Winter 12-10-2002

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Abstract

With the development of e-business, the collaboration between enterprises is increasingly strengthened, which, at the same time, challenges coordination technologies in distributed enterprise transactions. Workflow management has as its priority the support of coordination functions and workflow interoperability points the way towards collaborative business environments. Though WfMC, Workflow Management Coalition, specifies the abstract interoperability, differences such as workflow concept models, ontology etc. cannot be dealt with effectively because the specification is only technical. On the other hand, portal technology focuses on the integration of information and application services customized according to roles. It can provide support for the interoperability of workflows. In this paper, workflows are integrated with portal technology. And a role centric collaborative environment is proposed which is a way out for problems existing in workflow interoperability.

Key words: Role, Workflow, Interoperability, Ontology, Portal

1. Introduction

New economies and global markets with their accompanying intense competition have generated the need for organizations to develop and adopt new IT infrastructure to support double-win or multi-win collaborative business environments. An enterprise can hardly survive by itself facing such many global competitors. Furthermore, competitions have extended to a more macro-level, which is usually between supply chains, even value chains. In the information society environment, enterprises also need Internet technology to support their business collaboration. How to collaborate efficiently so complex business activities between organizations is a new problem facing business change management. As one of the recent IT research focuses, cross-organizational workflow technology mainly deals with the resources integration by multi-organization collaboration. It aims to establish a seamless process integration environment, to widen the business information scope, to improve the flexibility of the whole supply chain or value chain, and to ultimately improve the level of customer satisfaction.

A single organization usually cannot satisfy all customers' needs in electronic business environments, where necessary resources are highly distributive. Business organizations make great efforts to improve the quality of collaboration among suppliers, customers, and business partners, with a view to improve their own core competence. Based on role theory, the importance of collaborative technology in Internet-enabled business environments is firstly analyzed in this paper. Then it focuses on two important potential technologies for the interoperability, i.e. portal and workflow technology. At last, a role-centric collaboration environment integrating with portal and workflow technology is proposed, which can partially solve the problem of the interoperability of cross organization processes.

2. Role theory basic

Role is defined as comprehensive feature abstraction of a class of entities, which can be described by common structure, behavior, property, function, tendency etc. [1] Role is used as a reasonable standard to differentiate entities for their high competence to comprehensively describe entities. The role an actor plays is not static in cross-organizational processes, because which role an actor needs to play is determined by real cases. For example, an actor in a value chain, its upstream suppliers can view it as a customer, while its downstream customers also can view it as a supplier. From a more macro view of point, a value chain is composed of a series of links between customers and suppliers. Within an organization, intra-organization processes can also be viewed as a customer chain, which links all involved departments. Customer-driven is the most popular concept in nowadays business practice, in which customers' needs are various and need to be customized. Market is getting dynamic. Traditional linear value chains have evolved into a complex, flexible, refined, and agile value-net system. Sometimes they are referred to as value networks, which are woven by value threads [2]. Organization structures tend to be networked and business operations tend to be virtual. A networked organization is usually composed of a core enterprise ,its contractors and sub-contractors. The main duty of the core enterprise is to coordinate all members of the networked organization. How to define roles of participants in a networked organization is even more complex. Usually, multi-role property needs to be assumed to a participant.

Role theory has been widely used in the access control of databases and information systems in previous researches. It is used herein to analyze the business collaboration, in order to show the importance of coordination technology. As the initiator of an activity, role is the basic component of an enterprise or a virtual organization. In process change management, role is also the main object to be reengineered. In BPR, the change

of activities and the relation between them can be viewed as the reengineering of roles and the collaboration between them. That is, process management can be seemed as the analysis and adjustment of roles and their relation. Every role in the process has four basic attributes: rights, responsibilities, protocols and capabilities. When a participant acts as a role, its knowledge, capabilities and rights should meet the requirements of the role. He should also take the related responsibilities and risks, which result from his activities. The participant must act according to a special protocol, and need collaboration with other participants who take on the corresponding roles and try to complete all tasks defined by the roles within the limitation of resources, information, and rules.

