

Development and Research of Workflow Management System Based on Mobile-Agent and CORBA

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Abstract

The workflow model is used widely in modern society office, production and manufacturing fields in computer environment. It plays a more and more important role in the office circumstance, industrial and manufacturing domain with the development of computer automation in modern business. Workflow management system is a tool. It is also a platform to develop and implement the workflow. But heterogeneities under distributed network environments hamper the coordination among the tasks in a workflow management system. We propose a new workflow management system based on CORBA and mobile-Agent to solve these problems. And we make the detailed analysis of this system. Firstly, this paper introduces the research background and research status. The second part is the related concepts of workflow management system, CORBA and agent technology under a distributed environment. The third part is the new workflow management system. The last part is the conclusion.

Keywords: WFMS, Mobile-Agent, Multi-Agent

1. Introduction

Workflow is a concept which puts forward to aim at doing the conventional activities of fixed program in computer automation environment. It executes and monitors by dividing the work activity into well-defined tasks, roles, procedures and processes. The method can achieve to improve the production organization level and the work efficiency with computer. The concept of workflow originates in the production organization and the field of office automation. In the 1990's, the information resource of the modern enterprises shows more and more characteristics of heterogeneous, distribution, loose coupling and the extension of the network. These features indicate that the time of the centralized information process has passed. It becomes a trend to implement the heterogeneous distributed execution environment. It makes the related tasks operate effectively. The organization for standardization of the workflow management coalition of the workflow technology was established in 1993[1]. The establishment of this coalition marks that the workflow technology has entered a relatively mature stage. Besides, it plays a more and more important role in the research field of the application computer.

The workflow products on the market have a rapid development. They have continuous improved in the competition with each other [2]. However, the traditional workflow management system still exists many drawbacks. These drawbacks are as following: (1) It lacks the architecture which supports the loose coupling, such as the EAI model which is put forward by Losavio F, Oertga D and Perez M [3]. (2)It is short

of the common communication framework, such as the enterprise business system integration which is proposed by Erasala N, YenCD and Rajkumar T M [4]. (3)It lacks the self-organization ability, such as the multiple types of workflow model which is put forward by Oba M and Komoda N [5].

Agent is one of the most active frontier research directions in some fields. These fields include the computer science and technology, information engineering and communication field. M. Bardshaw introduces the agent [6].The international research has been carried out an agent for many years in the workflow management. Hironobu Kitajima and Fumhtiro Muaryama state the agent from the view of the information integration and knowledge representation [7]. They have got some preliminary application system prototype such as the automatic agent and the multi agent which is put forward by Nihcolas R. Jennnigs and KatiaSycara *etc.* There are some models which are applied in the field of industry that is put forward by H. Van and Dyke Punark. There are also some multi-agent modes which are put forward by Mark F Wood and Scott DeLoach [8-10]. In China, the research on this area is very few. It can be seen in some relevant literatures in recent years. It has not been the practical application of specific products [11-12].Swaminathan, J. M, Smith, S. F and Sadeh, N. M have studied the enterprise supply chain process. They map the supply suppliers, distributors and customers in the supply chain into an autonomous agent. They also establish the model to study the dynamic behavior of the enterprise supply chain [13]. Jeff Y. C. P and Tennbaum J. M and other scholars propose a multi-intelligent agent technology to establish the basic structure of the computer of the enterprise workflow management. They divide the complex business activities into several components. The task of each component is performed by an intelligent agent [14]. K. R. syacra and other scholars introduce a monitoring agent and several scheduling agent. They have established a distributed, heterogeneous, multi agent workflow control system [15]. Winedhlnad and Resll introduce the agent technology into the workflow planning and the system control. They divide a large and complex workflow management system into several relatively autonomous functional units. They achieve to manage and control functions by the cooperation among the various units [16]. Xu Qingsong and others analyze the enterprise management system requirements under the multi-association environment. On the basis, they introduce the multi-agent into a virtual enterprise. And they put forward the multi-agent enterprise management model which supports the dynamic alliance-AMIS [17].

