ARCHITECTURE AND KEY TECHNOLOGIES FOR SOA-BASED BUSINESS COLLABORATIVE MANAGEMENT SYSTEM

Yushun Fan
Department of Automation, Tsinghua University, 100084 Beijing, P.R. China
fanyus@tsinghua.edu.cn

Hongjun Sun
Department of Automation, Tsinghua University, 100084 Beijing, P.R. China
sunhj05@mails.tsinghua.edu.cn

ABSTRACT

In collaborative management system, SOA (Service-Oriented Architecture) is considered to solve existing problems among business collaboration within and across enterprise. However, the application of SOA in collaborative management system is still at an early stage and the practical theories together with products are few. Considering the fact above, in this paper, the lifecycle implementation methodology of SOA-based business collaborative management system is presented by using a lifecycle model. Based on the implementation methodology, we build the system architecture. Then, two key technologies are introduced. One is the collaborative meta-model based on the analysis and abstraction of enterprise collaborative behaviour; the other is model driven collaborative modeling based on meta-model. The case study shows that the proposed implementation methodology, architecture and technologies are effective for the solution of collaboration and integration within and across enterprise.

KEYWORDS

Collaborative Management System, Meta-model, MDA (Model Driven Architecture), SOA

1. INTRODUCTION

With the globally economic integration and rapid development of IT, the communication within and across enterprise is increasingly frequent, the social division is increasingly elaborate, and business contact is increasingly close and complex. Enterprise is not independent individual any more. The business collaboration is necessary within and across enterprise. In order to support collaboration effectively, and improve competitive ability of enterprise, it is significant to carry out the research and implementation of business collaborative management system.

Currently, the emphasis of enterprise information has transformed from basic platform development and information integration to the form of business collaboration as the core. However, it makes collaboration ability between enterprise business unit worse that business disjoints with IT, and IT system can’t adapt business change rapidly. The application results of enterprise information show that this is a main reason that the implementation of enterprise information can’t performs well. Therefore, the implementation of business collaborative management system is not only the requirement of enterprise business, but also the development trend of enterprise information technology.

Furthermore, a lot of information resources and services owned by enterprise are heterogeneous, distributive, dynamic, loosely-coupled, and even autonomous. Therefore, it is important for each industry departments to focus on how to integrate existent IT resources so that they can transform their application to integration and collaboration as well as to maximize the resource benefit.

Obviously, traditional software design methods can’t meet the requirement of business collaboration any longer. Recently, enterprise modeling methods, MDA, SOA get wide recognition, and become the mainstream technology of application software development. They provide solid technology foundation for the development of enterprise...
collaborative management system. Especially, the appearance of SOA provides theory foundation, technology route and development opportunity for the solution to the above problem. Furthermore, it provides full support to the collaborative operation and the integrative process, service, data and role within and across enterprise. However, the application of SOA in collaborative management system is still at an early stage and the practical theories together with products are few.

In order to solve the problems mentioned above, in this paper, we propose implementation methodology of SOA-based business collaborative management system, the architecture for the implementation methodology, and two key technologies including collaborative meta-model and model driven collaborative modeling.

This paper is organized as follows. Section 2 introduces related work about SOA-based business collaborative management system. In section 3, the implementation methodology of SOA-based business collaborative management system is proposed. Based on the implementation methodology, in section 4, we build the system architecture. Section 5 describes two key technologies, which are collaborative meta-model and model driven collaborative modeling. Section 6 gives out an application scenario of SOA-based business collaborative management system. The last section concludes the paper and proposes some future work.

2. RELATED WORK

Existing collaborative management systems mainly includes collaborative product commerce (CPC), enterprise resource planning (ERP), supply chain management (SCM), and etc.

1) CPC: The concept of collaborative product commerce is proposed by the famous consultant company, Aberdeen Group (Aberdeen Group, 1999). It is a kind of virtual organization to support the collaboration among the product design, product manufacturing, sales, and so on (Liu, 2005). Web service has gotten wide use in CPC (Chung, 2003, 2004). The main CPC software platforms include WINCHILL, Matrix, ENOVIA, and etc.

2) ERP: The enterprise resource planning systems are defined as configurable information systems packages that integrate information and information-based processes within and across functional areas in an organization (Kumar, 2000). They are unified information systems (Szitas, 1999). Research on ERP systems ranges from abstractions of the systems and feature frameworks (Holland, 1999) to implementation studies that attempt to find success factors for ERP projects (Kumar, 2000).

3) SCM: Supply chain management is a relatively new term, crystallizing concepts about integrated business planning, having been suggested by the academic community since 1950s (Shapiro, 2001). Some advanced technologies like web service, agent have gotten wide use in CSM (Xu, 2004 and Michalako, 2005). Collaboration, in the context of the supply chain management system, has received considerable attention. It is emerging in the mid-1990s (CPFR) (VICS, 2004). It has been strongly advocated by consultants and academics alike Vendor Managed Inventory (VMI) (Marloes, 2004).