From the object-oriented perspective, a role is similar to an object class, and it can be viewed as the abstraction of a class of agent objects. In system planning, roles provide templates for agents. Using roles to configure the agents can solve the problem of prematurely determining the role of a participant. Thus it can improve system flexibility to fit well with the challenge from dynamic market changes.

The formation and features of business collaboration will be further discussed from three aspects of roles, that is, competence, knowledge, and protocol.

2.1 Competence

According to the theory of organization competence [3], competence is the main resource of an organization, whose business scope is also decided by its competence. The core competence of an organization is the origin of its long-term competitive advantages. It includes some accumulated knowledge, especially that knowledge of how to organize processes and coordinate various participants and their different skills. This also means that an organization can be viewed as a combination of roles with various competences. Work dividing and collaboration between roles can improve individuals' competence and bring the improvement of organizational creativity. At the same time, work dividing can set up the organization boundary as a foundation for collaboration.

Organizational operations are composed of various basic activities. These activities are related to each other. Roles possess different competence to support its operations. Nowadays, a single enterprise cannot meet customers' various needs, which usually involve complex production and customized services. Businesses, therefore, need seamless collaboration and real-time interaction among R&D, suppliers, manufacturers, distributors, retailers, and customers so that the cross-organizational processes become the most important character of business operations in the e-business environment. On the other hand, enterprises can focus their resources on their core processes, and outsourcing other business operations. E-business enterprises will improve their whole competence by the collaboration and profit distribution between enterprises through the infrastructure of cross-organizational processes.

2.2 Knowledge

The theory of organization competence regards knowledge as the inner factors of organization competence [3]. Organizational activities need the coordination between professional individuals holding different knowledge. An organization runs as a system for knowledge integration. Its innovations are achieved by the knowledge sharing among roles.

Cross-organizational knowledge sharing brings more affluent resources of knowledge and intelligence, which will promote the technology and service innovation.

2.3 Collaboration

The rapid development of global economy intensifies competition among enterprises. An enterprise can hardly survive in the increasingly competitive environment without the efficient collaboration with other enterprises because its resources and competence are limit. Thus it has to focus resources on its core processes. That is to say, in order to effectively react to dynamic market changes, enterprises should concentrates on its most potential business domains, by integrating its intra- and extra-resources, outsourcing part of non-core business processes. These cross-organizational business processes aim to improve the whole competences of all member enterprises through seamless coordination.

3. Role-centric collaboration

3.1 Business collaboration

With the rapid development of electronic business, enterprises transfer their activities from traditional, direct market transactions to the whole process of value increasing, which involves the collaboration among participants on the value chain, besides the collaboration among departments and roles within enterprises. The concept of business collaboration mainly deals with the business activities and their interoperation between different enterprises. There is still no widely accepted common definition on *business collaboration*. Different definition emphasizes different scope and level of collaboration. In general, most definitions propose a well-organized combination structure of different enterprises in order to integrate suppliers, business partners, customers, and distributors on the supply chain widely into a virtual organization by Internet-enabled collaborative IT supports. Each of these member enterprises usually owns different core competence and resources. In such disparate business collaboration environments, newly emerging business models need a series of reconstruction of business collaboration structure, communication channel, and relation with customers and suppliers. The key of success of these models lay in the sharing and exchanging of information and knowledge, which are the basic needs of enterprise competence integration and coordination in this cross-organizational process management and change scenario.

In collaborative business environments, the whole supply chain or value chain becomes a collaboration system based on network and collaboration technologies.

Participants on the chain can share knowledge and information, and act in seamlessly connected cross-organizational processes, which aim to improve the response speed to customers' dynamic needs. Actually either partner enterprises, or their constitutive departments, or personnel of these enterprises can take on the collaboration roles. Such complex collaboration needs an interoperable platform to facilitate real-time information exchanges and knowledge sharing. This platform makes participants on the chain can share accurate information about their products and service in time.