However, with the development of network technology and the complexity of modern business office, the transfer among information is more quickly. The contact among every organization in an enterprise is more closely. Therefore, it is very necessary to establish the dynamic workflow management system in computer automation environment. Now, we introduce the distributed computing environment-CORBA. The traditional distributed computing can't adapt the complex, metabolic workflow definition. At the same time, with the development of mobile computing in a workflow management system, it is also important to introduce agent technology. This agent technology has some advantageous features such as continuous operation, intelligent processing and the ability of self-control *etc.*

Therefore, we put forward a mobile agent of the workflow management model which is based on COBRA. The COBRA can transfer information effectively among the organizations with the underlying communication model support. At the same time, multi-agent and mobile agent can dispose the workflow application together. It can also improve enterprise efficiency.

2 The Concept of Workflow, CORBA and Agent Technology in Distributed Environment

2.1. Workflow Management Aystem (WFMS)

The organizations will participate in the business process. In order to achieve the business goals, the documents, information or tasks transfer among the participants according to a set of planned definitions in that process. Workflow is a part of the process which is achieved automatically by the computer. Workflow management system is the system software which is used to define, manage and execute workflow. It interprets and executes the process definition by running multiple workflow engines. It interacts with an external resource and promotes the execution of a workflow instance. Workflow engine is mainly used to describe the necessary steps of a business process. We call each step as activity in the business process.

A workflow management system is constituted by the business process modeling and the workflow operation module. In the stage of business process, we simulate the realistic business process. Then, we use the data structure which can be processed to indicate. The process can be defined as a process definition. In the workflow runtime, workflow services create a workflow engine to manage, control and schedule every step of the workflow. Then it can achieve the process definition.

Workflow management model is an abstract description of the workflow. It is also an abstract representation of the business process. The model structure is shown as Figure 1. Business Process Reengineering (BPR) is used to estimate, analyze, model, define and operate a core business process in a department or other entities.

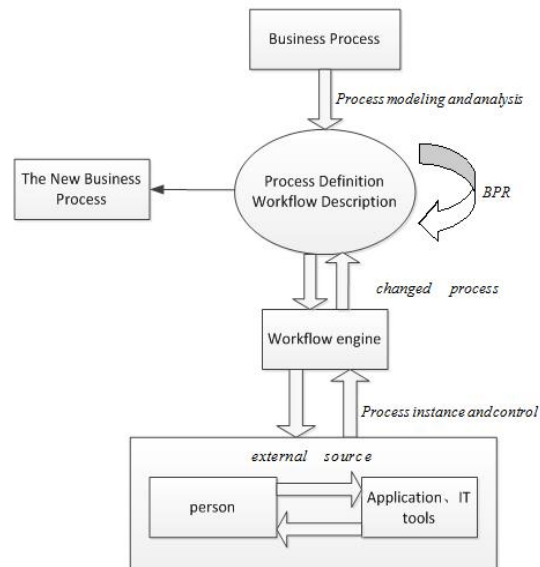


Figure 1. The Structure of Workflow Management Model

2.2. Workflow Interoperability

Interoperability is also called as Collaborative work. The workflow management coalition (WFMC) defines the interoperability as following: Interoperability is the ability of inter-

through and inter-operates through coordinating and operating the workflow instances by two or more workflow engines. The differences among the hardware, operating system, and network protocol and application software are in Internet. But Intranet has a characteristic of heterogeneous. Distributed computing platform demands that the workflow application system must have strong interoperability. The distributed workflow system which is based on Internet and it includes the internal protocol definition, program interface, the interoperability of data sharing and this connection. This connection describes that the workflow system is how to embed into other business system or how to achieve to connect with other heterogeneous systems. The implementation process of the workflow management system is showed as Figure 2.

