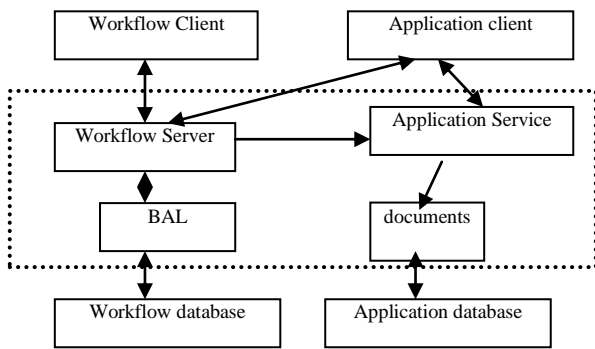


Figure 1. WFS framework structure

According to above analysis, we can know that if MIS function components are encapsulated and integrated with workflow management system, the system can not only accomplish enterprise's MIS function but customize and control process flexibly. The workflow system is a

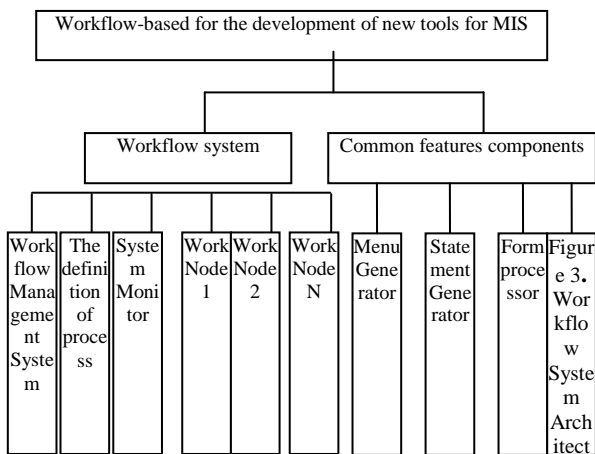


Figure 2. WFS Functional Architecture

kind of MIS which supports process customization and control and supports current function component platform. And it can smooth over the shortage of current MIS.

Therefore, we consider using workflow technology to support the implementation of flow customization and flow control, which contents some parts: workflow which is the core part and used to explain and control process executing; flow customization tool which is used to build the model to maintain process and system monitor tool which is used to the running of workflow system; work point which integrate workflow system with application smoothly via supplied interface. And function component can use current development tools. For accelerating the development of MIS function components, WF-MIS gives some common function components which can be used after simply customized. [3]

C. WFS system structure

WF-MIS which is composed of commonly function components and workflow system is described as Figure 2. The former assist to developing MIS function components ; the latter is used to build process model and control process being correctly carrying out and call transactional process application and accomplish integrating application with workflow system smoothly. [4]

1. Workflow system

Workflow is composed of customization tool, system monitor, workflow management and several work points. Process customization tool is responsible of customizing process model and offer it for workflow management system. System monitor reads workflow system running data and show system running situation. Workflow management system starts process according to process model and controls it running correctly to build the MIS fit to transactional process. Work point is the carrier of transaction process application, which accept task and carry out related transactional process application. The architecture of can be shown as Figure 3. [4] [5]