However, in these systems, traditional theories, methods, and related implementation haven't already met the enterprise requirement to business change on demand requirement. Enterprise modeling method (Fan, 2007), service oriented architecture (Michael, 2005), and model driven architecture (OMG/ORMSC, 2003) get a lot of recognition and are becoming the mainstream technologies of enterprise application software system development. Multi-views integration enterprise models provide strong technical support for the exact understanding of business requirement (Lin, 2001). SOA-based collaborative management system makes fully use of the predominance and features of SOA. Therefore, lots of application systems can be encapsulated in the form of service and are deployed on the top of collaborative system. By this way, it achieves data integration, process integration and knowledge integration between these systems efficiently. MDA provides good academic method and technology support for achieving the transformation from business model to platform-independent collaborative model, then to platform-specific collaborative model. These technologies provide good technique foundation for the actualization about business collaboration of change on demand.

3. IMPLEMENTATION METHODOLOGY

The implementation methodology of SOA-based business collaborative management system provides the overall plan for system development, construction, and implementation. Beginning with the enterprise business requirement, the lifecycle of SOA-based multi-enterprise business collaborative management system implementation is achieved based on the lifecycle of model. Accordingly, a closed-loop system is formed, which includes the model building, model mapping, service libraries
building, service oriented system architecture design, service matching and composition, system construction and operation, operation performance monitor and evaluation, and business collaborative model optimization.

The construction of SOA-based business collaborative management system can be divided into three stages: collaborative modeling, service oriented information system construction, and collaborative operation and evaluation. The implementation methodology can be illustrated by figure 1.

Figure 1 – SOA-based collaborative management system implementation methodology

3.1. COLLABORATIVE MODELING

Business modeling and analysis are the startpoint of the whole research. On the support of enterprise modeling and optimization tool, it provides enterprise with comprehensive and exact description. And it is the important basis of further building service architecture and collaborative system. Then, based on collaborative meta-model and related transformation rules, business model is transformed into platform-independent business collaborative model. And on the support of Model Driven Architecture, platform-independent business collaborative model is mapped into platform-specific business collaborative model. Finally, business collaborative model is used in collaborative execution and evaluation.

3.2. SERVICE ORIENTED INFORMATION SYSTEM

By comparing the business model and the functions of enterprise legacy application system, software modules in multi-enterprises information system are identified, encapsulated and published into services. Accordingly, service components libraries are built. The services in these libraries can be composed and choreographed according to business service requirement.

3.3. COLLABORATIVE OPERATION AND EVALUATION

In the process of system operation, the performance of enterprises business process is monitored, analyzed and optimized by workflow management system. Then, using business modeling tool, optimized business collaborative process is redefined and converted into new models. Consequently, new cycle of practice, operation, analysis and optimization is started up. Through continuous feedback, cycle and optimization, the
above process formalizes a closed-loop management method of business collaborative model lifecycle.

4. ARCHITECTURE

Based on the above implementation methodology, the architecture of SOA-based business collaborative management system is put forward, which is shown in figure 2. It can support all level collaboration modes within and across enterprise and is the sustainment of SOA-based business collaborative management system. It mainly includes service oriented information system architecture and five necessary modules. Information system architecture is its base and the five modules run collaboratively on the supporting platform of SOA-based collaborative management system. Application information system like PDM/PLM (Product Data/Lifecycle Management), CAD (Computer Aided Design), CRM (Customer Relationship Management), ERP can be encapsulated into services, and then are dispatched in this system. The details are as follows.

Figure 2 –SOA-based collaborative management system architecture

4.1. SERVICE ORIENTED INFORMATION SYSTEM ARCHITECTURE

Service oriented information system architecture provides advanced information technology support for the operation of enterprise business process. Adopting service oriented computing mode to organize enterprise information resource can integrate internal and external resource rapidly, improve inter-enterprise collaboration, improve the adaptability of intra-enterprise business system, and optimize internal process and system. Service oriented information system architecture includes three components libraries which are business service library, public service library and basic service library. The details are as follows.

1) Business service library: The services in business service library can support the realization of enterprise business functions. Through the encapsulation of enterprise application information system, such as CAD, PDM, CAPP, ERP, CAM, SCM, and CRM, it is formalize in the form of published service.

2) Public service library: Public service library comprises a set of universal services like service registration service, service publish service, which can be used by other services.

3) Basic service library: Basic service library is composed of a series of computing-oriented bottom services such as communication service, data interface service. It will provide basic bottom architecture support for business services and public services.