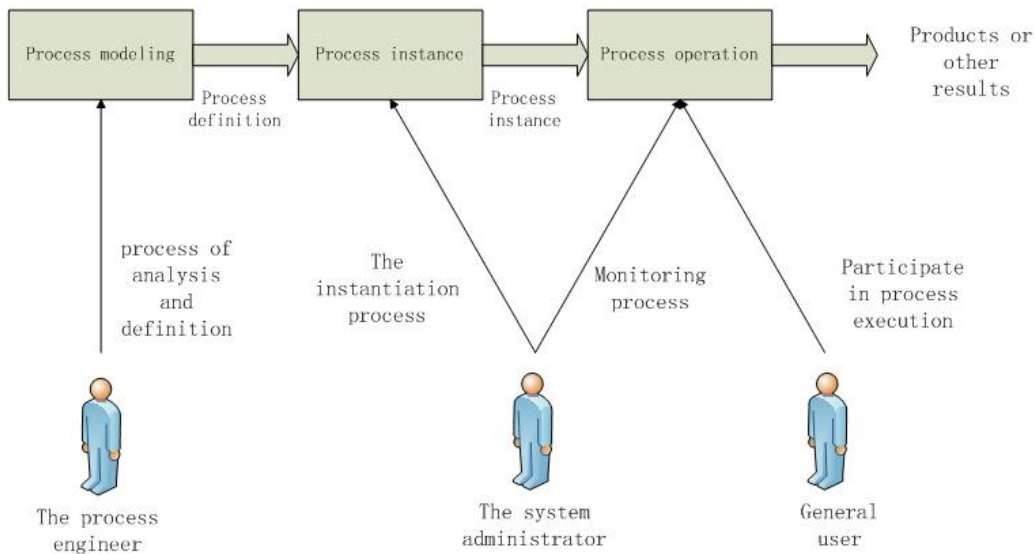


Figure 2. Implement Process of Workflow Management System

2.3. The Technology of CORBA and Agent in the Distributed Environment

2.3.1. The Concept of COBRA: Middle-ware is also called as a distributed computing system. It is a layer of software which is built on the network layer and the transport layer. It achieves heterogeneous standards and interoperability package by providing a series of application programming interfaces and the conversion between the client and the server. In order to achieve the interoperability of multiple system stages in a heterogeneous distributed computing environment, the object management group (OMG) puts forward a middle-ware based on distributed object technology. The core of COBRA (common object requests broker architecture) is ORB (object request mechanism). In this mechanism, objects can send request and receive a local or remote object response transparently.

2.3.2. The Concept of Mobile Agent: Agent is software which has a certain Agent. It can help users to complete simple or repeated operations. It usually keeps a certain state. It can also exchange information between its all owners and the other Agent to achieve the collaborative work. The Mobile Agent is running on heterogeneous networks. It can be autonomous mobile and running continually according to certain rules. In the domain of distributed computing, we usually call the computing entities as a mobile Agent. These

computing entities have some features such as autonomy, interactivity and reactivity. The actual operation location is called runtime environment. The user's application is bound to a mobile Agent execution environment. Application can pass the parameters to the Agent program through an Agent execution environment by using the API. Then, it can make the Agent program perform a variety of tasks. Agent program can also return the parameters to the application program.

2.3.3. Mobile Agent Remedies the Deficiency about COBRA Technology: In distributed computing technology COBRA, different objects use client/server which is based on request/response mode. If we want to receive a service, we must call a kind of method about the remote object. Then, we need to keep the communicating network between client and server for remote data transmission and information exchange. We describe the interface between client and server by using IDL language. Mobile Agent which is based on RP (Remote program) is an extension of traditional client/server model. For a task process, the request codes transfer to the data point and complete the calculation. In this process, the connection between calling and called nodes just needs to keep going when the process moving and returning the results. Then, it can achieve the ability to transfer and acquire resource information in asynchronous transfer mode. It is the true meaning of distributed calculation. From the technical point of view, COBRA is perfect. But it can't make the real independence on the interface between the client application and the object implementation. The component interoperability and reusability also stay in code level. Mobile Agent which has cross platform running and self-control ability is a distributed object computing in the heterogeneous network applications. The object encapsulation, inheritance and reuse characteristics rise to the level of semantic and knowledge. It can make up for the deficiencies of COBRA.

2.3.4. The Deficiency of COBRA and Agent: In a distributed and heterogeneous environment, COBRA and Agent technology are complementary. On the one hand, Agent can make up for deficiencies of COBRA in application integration, interoperability and reusability. On the other hand, the COBRA specification has good flexibility and security. This advantage provides an ideal foundation structure for Agent in independent mobility, migration patterns and security. We combine these two techniques together and construct a workflow management system framework of mobile Agent which is based on the COBRA standards. It opens up a new space for development in heterogeneous environment workflow interoperability, openness and scalability.

3. Multi-Agent Collaborative Workflow Management System

We apply CORBA and Agent technology to the distributed workflow management system. We also establish the hierarchical workflow form as shown in Figure 3. The underlying communication architecture of this structure uses CORBA distributed processing environment, monitoring coordination workflow engine, a user application, and resource management system. They are realized by different Agents and the form the multi Agent cooperation system.