Networked organizations operate through the collaboration among roles. Cross-organizational processes connect member enterprises by means of some activity points. It ensures accurate decision-making and high operation efficiency. The whole system of a networked organization can be highly effective and efficient, when roles collaborate well.

Besides those technical factors, cultural differences between collaboration partners are also very important. In some cases, the collaboration difficulty comes from partners' different business tradition. For example, some enterprises are not willing to share information with other enterprises by its traditional business practice. Furthermore, many enterprises may use different modeling methods to describe their processes, or may manage their processes in different ways. According to social psychology theory, most enterprises tend to put an enlarged importance on their own business practice, which is usually supported by their past successful experience. The difference of ontology of different enterprises brings even more challenge for designing and implementing the cross-organizational process management. Interoperability and communication between these partners having different cultural background are even difficult to be overcome both technically and culturally in these environments.

The key of successful collaborative business is the tight cooperation among roles in the form of knowledge and information sharing. Some researchers regard collaborative business as the next generation of electronic business. Electronic business model is concerned with the abstraction of roles and their relations among an enterprise, its customers, suppliers, and business partners. The flow of production, information, and capital can be clearly described in business model. One of the main research areas on collaborative business is to solve the problem of how to establish a collaborative platform for different roles with the support of Internet-based information technology. According to current technical level, cross-organizational workflows or distributed workflows are feasible solutions to this problem.

3.2 Cross-organizational workflow technology

Workflow management technology is a tool for process automation and standardization. Since its first emerging in 1970's and fast development in 1990's, Workflow technology has been successfully adopted by many enterprises of different industries. Most of these workflow application cases are limited to intra-enterprise, where it is usually applied in a relatively unified application environment or at least within a common business culture background. Although the *WfMC* (Workflow Management Coalition) has proposed a series of workflow standards, the interoperability between different *WfMS*s (workflow management systems) is limited to messaging mechanism. Sheth et al. estimate that the number of readily available workflow systems is between 200 and 300 [4]. It is nearly impossible to enforce all members in a networked organization to use a unified WfMS. Many enterprises use different workflow conceptual model, which is called as ontology by some researches. This difference brings the problem of interoperability of different workflow systems used by different enterprises.

Two important collaboration technologies, i.e. the cross-organizational workflow and portal technology is discussed in this section and next section 3.3. Then, in the section 3.4, their integration is discussed. It is suggested to be a very effective support technology to cross-organizational workflow management.

Increasing customer needs on tailored service and the complexity of production process require the tight cooperation and real-time interaction betweens roles of R&D, Suppliers, manufacturers, distributors, retailers, and consumers. These activities need corresponding cross-organizational processes for role coordination and some standardization prescription on communication and interface protocols. More and more business processes become cross-organizational. The main research purpose of cross-organizational process management is on how to coordinate their activities in distributed and heterogeneous dynamic environments.

Cross-organizational workflows are one of the most important tools to support cooperation between roles. Current solutions for cross-organizational process coordination are mainly dependent on the interoperability of workflows. While different enterprises usually have their own organization structure, business practice, and their special ontology, the workflow integration sometimes becomes very intractable. Ontology describes basic concepts and their relation in a domain. It acts as intermediary for knowledge integration, sharing, communication and abstraction, usually domain dependent. One of the solutions for the discrepancy between enterprises' ontology is to comply with a unified ontology for all members. But this solution is too expensive to be put into practice, especially for those large-scale networked organizations, which usually have invested in a great volume of legacy systems. Another more feasible solution is to define a high level common ontology, which is changed into all members' local ontology and vice versa. Using this method, the information senders packet data and information according to the common ontology; then the information receivers decode the package in the form of common ontology into their own ontology. The transformation rules for different ontology is a valuable area for further

research. In the area of information and knowledge sharing among different roles, our recent research has conducted on how to use high-level ontology as a commonly understandable and acceptable term set for cross-organizational process communication between different enterprises.