4.2. COMPONENTS

SOA-based business collaborative management system is composed of enterprise business modeling tool, collaborative modeling tool, service adapter, operation evaluation tool, collaboration operation platform based on workflow technology and database. The details are as follows.

1) Enterprise business modeling tool: It supports multi-views and integrated enterprise modeling.
Furthermore, it can support business model optimization based on simulation.

2) Collaborative modeling tool: On the basis of collaborative model research, it supports to create collaborative model rapidly from optimized enterprise business model by model transition technology.

3) Service adapter: It is responsible to encapsulate existing information system into service.

4) Operation evaluation tool: Based on data mining technology, through the monitor, analysis and abstract of system log and other execution data, it can actualize business process operation performance evaluation, control, management and optimization.

5) Collaboration operation platform based on workflow technology: It is the core of collaborative management system and supports process navigation, service composition, man-machine interaction, inter-role cooperation and data integration.

5. KEY TECHNOLOGIES

In SOA-based business collaborative management system, running through the full lifecycle of model, the collaboration within and across enterprise can be achieved based on business-driven management method and MDA technology. Obviously, model is the carrier of collaborative management system, the precondition of business collaboration, and the foundation of fusion between business and IT. It is significant to research business collaborative model. Considering the importance of model in SOA-based collaborative management system, here, two most important technologies about model are introduced, which are collaborative meta-model and model driven collaborative modeling.

5.1. COLLABORATIVE META-MODEL

The motivation and the goal of meta-model are to help to establish an environment in which business knowledge can be captured and business rules can be traced from their origin in the business environment through to their implementation in information systems (Yu, 2003). In order to get business collaborative model, it is very necessary to carry out the study on business collaborative meta-model based on MOF.

Business collaboration mainly refers to four elements: process, role, service and data. Process is the abstract of business process elements. Data is the abstract and unification of business information, such as database, XML and file. Role represents any entity that has the ability to initiate actions on other objects. In service oriented environment, Service is used to abstract and organize enterprise information resources. According to the difference of main bodies taking part in collaboration, collaboration can be classified into collaboration between process and process, process and service, service and services, role and role, role and process, role and service, data and data and etc (see figure 3). The details are as follows:

1) Collaboration between process and process: Circling around business development activities, cross-organizational collaboration usually can be achieved in the form of business collaboration. The collaboration among business activities can come down to inter-process collaboration finally.

2) Collaboration between data and data: There are large numbers of heterogeneous data (database, XML, file and etc) in enterprise. In order to ensure inter-enterprise information share and transformation, the integration among these data should be considered.

3) Collaboration between role and role: In the

![Figure 3 – Collaborative modes in SOA-based collaboration management system](image)
process of enterprise business collaboration, the cooperation between roles is multi-levels. On the one hand, enterprises that can act different business roles finish altogether each business role taking on in the process of business collaboration. On the other hand, person and enterprises taking on different roles finish the same external service altogether, taking collaborative workspace for example. It is obvious that this kind of collaborative process includes communication and collaboration among persons.

4) Collaboration between service and service: In SOA-based collaborative environment, in order to achieve mutual access and inter-enterprise transfer of business function, business achievement should be encapsulated into service and is shared and integrated in collaborative service bus. It can be used to support inter-business process collaboration and inter-role collaboration.

The research on collaborative meta-model is to abstract all level collaboration within and across enterprise into the collaboration between any two of process, service, data and role. That is to say, collaborative meta-model is composed of these four elements.

Business object is the mechanism denoting business entity abstractly. Business state machine is used to describe behaviour characteristic of business object in collaboration. In collaborative meta-model, in order to represents collaboration between any two of these four elements, business state machine is used as the core and description manner of collaborative model. In business state machine three elements are composed, which are state, business activity and business rule. And it is used to describe the four collaboration elements.

5.2. MODEL DRIVEN COLLABORATIVE MODELING

In SOA-based business collaborative management system, collaborative model need not only to support complex collaborative relationships, but also reflect enterprise business requirement. Therefore, in order to keep the consistency between business collaborative model and enterprise business requirement, we adapt model mapping method. Through this method, business collaborative model can be gotten from existing enterprise business model which embodies enterprise business requirement.

Existing business model is used to describe business requirement in collaborative environment. Collaborative business requirement is depicted in the form of a group of enterprise models, including product view, resource view, process view, function view, organization view and information view (Lin, 2001). The conjunction of these views is achieved through process view. Here, in order to get business collaborative model based on collaborative meta-model, these views will be abstracted into collaborative business elements: business state machine, business rule, business object, and business activity. Here, business process and interaction between any pair of them is modelled into business state machine, information view element is modelled into business object, organization view elements is modelled into role and others such as function view is mapped into service. Based on these rules, business requirement can be transformed into platform-independent business collaborative model through map technology. Business collaboration model reflects all kinds of collaborative scenes, service composition of each industry and application, man-machine conversation, collaborative logic, data interface and etc.