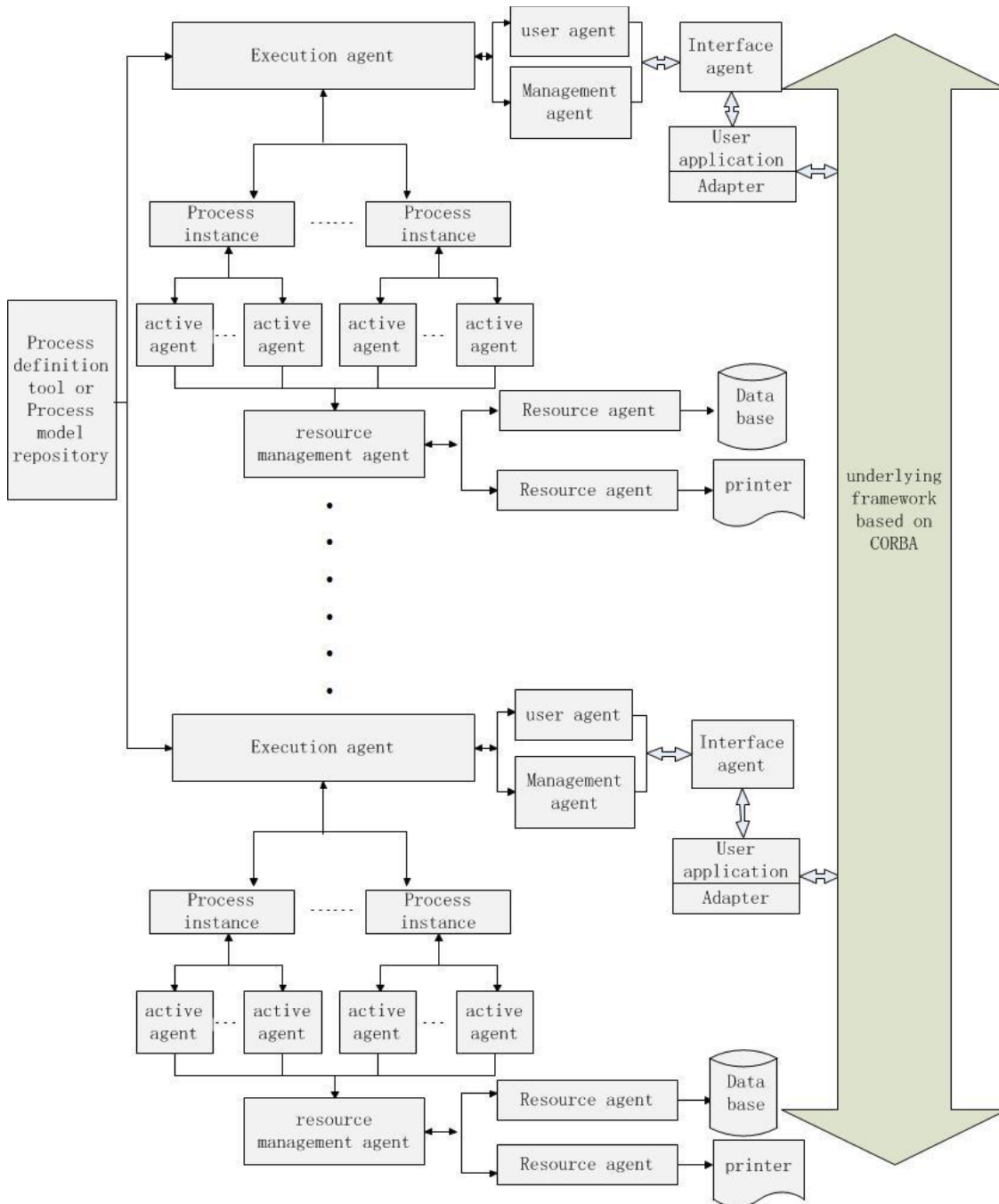


Figure 3. Model of Workflow Management System based on Multi-agent and COBRA

3.2. The Underlying Architecture of CORBA

In this structure, object requests broker (ORB) provides communication services to other objects. These objects include event, naming, query, monitoring unit and object service which are composed of the recovery mechanism. This process describes the Interface with the IDL

language. Different components and different functions Agent are connected to the ORB directly. External application system connects to the ORB through the interface adapter.