Cross-organizational process research originates from the increasing needs for the cooperation between different enterprises. The most popular form of this cooperation is outsourcing, which is usually contract-based. Besides its legal meaning, contract is also one of the main ways to abstract cross-organizational process interaction, which includes most ontology of cross-organizational activities, such as searching for partners, interconnecting related workflows, controlling outsourced workflows, sharing workflows, etc [5]. It is a relatively practical way to solve the problem of heterogeneous ontology. One of the European Esprit FP4 program, CrossFlow [6] carries a deep research on contract-based cross-organizational workflow coordination standard and its basic structure, which becomes a candidate standard of WfMC. Contract is regarded as a common understandable describing language for cross-organizational process and process interoperation. Either WfMC standards or *XML* (Extensible Markup Language) can be used as the describing language for contract making and enactment. The main task of workflow interaction is to transfer right information to right participants in right time. The shortage of information sharing usually results in weak interoperability of cross-organizational workflows. Fortunately, it can be partially solved by portal technology.

3.3 Portal technology

Some problems, such as drowning in data but starving for information, lack of personalized information service, and lack of proper information consistency by dynamic data association, all result in difficulties of the interoperability of cross-organizational process. It need a competent and consistent collaboration platform to provide inter-organizational information exchange service and workflow interoperability for different business roles. From a technical viewpoint, collaboration platform is a dynamic cooperation environment for dynamic information exchange between enterprises. It can be used as a basic integration framework for information and services.

As an Enterprise collaboration platform, portal can integrate many services, such as information obtaining and sharing to ensure the consistency between intra-organizational and inter-organizational collaboration. Every role can obtain all information and services from a fully personalized portal. It is an important foundation for roles to participate in collaborative activities actively.

The fundamental of portal technology is to integrate enterprises' all data resources, applications, and services by a unified information portal, which can provide personalized information and service to various participants according to their different role, referred to as role-based access control. This information sharing mechanism also involves some security and customized service applications to provide services to all participants such as customers, suppliers, and business partners.

Portal also provides a unified access interface between users and integrated functional systems and various cross-functional applications. Enterprise portal usually consists of a unified interface and various information or service resources. Users consist of intra-organizational employees, customers, suppliers, and business partners. They can obtain information searching service through the interface. This portal-based method of information integration offers clear and unified resources for decision-making by providing a whole view of all information within an enterprise or a networked organization. The portal technology integrates existing legacy systems such as ERP, EC (electronic commerce), SCM (supply chain management), CRM (customer relation management), and HRM (human resource management), KM (knowledge management) systems etc., for all intra- and extra- participants. A true portal can act as the workflow management infrastructure for information exchange and business process interoperation. See Figure 1.

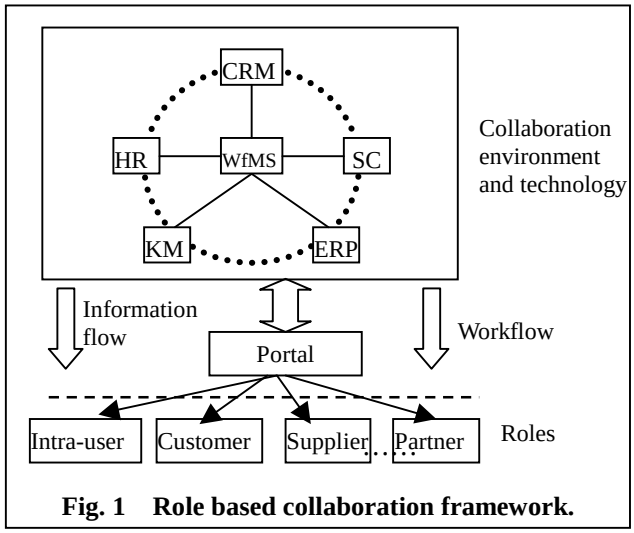

Fig. 1 Role based collaboration framework.

