MASOAERP: A MOBILE AGENT-BASED SERVICE-ORIENTED INTEGRATION ARCHITECTURE FOR BATCH CUSTOMIZATION ERP PRODUCTION

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Abstract: The IT infrastructures in traditional ERP were managed and owned by one enterprise being switched to networks of applications owned and managed by many business partners. Through this revolution, ERP system can be more robust and agile to the transient market opportunities. In view of the fact that distributed organizations are generally managed using heterogeneous software systems running on heterogeneous computing environments, Web Services technology provides a higher-level interoperability for leveraging business activities across the Web either within an enterprise or among collaborating enterprises. On the other hand, the characteristics of mobile agent systems present a way for resolving heterogeneity. We believe that the combination of Web services and mobile agents provides a promising computing paradigm for efficient service selection and integration of inter-organization business processes. This paper proposes MASOAERP, a mobile agent-based service-oriented integration architecture for batch customization ERP production. A prototype system is designed to demonstrate that MASOAERP can custom the collaborative ERP software under the opening, dynamic and changeable environment, realize the business enterprise alliance resources service of the dynamic state integration.

1 INTRODUCTION

The manufacturing enterprises of the 21st century are facing an environment where markets are frequently shifting, new technologies are continuously emerging, and competition is globally increasing. The rapidly changing needs and opportunities of today's global market require unprecedented levels of interoperability to integrate diverse information systems to share knowledge and collaborate among organizations. The traditional ERP, which is C/S or N-layer architecture, can only solve the problem of business process integration inside of the enterprise, but for the resource integration and knowledge sharing among the alliance enterprises it has severe limitation. The IT infrastructures in traditional ERP were managed and owned by one enterprise are being switched to networks of applications owned and managed by many business partners. Through this revolution, ERP system can be more robust and agile to the transient market opportunities.

In the future, the ERP system production under the Internet computing environment is based on a platform, which is fruitful in ERP service resource and has open, dynamic and changeable software architecture. The challenge provides a scarce opportunity for our studying collaborative ERP system theory, method and technology, the study emphasis of ERP system software and support platform is changing from C/S to new system platform. The constructing technology of ERP system based on new middleware platform shall make a breakthrough. In the project supported by national 863/cims subject aid financially (granted No. 2002aa414040), and the project supported by Jiangsu province natural science foundation, China (granted No.07KJD520089), we proposed MASOAERP, a mobile agent-based service-oriented integration architecture for batch customization ERP

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production, construct service-oriented dynamic architecture ERP model under the internet environment, and discuss the customization production implement of collaborative ERP system.

2 RELATED WORK

Currently the technologies of enterprise resource integrations, such as CORBA, XML, Agent and UDDI, are insufficient for the support of the dynamic enterprise alliance resource integration, especially for the support of the inhomogeneous cross-platform information system are insufficient and cannot satisfy the customized production of cooperative ERP based on the Internet computation. New technologies based on single Web, such as Web services and mobile Agent, also cannot fulfill the needs of the dynamic enterprise alliance resource integration (Wang et al., 2006). Reference (Wang et al., 2006) presented the cooperative model of the enterprise inner work-flow, in the proposed model, agent-based technology provides the workflow coordination at both inter- and intra-enterprise levels while Web service-based technology provides infrastructures for messaging, service description and workflow enactment. Reference (Lau, 2006) designed and developed the distributed service discovery and negotiating system for the implementation of B2B E-business with the web service and intelligent agent technology. Reference (Foukarakis et al., 2006) presented a mobile agent platform based on the integration of the mobile agent computing paradigm with Web Services, WebMages (Web-based Mobile Agent System), which providing a lightweight agent run-time environment inside a web container, thus adding agent functionality to existing Web Servers. Reference (Artail and Kahale, 2006) presented an integrated framework based on multi-agent collaboration and case-based reasoning that can resolve collaboration issues in the supply chain. Reference (Kwon, 2006) indicated the deficiencies of the web service, namely insufficient for the abundant representation methods and the attractive strategy, and presented intelligent service and web service autonomy mechanism based on semantic cooperation. References (Cil, 2005), (Arantilis et al., 2006), (Yuan, 2006) researched the web based information system integration. On the other hand, many researchers have researched the web based ERP system. Reference (Zuo-ming et al., 2006) presented and developed the web based ERP system, which solved the problem from the simple office automation to the complicated supply chain management for the management of the real world operation process. Chinese scholars have done some work also, for example, Reference (Petrie and Bussler, 2003) analyzed the evolution trend of ERP, proposed the element model of the service oriented architecture and the ERP system integration strategy. Based on the traditional ERP architecture, it also proposed a kind of service oriented ERP integration model. The author also made in-depth study on the ERP production model, reference[11] proposed the ERP batch customized development model based on version management driven by enterprise requirement and exactly pointed out that the batch customization is the direction for the ERP production mode. Enlightened by the references above, through studying about the Service-Oriented Architecture and mobile agent technology, we propose the service oriented collaborative ERP customization based on mobile agent. The aim of our study is to provide a new implement project for the batch customization of collaborative ERP product under the internet computing environment by utilizing the application resource intra- and extra-enterprise to dynamically integrate and aggregate the service component according to the enterprise demand and the dynamic model.