Objects between CORBA collaborate to realize the programming language independence through IDL call. Above measure not only realizes the seamless connection of heterogeneous, autonomous and distributed information resources, but also the object interface and object implementation phase separation. The goal of this measure is to make the change of internal behavior will not affect the customer access to this object. Application system can be easily integrated into the workflow system through the pile, the frame or adapter. All of these bring good reusability, reliability and scalability for workflow management system.

3.3. Function of multi-agents

(1) Interface agent: The management of activity is actually to manage the activity of people. Interface agent links with the different user in the enterprise. It plays a role to management user, assist user, collect resources and collect resources. Sometimes it makes an intelligent decision to replace user.

(2)The executive agent: The executive agent is the core organization in this system. It is also the management service of the workflow execution service. It allocates and manages the behavior and cooperation of the other agents in the workflow execution service directly or indirectly. It communicates with the other agents by the method of message negotiation. Further, to some extent, it can ensure that the other agents have autonomy. It's mainly functions are as following:

① Management of process definition model: The mission of executive agent is that it needs to load the workflow process definition model necessarily from the storeroom of workflow process definition model. Then, it can achieve the initialization work of every workflow process definition.

②Management of system information: After the executive agent is created, it will manage to relate to data of the workflow in the system.

③Create and manage the process agent: For each separate workflow instance, firstly, executive agent will create a process agent which is based on the response workflow process definition. The process agent is responsible for the operation of the workflow instance. Besides, the executive agent is also responsible for setting the executive environment of the workflow instance which is corresponding to the process agent. Then it dispatches the process agent to the appropriate to execute. The executive agent also monitors the operation of the process agent.

(3)The process agent: The process agent is in charge of the execution of a workflow instance. The active agent takes charge of every active agent. And it controls the execution and scheduling. When the system starts a workflow process instance, it will create a corresponding process agent to responsible for. The process agent completes every specific task by creating an active agent. The process agent promotes the process instance by knowing the executive order of the activity and the actual information. After the process agent was created, it will not be intervened by the executive agent.

(4)The active agent: For each activity in a workflow instance, the process agent creates a unique active agent to execute. The relationship between the active agent and the process agent is management with each other. The interaction between the active agent and the process agent is by using message. The active agent is charged with the management of activity instance. Besides, a majority of works are done by the interaction with users and

resources. It visits and requests all kinds of resources by resource management agent while achieving the interaction with the relative participates by the user agent.

(5)The resource management agent: The resource management agent is used to manage resource information and the resource agent. It provides the relative information to the information resource agent. If the other agents want to interact with a resource, it will inquire the information from the resource agent. Each resource agent will register with the resource management agent when it begins to operate. The resource agent will cancel it to the resource management agent when it need not resource agent.

(6)The resource agent: Most of the activities in the workflow management system complete by the interaction with the resources. Workflow involves a variety of resources. Broadly speaking, resources can include software objects (such as component objects, application etc) and hardware devices (such as printers etc). But in this system resources refer to the relative software and hardware resources. The system creates the corresponding resource agent for every resource. The system uses the resource agent to contact resources.

(7)The user agent: The user agent is charged with the interaction between system and the outside world. It provides the connector between the system and users. It also manages the users and assists users to complete the daily repetitive operations. The user agent of this system can also be viewed as an assistant agent.

(8)The management agent: The management agent is used to monitor and coordinate the normal execution of the other agent. It divides into the monitor agent and the coordination agent. Monitor agent monitors and detects the activity schedule. It transmits the abnormal conditions and performance bottleneck reports to the coordinate agent and administrator by moving each site and log online. The coordinate agent focuses on the coordination among each related workflow execution service. When it encounters the resource conflict shortage or other reasons which cause the activity could not continue, it will hand the problem to the coordinate agent to solve. Then, it returns the results to the workflow execution service to operate. It can ensure that the whole activity runs orderly and efficiently. The mobility of the agent can achieve cooperation among the workflow services of different hosts or sites. It can also achieve the application of the distributed systems in future, such as integrated product development and enterprise alliance *etc*. Besides, the management agent is also responsible for the functions of system management. The functions include user management, role management, rights management and process management *etc*.