Intra-organizational employees, customers, suppliers, can effectively collaborate on different levels, such as employee-to-employee, department-to-department, and enterprise-to-enterprise, through customized portal services. Nowadays, most of enterprise information are distributed, various and vast. All these features bring the difficulty to get proper, consistent, and accurate information in time. The portal technology provides a solution by integrating different data sources and presents information in a unified, clear, and understandable form to participants according to their current roles [7]. Thus it can effectively support decision-making and improve work efficiency. The main characteristics of the portal technology are discussed as following.

- **Role-based technology**

Different participants need diverse information,

applications, and interfaces to support their activities. The role a participant plays can be changed in different business circumstances. Portal should be able to change their service portfolios according to participants' roles. The introduction of role theory to portal technology aims to simplify personalized portal service management. Role-based portal technology can provide more enough information to participants in need, with personalized interface and service portfolios, as well as access authority.

Different roles obtain content information in their personal ways. Portal designers need to analyze business scenarios and abstract types of roles. Usually there are three main types, i.e. intra-organizational users, customers, suppliers and business partners. Every type can be further divided into sub-types. Portal is not only the integrating point of applications and services, but also an environment for describing roles' responsibility. Roles can access intra- and extra-enterprise data on the basis of their authority through portal, which operates as an information intermediary. Take the CRM system as an example. CRM system integrates customers into R&D, manufacturing, marketing, and service management. Thus it can provide an effective and efficient way to manage existing customers, potential customers, and business partners. The portal system offers an information-exchanging channel for customers, distributors, retailers, suppliers, and intra-organizational users. The integrated portal service also can provide channels for cross-organizational process interaction. For example, marketing personnel can access customer information to have customized service portfolios for customers and other extra-organizational users. Marketing personnel can also use portal technology to provide differentiated production and price lists to distinct types of customers or retailers. Intra-organizational users can also access knowledge base through the portal to get necessary knowledge. The portal services can be dynamically adjusted in order to fit for each user's knowledge accumulation process. It provides a knowledge management platform especially for learning organization.

- **Integrating both content and functions**

Portal technology is characterized by flexibility and openness. It can collect many forms of information, such as XML, HTML, JAVA and other proprietary forms, from distributed network, to provide tailored information services. With the help of web technology, information association is achieved. For example, when an information point is found, all related information could be tracked by hyperlinks.

A true portal should create a full service collaboration environment, which integrates all applications and the applications can be dynamically connected according to users' changing needs. By virtue of portal, roles can obtain intra- and extra- enterprise information and functional supports, which can be used to facilitate workflow coordination. Thus the value of portal is fully realized. Portal is not only the interface between application and service, but also the interaction window between roles. From the perspective of role theory, workflows can be viewed as a series of interaction between roles. This property just coincides with the function of portal. So, portal can be regarded as an intermediary for workflow interoperation. For example, in the process of production designing, all participants can exchange information through portal, to realize a concurrent designing process, which usually involves different departments or organizations.

Portal technology can integrate with other enterprise applications, such as CRM, SCM, KM systems, etc., to improve the quality of decision-making and collaboration. Portal is also based on collaboration management theory. As a collaborative support platform, portal enables a strong association among integrated function into its portal logic, which suits well with collaborative work in present business environments.

Collaborative support platform breaks down the boundary between enterprises in order to send right information to right participants in right time. Every role's tailored portal service usually involves a variety of distributed applications. A cross-organizational workflow also involves collaboration of different roles from many organizations. So it may need long time to establish the final collaboration environment by various forms of cooperation. In general, an enterprise on the value chain establishes its own applications, which are related to its workflow activities, according to the role it play in the chain. Then portal integrates these distributed applications. This solution evolves from the traditional intra-organizational integration, such as EEP, to a total integration of both intra-organizational and inter-organizational applications, which is based on some new technology standards, such as XML.