3 INTEGRATION OF SERVICE-ORIENTED ARCHITECTURE AND MOBILE AGENT

Service-oriented computing (SOC) is considered as a new computing paradigm after the object-oriented paradigm. It utilizes services as fundamental elements for developing applications/solutions. Services are autonomous platform-independent computational elements that can be described, published, discovered, orchestrated and programmed using XML for the purpose of developing massively distributed interoperable applications. Web services technology is part of the SOC paradigm and can be considered as an implementation of the SOC model. Web services provide an appropriate paradigm for building open large-scale application environments, such as ERP. In such environments, services are not treated as isolated and one-time affairs but rather as elements of an interactive, dynamic and collaborative architecture.

Mobile agent is a kind of program that can be transferred autonomously from one host computer to another under the heterogeneous network environments and can interoperate with other agent

or resource. Besides of the properties of software agent, mobile agent has the property of mobility, it can be transferred autonomously from one host computer to another in the network to realize the appointed task for the user.

The customization production of collaborative ERP product under the Internet computing environment is driven by enterprise demand and based on enterprise dynamic model to realize the cooperation integration of enterprise service. Pure Web-based technologies, including Web services, cannot fulfill the needs of enterprise applications, particularly in that: (1) the Web service discovery mechanism is not enough for driving enterprise alliance creation at run time; (2)the Web service description is not enough for driving enterprise alliance services description that is semantically intensive; and (3) the Web services business processes description, orchestration, and security have hardly reached a maturity for process automation.

Combining Agent with Web services is the developing direction of SOC. In the computing paradigm, every software component is a service and an agent also. Under the special application environment, it provides uniform service. Huhns and Singh predicted[12]:"Agent would become the important part of most Web based application."

Here we propose a different integration method of MA and Web services. In our method, MA is a kernel inside every Web service, and Web service is a container. MA is the base of Web service architecture. In this model, MA isn't used as the former or protocol of service communication, but used as basic software entity encapsulated in Web services.

We combine MA with Web service to construct the architecture of enterprise application. This method not only could make full use of both advantage, but also conquer the limitation derived from applying the two techniques separately, and construct the service integration architecture required by the mass customization of ERP product under the Internet. The publishing, finding and binding of Web service could be looked as terminal service programs with relatively long life cycle, which usually responds remote request and is fit for remote service transfer. MA is intellectual software component, which is conscious, dynamic and autonomous. It could contain state parameters and data, and automatically move between two running host computers, so it is fit for part service transfer. Because classical agent is on special platform and designed tight coupled with special agent, which means it couldn't coupled with agent of other kind, the service model restricts the interoperability of agent. Our method provides an independent platform to realize MA system. We put the MA into Web service, and use XML to describe the state and data of MA. SOAP is used for the communication of agent to transmit state parameters of MA and attachment information. The remote communication of MA is realized by Web service as follows. Firstly Web service publishes the service with intellectual element of MA; and then finds and binds the object service by service agent; finally, the host computer of Web service accepts, executes and dispatch agent code.

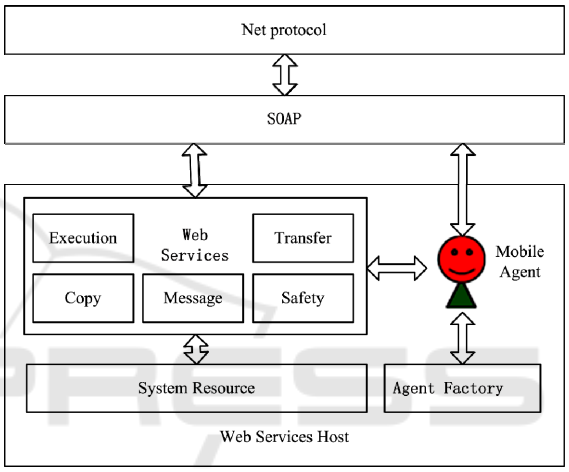

Figure 1: The integration model of MA based Web service.

Dynamic model based on MA and interoperation protocol based on Web service could provide flexible, re-constructed and coordinate solution to execute the business process management inside or cross the enterprise. The integration model of MA based Web service is shown in figure 1. During the moving process, SOAP is used as transmission, communication and safety mechanism. Web service is executed in the host computer through MA, and visits other service resource safely. The figure has three parts:

(1) MA: it is consists of code, state and data. At first it is run in a host computer, and then transferred to another host computer to accomplish task.