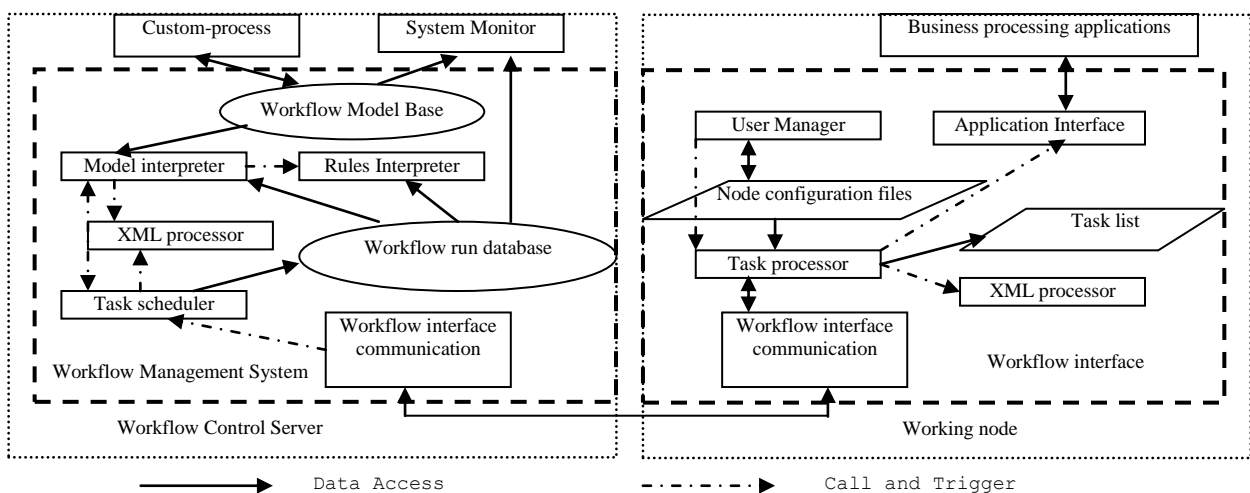


Figure 3. Workflow System Architecture

Process customization tool: It runs in workflow server as independent application, which is used to build maintain process and write process data to workflow model base. A group of basic elements such as work point, incident, condition, connection are supplied, in order to give the rout describing process. In addition, it permits several child processes embedded in process to support process reused.

System monitor: It runs in workflow control severer, which analyzes and calculates workflow running data and monitor process running situation in system and shows it with digraph to administer.

Workflow management system: It runs in workflow control severer which is composed of workflow communication interface, task management, XML processor, model explainer and procedure explainer. Workflow communication interface accept the XML document which is result from work point, and hand it to task manager. Task manager call XML processor to process application running result, XML document, and hand the result to model explainer to process. According to the result of application running and process model, model explainer found appropriate procedure and calculate it to decide the next work point.

work point: It is the carrier of transactional process application, which carry out correctly according to workflow management system calling, setting up work interface in it to implement integrating application with workflow. Workflow interface is composed of workflow communication interface, task management, XML process, model explanation, rule explanation. Workflow communication accepts task data, XML document, and hand

It to task process to deal with. Task process call XML process to process task data, XML document, to get task data and integrate it with relevant data in point disposition document to make a whole task calling data, and store it to task table. XML process explains the task data that is got by XML document. User interface calls application according to point user's choice and corresponding task data, and sends the executive result to workflow management system through task process and communication interface.

3. Common function components

Common function components are relevant with MIS application closely, assisting to the development of MIS function component. WF-MIS gives four components.

Menu maker: It supplies convenient visual menu make tools. The developer can "draw "needed menu and set relevant attribute to adjust the display style of menu. After drawing menu, the tool generates the corresponding program code (including VB, Delphi, Java, PowerBuilder), and it can be added to program.

Table maker: It is the ultimate form, which supply with data to manager, and it needs strict data show. The function component give a table maker in the form of JavaBean, which can make sure the data source, assign the table layout, and get initial table which is modified to satisfy needs. The ultimate table is outputted in the form of PDF, HTML, and Excel.

Data table processor: It is the common form of transactional data, which operator use to get data. It has three functions: auto generating data table, controlling authority, and controlling process. First, we can assign the source of table data and it relevant attributes to generate data table. Second, it decides who can see relevant table and generates relevant table according to the authority to relevant field. And it control tables running in relevant transactional process according to the relation of the transaction in table and other transaction process. [6]

Database access component: Most MIS access functions are based on the operation of accessing database. The component encapsulates common operation of accessing database to form JavaBean component which can be integrated to program. It can pass not only the signal of database model, password but also operate database with the method it give.

2. Workflow-based WFS development tools implementation

WFS is developed with Java, so workflow system can integrate transactional process application in different platforms. It describes system data with XML. With the aid of its powerful capacity of describing data, system data is convenient read and used by other systems, and system's extension is raised. Workflow system integrate with transactional process application smoothly to make sure process carried out correctly. The application interface in workflow interface is used to application integration. But owing to the complex situation of transactional process application, the implement of application integration is very complex. (1).If it is common executive program, it can be called. (2).If it is WEB application, it use Request object to pass start parameters to application. (3).If it is component program, it should be integrated as possible. If necessary it can be integrated as WEB serve and implement WEB serve client. Development worker use Jobuilder 9 to develop relevant component and implement relevant integration [7]