3.4 Integrating portal with cross-organizational workflow technology

WfMS is a groupware to support collaboration between different roles involved in workflows. Currently, most existing WfMSs mainly use activity lists and alarm mechanism to support roles' activity during workflow processes, but they are lack of the ability to support role-based access control over information from different participants. Customers, suppliers, business partners apply different ontology, which is difficult to be unified, since they use different conception models, especially in the case of cross-organizational processes. The interpretability of current WfMSs is only technical, which results in the difficulty of knowledge sharing between different participants. As discussed in 3.3, portal technology can support cross-organizational workflow management. Workflow technology is complementary to portal technology. The integration of workflow technology with portal technology can improve participants' work efficiency as well as effective communication. Portal technology can work as an integrator to provide comprehensive activity lists by decompounding and re-compounding distributed activity

lists induced from different systems. Thus, roles can allocate proper resources and time for activities according to their priority.

The interoperability of traditional workflows usually has recourse to a messaging-based method by the mechanism of request and response. It only supports simple workflow interoperation, while portal technology is more versatile, that it can deal with more complex workflow interoperation. As illustrated in figure 1, WfMS is the center of the business collaboration system. It works as a neural system, which links all participants and their systems. WfMS transfers all tasks to personalized portal of every participant. By role based access mechanism, all intra-organizational users, suppliers, customers, distributors, business partners, can be integrated into E-business processes, where participants can exchange information for seamless process interoperation.

In general, the portal technology can integrate with workflow technology at least in the following three ways:

- Portal provides customized function and information support. It sets different access priority for different roles.
- Workflows can be used in portal technology [8]. For example, Peoplesoft co. designs portal as a hub-and-spoke WfMS integrator by the XML-based application messaging mechanism. It can integrate different WfMSs and other systems, providing comprehensive lists of activities allotted to participants so that they can properly allocate resource and time to activities, according to their importance.
- Portal can be used as an intermediary for the interoperation of different WfMSs. As a collaboration support module, portal can also called by WfMSs as illustrated in Figure 2. This partially solves the problem of direct interoperation between different workflows. In agent-enhanced workflow architecture, the interoperation of cross-organizational workflows is supported by the broker mechanism, which mainly deals with the bilateral ontology translation [9]. In this sense, portal can be regarded as an extended broker, which provides more affluent supports in addition to information transformation.

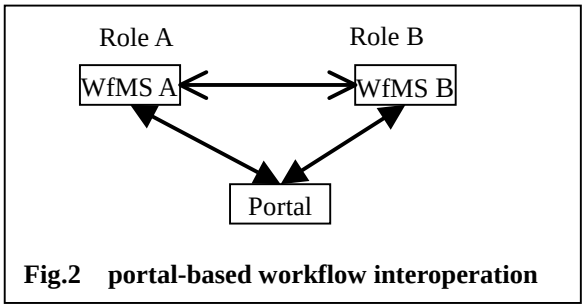

Fig.2 portal-based workflow interoperation

4. Conclusion

With the development of E-business, one of the most competitive business strategies is to form alliance among enterprises according to their special core competence. The collaboration between alliance partners usually involves many cross-organizational processes, which break down traditional enterprise boundary. It results in the urgent need of a new collaboration environment to fit for cross-organizational interoperation, especially in strongly coupled cases. Improving the workflow interoperability is one of the main tasks for this challenge. In doing so, WfMC has published some specifications on the issue of workflow interoperability.

Due to the technical limitations of current process modeling and management, as well as workflow technology in its fancy, it is still difficult to effectively deal with the interoperability problem, which also results from the difference between heterogeneous workflows and their ontology. Some distributed WfMSs are still under experiment. The key to solve the interoperability of cross-organizational processes is to design an effective method for information sharing and distribution. Fortunately, portal technology provides a partial solution as an effective tool for workflow interoperability with its customerized service portfolios according to the need of roles. At last, the integration of portal technology with workflows is proposed. It is a feasible solution for building up cross-organizational workflow collaboration.

Future research will focus on developing a prototype system to demonstrate the ideas.

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