(2)Web service host computer: Web service is installed in the host computer and it realizes the functions that correspond with accepting and transmission MA.

(3) Agent factory: MA is established and dispatched to the network.

4 MASOAERP: MA-BASED SERVICE-ORIENTED ARCHITECTURE COLLABORATIVE ERP SYSTEM

The "description, publishing, finding, binding and interaction" enterprise service architecture expressed by SOA and the "establishment, execution, freezing, migration and extinction" of software lifecycle of mobile agents fulfill the characteristics of the application dynamic service integration in the open Internet environment. Mobile agent-based, and service-oriented collaborative ERP software solution has to meet with following requirements: 1) The whole collaborative ERP software system should be built by a series of "rough grain" component, which are mobile agent-based enterprise business service component, inner-enterprise application services and inter-enterprise service cooperative agents, and should be loosely coupled. The functions are expressed in the form of rough grain services, and each kind of service can express its business value clearly. The rough grain service providing form makes the large-scale software service possible, and provides the agility of construction and reconstruction of ERP systems in the open, dynamic and uncertain environment of Internet. 2) Self-description of application service units of each layer can be made in a standard way. The descriptions should be understandable by enterprise cooperative agents, and processable by computers. Dynamic publishing, finding, matching, binding and management services can only be carried out according to these descriptions. 3) Lifecycle management systems of enterprise system service components, in charge of the test, simulation, and optimized assembly and migration, should be provided. 4) Lifecycle management systems of enterprise services, in charge of dynamic creation, state migration, performance monitoring, and service termination, should be provided. 5) Management systems of enterprise applications, in charge of registration, access, controlling, and service relationship termination, etc. should be provided. 6) Enterprise application solution based on process integration should be provided. Flexible information sharing mechanism should be provided.

In the open, dynamic and uncertain environment of Internet, the architectural structure of the mobile agent-based, and synthesized service-oriented cooperative ERP software is depicted as figure 2. The services are divided into three layers: inter-enterprise web services, intra-enterprise application services and composite application business component services. Accordingly, the three layers' services can be described by three domains, namely, inter-enterprise service domain, enterprise application service domain and business component service domain. The services are managed layeredly, and layers of the services indicate the constraint and dependency between services. Inter-enterprise web services, intra-enterprise application services, and composite application business component services are of the first, second and third layers, respectively. Inter-enterprise services are top-layered, while the application business component services are bottom-layered. And higher-layered services are dependent on the implementation of lower-layered services.

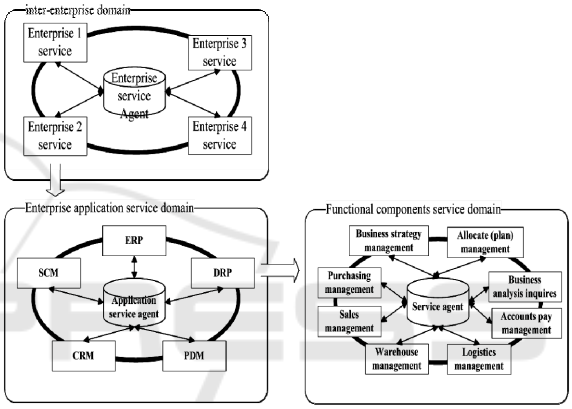

Figure 2: The mobile agent-based service-oriented cooperative ERP software model.

In the enterprise service domain，on the one hand, business users can release their services to the enterprise service agents through their own self-description enterprise Web services, register enterprise Web services in the business services agents, publish enterprise service functions and interfaces. Enterprise service agents are responsible for the coordination and management work, such as information Enterprise service registration, positioning, bundling services and so on. On the other hand, when enterprises users request for service, the users register in the enterprise service agents first, after the success of registration, the enterprise service agent match the demand service by the petitioner, and sent the service information to the service requester, the service request Mobile Agent visit to the service providers, service providers and service bundle with the petitioner to provide them services. Here the following detailed descriptions：

(1) Enterprise Service Agent is a set of server groups.

(2) Mobile Agent-based enterprise Web services, strip heterogeneous characteristics of local resources through standard protocols to provide transparent services. Mobile Agent-based business services have reciprocal (P2P) authority, that is, to meet a variety of agreements and norms under the premise of equal use of resources. All Mobile Agent-based enterprise Web services, in accordance with business needs and business model of dynamic work flow services, share Resources, collaborate Mutually, serve each other and Complete a common task. When Mobile Agent-based Web services rely on the relationship between them, we can gain the control and Management through mutual consultation and cooperation.

(3) Mobile Agent-based business services are independently responsible for their own resource scheduling, and dynamically interact with the business services agents ,to make them understand real-time enterprise resource information services and dynamically change management decision-making , coordinate resources "compete" resources "exclusive" and other conflict resources, in accordance with specific circumstances.