V. STUDY OF LARGE-SCALE HOSPITAL INFORMATION SYSTEM INTEGRATION

A. Large-scale hospital information system integration system

Hospital information system integration using process customization and process control as the main line is a new MIS workflow-based development tools for the integration platform. Any other business subsystems are based on this platform to achieve interconnection and information exchange, as well as the application and data integration. The platform is divided into three layers, namely, business process layer, business layer and business agent system layer. The main features of this program is based on the business process workflow management, system architecture for the platform through standard adapters, application systems across the communications and XML-based unified data model

1. Overall system architecture

In order to achieve heterogeneous integration of hospital information system, The overall structure of the

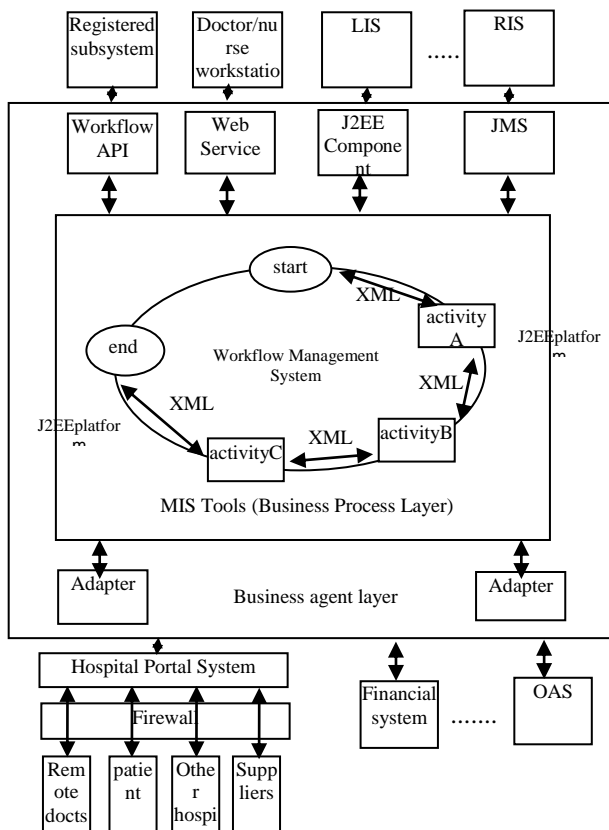


Figure 4. System architecture diagram

system is designed as Figure 4. The business process layer is in the center, and the realization of process management is the core of the system. The business system layer through the various agents of the business agent layer achieves the business system interaction to achieve the hospital's business processes. Layer of its business agents using various agents J2CA based on the Adapter, Web Services, Workflow API J2EE Component, such as technology or JMS. Our platform is based on J2EE, in which the business process layer and business proxy layer run on the J2EE Server and share services such as security and Services provided by J2EE Server.

2. Business Process Layer

The main function of the Business process layer is the design of business processes, to explain the implementation of business processes, and the use of XML format data to achieve all of the information transmission subsystem, thereby to accomplish the hospital's business. In addition, it has to process monitoring and statistical functions for the hospital management to provide process data to help them find the bottleneck of the system in order to optimize the process.

Business process layer by the workflow management system to achieve, that is a software system used to define, achieve and manage the workflow and interact with the workflow actors (people, applications) to promote the implementation of workflow instances and monitor the work of running stream. A workflow, including a set of activities and the order of their mutual

relations and activities also include the process of start-up and termination conditions, as well as a description of each activity. For commonly used business processes, can use in the future in "template" form of preservation. The introduction of workflow management system makes the system can be configured to provide a flexible link, process customization and scheduling algorithm to choose the functions and carry out in accordance with the configuration of various business processes customized requests and scheduling. It can achieve the various business processes of a unified planning and processing, from the point of entire system view. On the one hand, a variety of requests to ensure that all aspects of the system's smooth handling, on the other hand, to ensure that these operations can be the best allocation process. Operational requests may be made from the patient for treatment, but also can come from doctors, nurses and managers.

The system of workflow management system is running on the J2EE platform as part of the J2EE Server. The development of workflow management itself is not a hospital system. To a large extent, workflow management system provides a software support environment for the integration and operation of the hospital system. In the workflow management system, supported by development tools, it is able to complete a good run of the supporting and the control of hospital business process through the integration of specific business systems and associated interface operation use of personal.