Based on MDA, according to the same collaborative meta-model, platform-independent business collaborative model is mapped into platform-specific business collaborative model. In the process of system operation, the performance of enterprises business process is monitored, analyzed and optimized by workflow management system. Then, by using business modeling tool, optimized business collaborative process is redefined and converted into new models. Consequently, new cycle of practice, operation, analysis and optimization is started up. Through continuous feedback, cycle and optimization, the above process forms a closed-loop management method of business collaborative model lifecycle. Furthermore, in order to ensure model correctness, consistency algorithms are used to keep modeling consistency of business model, mapping consistency between business model and platform-independent collaborative model, and transformation consistency between collaborative models.

The modeling process shows that business collaborative modeling has some new characteristics in contrast to other business modeling methods. Firstly, it is composed of process, role, service and data. Secondly, it can describe and support the complex collaboration relationships existing in business process. Thirdly, business function and achievement are encapsulated into services. Furthermore, it reflects enterprise business requirement. These characteristics indicate that collaborative model can well support SOA-based collaborative management system.
6. CASE STUDY

Here, we take the collaborative management of sales contract signature about ZheJiang HuaXin enterprise group ltd for example to illuminate the application scenario of SOA-based business collaborative management system. The approximate business processes of sales contract signature are composed of order submission, custom credit check-up, production schedule confirming, purchasing plan making, production plan designing.

6.1. PROBLEM ANALYSE

Some application unit systems have been used to improve the operational efficiency in this enterprise. Currently, the main problems existing in enterprise application system operation are that information among each application system can’t share efficiently, and business process can’t continuously operate between each pair of application systems. In a word, information integration, process integration and application integration is the most important problems which need to solve imperatively.

6.2. SYSTEM STRUCTURE

The Figure 4 shows the whole business process from requirement order submission to sales order signature, then to production order creation within enterprise on the support of SOA-based business collaborative management system. It lays out how customer requirement outer enterprise is transformed into production plan within enterprise.

Figure 4 –Business process on the support of SOA-based collaborative management system

After the customers submit requirement order, the whole process of sales order signature will refer to customer, marketing department, design department, warehouse department, purchasing department, related departments of enterprise production and manufacturing, and etc. There are relevant business unit application systems to support business operation in different business departments. SOA-based business collaborative management system is the support platform of enterprise application integration. It aims at supporting all application units to be connected dynamically and flexibly in the form of service, and confirming information share and process integration among application systems on the operation of business process. Consequently, enterprise can respond the customer requirement rapidly, and the responding time from requirement order acceptance to production plan creation is shortened.

6.3. IMPLEMENTATION METHOD

According to requirement analysis above, the implement scenario is as follows:

1) Business unit application systems are encapsulated and composed into services. We open with the function analysis and decomposition of existing business unit systems. Then, with the help of public interface standards, such as WSDL, SOAP, and UDDI, these function modules are identified and encapsulated into services. Here, the composition and choreography of business process need to use Web service choreography language, such as WSFL, BPEL4WS.

2) The design and development of SOA-based business collaborative management system is achieved. Firstly, we analyze system’s main functions. Then, based on the reference model of SOA, SOA-based business collaborative
management system is built. Furthermore, the second development and deployment of system is implemented.

3) Business unit systems are connected to collaborative management system in the form of services. These systems are published into service. And the business operation functions are provided by service interfaces. Accordingly, every business service components may connect with business collaborative management system flexibly.

7. CONCLUSIONS

In this paper, the lifecycle implementation methodology of SOA-based business collaborative management system is presented, which lays solid theoretic foundation for the system development and implementation. Then, we build the system architecture for the implementation methodology. Considering the fact that collaboration is actualized based on the model lifecycle, in the section of key technologies, two important technologies related to collaborative model are introduced, which are collaborative meta-model and model driven collaborative modeling. The proposed method, architecture, and technologies can support well business collaboration within and across enterprise, achieve the fusion of business and IT, integrate heterogeneous information resources, and etc. The results of case study indicate that this system can well meet current enterprise business requirements. In the future, the emphasis should be focused on the software development of SOA-based business collaborative management system and the application implementation in enterprise.

8. ACKNOWLEDGMENTS

The above research was made possible by grants from the National Natural Science Foundation of China under Grant No. 60674080 and the National High Technology R & Development Program of China under Grant No. 2006AA04Z151, 2006AA04Z166.

REFERENCES


Marloes Claassen, “Vendor Managed Inventory living a dream ,or easily satisfied?”, Management report, TU/e technische universities, 2005


VICS (Voluntary inter-industry commerce standards association), “Collaboration planning, forecasting and replenishment (CPFR)”, available at: www.cpfr.org, 2004