(4) The Mobile Agent-based business services to other business services and information through the use of authority, can only be authorized by business service agent. Once two Mobile Agent-based business services establish connections, all matters can be completed by coordination between the two sides without intervention of enterprises services agent.

Depending on the given task's requirement, the cooperation between two mobile agent-based enterprise service can takes the direct/active model or direct/active model. Using the direct/active non-terminate model, the service requester mobile agent sends active non-terminate service request to the service provider mobile agent, asking the provider to actively provide service to the requester when the conditions are met. When the provider has received the service request, it will make direct/active service promise to the requester. Immediately the conditions are met, the provider will provide service actively, and return the result accordingly. Using the direct/active terminate model, the service requester mobile agent sends active terminate service request to the service provider mobile agent, asking the provider to actively provide service to the requester when the conditions are met. When the provider has received the request, it will make active terminate service promise to the requester. Immediately the conditions are met, it will provide service actively, and return the results accordingly, and the cooperation is terminated.

In the enterprise application service domain, application service agent is established. The agent is responsible of the query, detection, binding coordination, and other enterprise application services. Enterprise applications (such as PDM, DRP, CRM, SCM) are encapsulated using mobile agent-based web services, and registered at application service agents. Implementing the Enterprise Application Integration (EAI), the working mechanism is similar to the inter-enterprise services, except it is confined intra-enterprise.

Business component is the software component that can finish some enterprise business function, such as production plan management, storage management, order management and plant control. In the collaborative ERP software production based on mobile agent and service-oriented integration framework, the business component is the service component encapsulated by web service based on mobile agent technology and is different from the traditional business component. In the business component service domain, the agent based component function structure is composed of service encapsulation module, communication module, apperception module, control and cooperation module, task processing module, which is shown as Figure3.

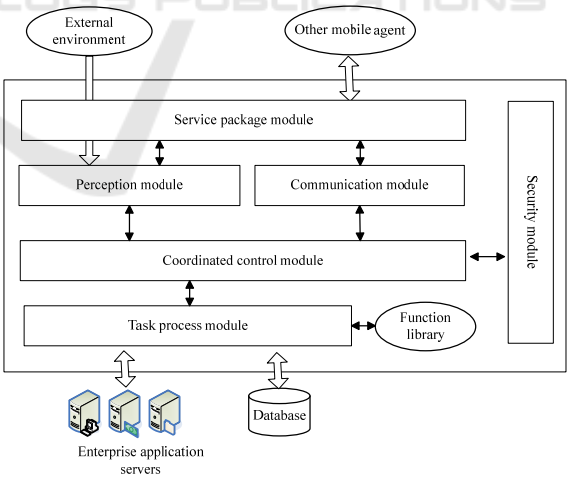

Figure 3: Based on MA function structure.

(1) Task processing module. Based on current knowledge and certain rules to judge the reasoning, the implementation of specific function or functions of the method. By this way, the task is accomplished.

(2) Communication module. It mainly responsible for the link between the Mobile Agent. It can not only transmit other Agent request / response signals to the task processing module, but also transmit collaboration / consultations messages of task processing module to other mobile Agent.

(3) Sensing module. It is used to sense the stimulation from external environment, and transmits the corresponding information to the control module. Firstly, control and coordination module do the filting and abstract process. The result is formatting meaningful symbols which corresponds the objects in external environment. Then it search corresponding method in the function to match. So the corresponding decision-making is got.

(4) Control and coordinated module. It is central role in all modules. All modules are managed by it. Through the coordination of the results, the final decision of the implementation of specific tasks, storage and management of all processing tasks and records the task of state.

(5) Service encapsulation module. It will encapsulate the Mobile Agent into independent service. It has the characteristics of SOA framework. And it can access through a standard interface so that the different components of services call each other. As independent service resources for the provision of in the network to other components, it can provide service to other components of a more flexible relationship between loosely coupled.

(6) Security module. To meet the business components with high reliability and security requirements, we add security module into application business components. The multi-level authentication and security mechanisms are increased. Business services component of the integrity of the information is ensured.

5 CONCLUSIONS

Under the opening, dynamic and changeable Internet environment, the resource sharing and integration has become the challenge of the computer software technology. This paper presented the MASOAERP, collaborative ERP software model based on mobile Agent service, to construct dynamic collaborative ERP software model based on service under the opening Internet environment, and solve the ERP resource integration under the opening, dynamic and changeable Internet environment. In addition, we discuss the ERP product custom-built batch implementation under the opening Internet computing environment. The prototype system implemented according to the model will prove that the service-oriented integration framework can construct the collaborative ERP system, implement the resource service of the dynamic enterprise alliance, and construct the new web based collaborative ERP software production model.

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