3. Business agent layer

Acting through the following business layer technology to achieve a variety of business systems in each layer with the business process layer interaction, and business processes through the various layers to achieve the interaction between business systems and achieve specific business processes of hospitals. We use the J2EE platform, so each agent business agent layer are J2EE-based technology, which is based on J2CA the Adapter, JMS, Web Services, Workflow API, or a J2EE Component Technology.

Based on J2CA the Adapter J2EE Connector Architecture defines a different types of information system (EIS) to connect to the J2EE platform, the standard architecture. J2CA also defines a series of scalable, secure, transactional mechanisms to connect the heterogeneous EIS with the application and systems. J2CA also defines the CCI (Common Client Interface) to be accessed on the EIS. J2CA allows EIS suppliers to provide a standard resource adapter for their EIS. The resource adapter can be embedded application server, in order to achieve the EIS application servers and enterprise application connectivity.

JMS (Java Message Service) message-oriented middleware (MOM) is increasingly becoming the main component of application integration. It is critical for systems to exchange data and events to trigger the provision of a reliable and flexible service. In order to enhance its portability, J2EE platform gives a JMS (Java Message Service), and JMS enables Java code to create,

send and receive messages in a common way, which makes Java code written in JMS adapt to different message middleware products.

Web Services is a new SOAP-based service delivery model. The basic elements of the model is a SOAP / HTTP, XML, WSDL and UDDI. Web Services use a loose bundle of services form to develop, publish, discovery and achieve dynamic binding application fast and with a low cost, but also can achieve the application-level functions or methods of integration. They are not natural-based services, while providing a basic "request / response" feature. The current version of Web Services exists a performance, complexity and security issues, but it is still quite useful for interactive cross-platform. The interaction between Components under different platforms can be achieved as long as the realization of a Web Services interface for them.

In order to more flexibly control the process, we make use of the Workflow API provided by the Workflow Management System to achieve direct control of the process. By using it, we can customize the functionality that workflow management system provides to the customer, which makes the work flow management and Control easy to melt in our business systems. For example, expanding the worklist of workflow capabilities and adding features in business systems, can make it more in line with our request.

J2EE Component (J2EE components) J2EE Component refers to the deployment of J2EE Server in the EJB component. EJB component J2EE Server to provide access to various services, making the preparation of EJB components simple. Various business systems through the deployment of the J2EE Server's EJB component provide services to other business systems in order to achieve the interconnection.

4. Business system layer

Business system layer is to achieve specific business operational hospital level, including the registration system, doctors workstations, reproductive center management system, management system for physical examination, blood transfusion management system, surgery, anesthesia management systems, subsystems clinical experts, medicines management system and economic management system, integrated management and statistical analysis systems, data security management system, laboratory and central laboratory information systems, picture archiving and communication system, office automation systems and external systems and so on.

Business system layer that is the layer of the most important task is to provide the agent of the business agent layer. Because the business system layer of the business systems is achieved by different vendors, and other suppliers can not know how to implement the technology with the Internet, so it can only be made by all suppliers of business systems business systems to provide their own agents. Workflow system is running in the process, through a proxy to achieve with the various business sub-systems interact to achieve the entire process from.

B. large-scale hospital information system integration Case

During the system integration, Registered patients is the function of the patient registration system, doctor's orders belongs to the functions of the workstation, fees and charges are charging function of the system, checked under the PACS system function, testing is the function of LIS system, medicine is medicine management system. Subsystems realize agents by the various techniques described in the integrating program, and access business processes layer through a proxy. In this case a simplified outpatient procedures are used as an example to discuss the workflow-based large-scale hospital information system integration process. Each activity in the Figure through a proxy to interact with various subsystems in order to complete the business process. The workflow model is shown in Figure 5.