3.4. Operation Process of Multi-agents

The process of this system is as following:

1. The start of the active agent: The start of the active agent can be triggered by system administrators and ordinary users. It mainly completes the system initialization. It includes that the relative data of the initialization system, loading the process definition model necessary and creating and managing the necessary process agent.
2. After the executive agent receives a request to create a new workflow, it will create a corresponding process agent. Then the executive agent transfers the necessary parameters to the process agent. It includes that the corresponding process definition and the relative workflow data. When the process agent has initialized, it starts the process. When the process

starts, it will hand it to the process agent to responsible for its operation, management and control. If necessary, it will be terminated by a process complies.

3. When the process agent starts a process, it needs to explain the corresponding process of the process definition, the generation process route and the corresponding strategies. Process agent creates each activity agent according to the process route. The specific definition of the activity of the process model will be acted as a parameter which is passed to the active agent. The active agent is responsible for completing each specific activity.

4. When the active agent acquires the permission to start execution, it will start up the corresponding activity. While the activity is running, it is possible to interact with some users. The active agent is also responsible for communication with each resource agent. It asks the resource which is using freely or not. Then it acquires the resource and completes the task together.

5. When the active agent executes its own task, it returns the results to the process agent. The process agent determines the next activity according to the rules of the process execution. It creates the corresponding active agent. If it could not find the performance activity, active agent needs to judge whether the process is finished and report the results to the execute agent. If the process does not finish, the process agent will execute all of the operations. Then it cancels itself. The results of this process are delivered to interface agent. And then they are transmitted to users though COBRA. The execution of the process is completed.

6. Because the model is a distributed application system, it can achieve the remote resources or functional call. It can also correspond with the remote site agent by the mechanism, carrying code, state or data to complete an action or task (such as computing, query *etc.*).Then it returns the results to the local site.

3.5. System Management Module

System management module includes: rights management module, operation management module, role management module, department management module, user management module and process management module. The results are showed as Figure 4.

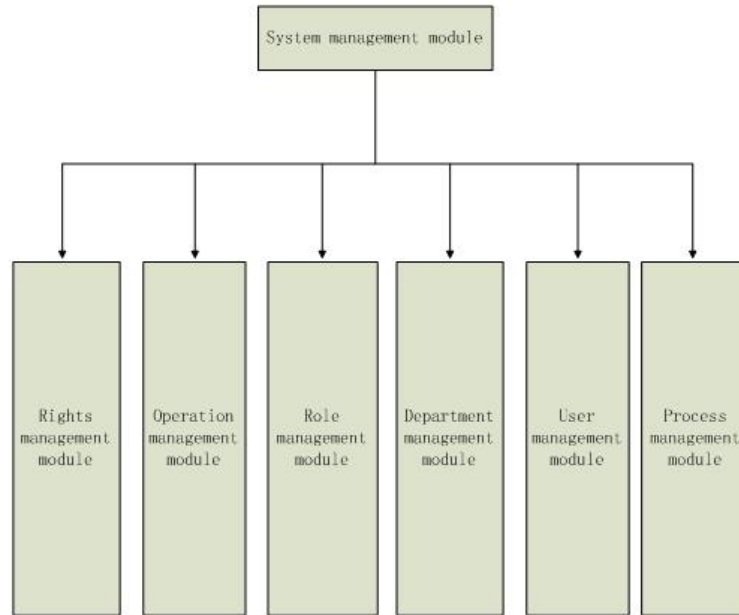


Figure 4. System Management Module

Rights Management module: Manage the rights of users.

Operation Management module: establish the new process and alter established process.

Role Management module: Manage the roles of users.

Department Management module: Manage the department users belong to.

User Management module: Manage the information of users.

Process Management module: Manage the operation and activity.

4. Conclusion

In real life, workflow model is used widely in modern society and plays a critical role in computer environment. Modern enterprises have higher requirements for workflow system. In this paper, we discuss a workflow management system based on mobile –agent and COBRA. In this model, we set COBRA as a communication language in this model. This technology can make up for the lack of an agent. On the one hand, Agent can make up for deficiencies of COBRA in application integration, interoperability and reusability. On the other hand, the COBRA specification has good flexibility and security. The model combines the advantages of agent and CPBRA, so the new system can improve the system flexibility and applicability greatly.

It is a very complex project to realize a workflow management system of powerful function, convenient operation and excellent performance. There are still many works to perfect and optimize. For example: the correctness and integrity verification of the workflow process model and refine system component function and so on.

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