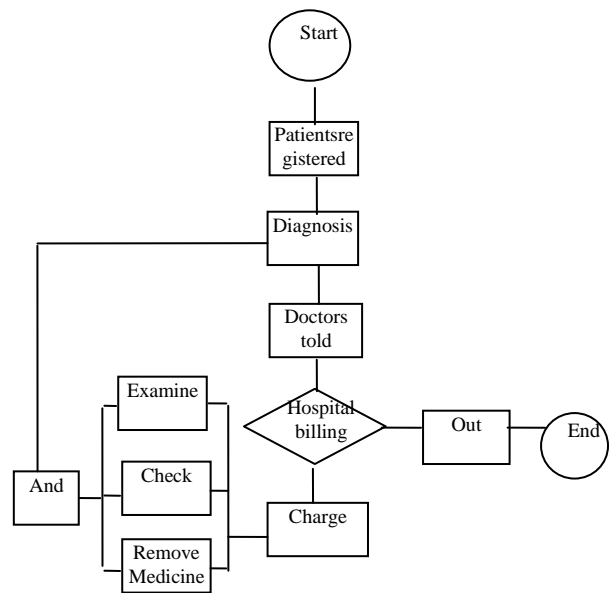


Figure 5 out-patient flow chart

VI. CONCLUSION

Practice has proved that: This paper presents a workflow-based large-scale hospital information system integration solutions using WFS development tools as the integration platform, using each business expert system as working nodes, which allows developers to only use WFS provides application integration components to do some appropriate programming to achieve the strong coupling links of the application interface of the working nodes. Service Agent-layer technology achieves the various subsystems into the business process layer of the hook, the running of process fully describe that information in various subsystems has a good transmission. Information adopts a unified XML format, which is a good way to achieve a unified data format and conversion.

Through this integrated platform we can integrate information resources inside and outside the hospital

achieve the hospital business norms, streamline and accelerate hospital business processes, and achieve high efficiency and low-cost operation. At the same time, we can increase efficiency and management of hospital clinics to provide patients with more convenient medical services. Therefore, to achieve large-scale hospital information system integration is a guarantee of sustainable development to hospital information system.

ACKNOWLEDGMENT

This work is supported by Youth Fund of Sichuan Education Department (NO.2007B021) and Youth Fund of Neijiang Normal University (No. 07NJZ-09)

REFERENCES

- [1] D. Hollingsworth, The Workflow Reference Mode, Workflow Management Coalition , 1994, pp.11-35
- [2] F. Casati, S. Ceri, and B. Pernici etc, Workflow evolution Data Knowledge Engineering, 1998, pp.211-238
- [3] F. Leymann, D. Roller, "Workflow-based applicaion", IBM Systems Journal, 1997, pp.102-123
- [4] S. Khodakaram, W. Mike, "Petri net-based modeling of workflow systems An overview", European Journal of Operational Research, 2001, pp.664-676
- [5] C. Prior, Workflow and process management, Workflow Management Coalition Handbook , 2002, pp.34-45
- [6] G. F. Paul, R. R. Vries, "A Reference arochitecture for Workflow Management System", Data & Konwledge Engineering, 1998,27pp.32~34,38~42
- [7]] R. Agarwal, G. Bruno, and M. Torchiano, "An Operational Approach to the Design of Workflow System", Information and Software Technology, 2000, 42, pp.549~553
- [8] Karl R.P.H Leung et al. The Liaison Workflow Engine Architecture. Proceedings of the 32 Hawaii international conference on System Sciences, Hawaii, Jan 1999
- [9] R. Tagg et al. Preliminary Design of a Lightweight Workflow Server.Australasian conference Information Systems, Australia, 1997
- [10]] Y anbo Han, Amit Sheth, Christoph Bussler. A Taxonomy of Adaptive Work(CSCW'98),Towards Adaptive workflow Systems Workshop,Seattle,1998
- [11]] M. Kang, J. Froscher, A. Sheth, et al. A Multilevel Secure Workflow Management System. Proceedings of the 11th Conference on Advanced Information Systems Engineering(CaiSE'99),Heidelberg, Germany, 1999
- [12] Mathias Weskel, Thomas Goesmann, Roland Holtenl, et al. A Reference Model for Workflow Application Development Processes. Proceedings of the ACM 1999 Conference on Work Activities Coordination and Collaboration, San Francisco, 1999
- [13] K. R. Abbott, S. K. Sarin. Experiences With Workflow Management: Issues for the Next Generation. Proceeding of the ACM 1994 Conference on Computer Supported Cooperative Work (CSCW'94), 1994