AN ARCHITECTURE FOR CROSS-ORGANIZATION BUSINESS PROCESS INTEGRATION

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ABSTRACT
In the age of global economy, the cooperation among enterprises is becoming more and more frequent and important. Although many enterprises have constructed their own information systems to help intro-enterprise management, challenges of integrating multi-organization data and processes cost effectively, reliably and securely in the real time and maintaining clear paths of communication and collaboration throughout the complex network remains an open area in e-manufacturing. In this paper after a survey into the cross-organization cooperation scene, the atomic cooperation process pattern and their execution mode, and an analysis of the limitation of the prevailing “business service” model, a new architecture for cross-organization business process is proposed to meet this end. And one of its important parts, the novel agreement model is also addressed. This architecture is already used as a guideline of IPP-SYS, a national 985 project.

Keywords: Workflow, Inter-enterprise business process integration, B2Bi

1. Introduction
In the age of global economy, manufacturing enterprises face intensive competition and great chances as well all over the world. Many organizations form dynamic partnerships to effectively deal with market requirements. In this circumstance, they find that they need to deal with hundreds of business partners, millions of buyers and sellers, while meeting incompatible IT systems and business logic. Although many enterprises have constructed information systems of themselves to help intro-enterprise management, challenges of integrating multi-organization data and processes cost effectively, reliably and securely in the real time and maintaining clear paths of communication and collaboration throughout the complex network remains an open area in e-manufacturing. Now many researchers who study in this field propose “business service” to meet this end. The service may be an atomic task or a business process, which is like a black box in the view of its consumer. Through the request-implement of the services offered by different enterprises, the cross-organization business processes are automated disregarding the heterogeneous information system of different enterprises and not sacrificing their privacy. This model is sound in some cooperation scenes especially in managing routine cooperation processes. But after a survey into the cross-organization cooperation scene and the corresponding cooperation process patterns and characteristics, we find that an architecture with only service model is limited in flexibility and efficiency to integrate the enter-enterprise processes in that: 1) the service model cannot describe cooperation pattern completely; 2) service model is too trivial to offer a full blue print of a cooperation process; 3)
services, viewed as a black-box, can hardly be negotiated and are not flexible enough for the complex commerce environment.

Actually the inter-enterprise business processes can be divided into two types: the main cooperation processes, which describe the whole cooperation work series and the routine daily interaction interactions, such as product data updating etc. To support both of these two types, a new architecture with three layers is put forward in this paper. This architecture is already used as the guideline of IPP-SYS, a national aid 985 project which is to construct an enterprise platform to support EAI (Enterprise Application Integration) and B2Bi (Business to Business Integration).

This paper will be organized as follows: in section 2, we will discuss cross-organization cooperation scene, the cooperation process pattern and the cooperation process’s execution mode; in section 3, after analyzing the limitations of the prevailing “business service” model, a new architecture for cross-organization integration is addressed; and in section 4 some related work is listed; and in the final section, there will be a summary and a proposal to the future research.

2. COOPERATION SCENE, ATOMIC COOPERATION PROCESS PATTERN AND THE EXECUTION MODE

2.1 Cross-organization Cooperation scene

Cross-cooperation cooperation mostly happens in two types of scenes:

- Trades of product or service in the supply chain
  - In this part, the cooperators are buyers or vendors. And their cooperation has the following characteristics:
    1) mostly binate, with a buy and a vender;
    2) loose-coupling, the interface between the cooperators is simple, the interaction is mostly routine work, such product information exchange, order document exchange etc.

- Collaboration in design or manufacture
  - In this part, the cooperators are not just buyers or vendors but peer-to-peer partners who take charge of different parts of a task and share the interest. This kind of cooperation scene is always happened in new technology research in a virtual enterprise or a virtual research institution. And its characteristics are as the follows:
    1) Maybe multi-sides;
    2) Compact-coupling, different projects may have special cooperation processes, in another word, public business processes. And the cross-organization interaction is mostly based on complex business processes, some parallel tasks with synchronization may be needed.

2.2 Cross-organization Cooperation atomic process pattern

The atomic cooperation process pattern can be turned down into four patterns: single request, single response, request-response and parallel collaboration.

- Single request
  - As is shown in figure 1, in this pattern, one partner just sends a requirement for a function to another partner, but does not wait for the latter's response.
Figure 1 Atomic cooperation process — Single Request

- Single response
  As is shown in figure 2, in this pattern, one partner actively sends some information to another partner, and does not request the latter to do anything.

Figure 2 Atomic cooperation process — Single reply

- Request-response
  As is shown in figure 3, in this pattern, one partner actively sends a request to another partner, and waits for its response.

Figure 3 Atomic cooperation process — Request-response

- Parallel Collaboration
  As is shown in figure 4, in this pattern, there is no request or response parts, both partners take part in a collaboration task coequally, such as a meeting.

Figure 4 Atomic cooperation process — Parallel Collaboration

The four atomic cooperation patterns can occur in two kinds of cooperation scenes. But in the trading scene, the interaction is mostly of the front tree patterns while in the collaborative design/ manufacture scene, the fourth pattern may be frequently used.
2.3 Cross-organization Cooperation processes’ execution mode

The prevailing technology for business process automation and management is workflow technology. And workflow management system (WFMS) is the system which helps define, manages and executes structured business processes, workflows, so as to make sure that the right tasks are executed at the right time by the right people using the right tools.

Corresponding to the cooperation process patterns, WFMC (Workflow Management Coalition) proposes four types of public process (cooperation process) execution mode, which define how the workflow systems of different enterprises cooperate with each other to enact a public process. The four types are SWP (Sequential Workflow Parts), NWP (Nested Workflow Parts), PWPS (Parallel Workflow Parts with Synchronization), CIWP (Complete Integration Workflow Parts).

- **Sequential Workflow Parts——SWP**
  In this mode, workflow engine A uses a process instance to send a request to workflow engine B to create and enact a sub process instance. But there is no data returned to workflow engine. This execution mode is fitted with the enactment of the single request and single response atomic cooperation process and is easy to control.

- **Nested Workflow Parts——NWP**
  In this mode, workflow engine A uses a process instance to send a request to workflow engine B to create and enact a sub process instance, then the process instance in workflow engine A will hold up until the sub process executed by B is finished. And their interaction process is shown in figure 5.

- **Parallel Workflow Parts with Synchronization——PWPS**
  In this mode, the process instances are executed by both workflow engine A and B parallel, and when they come to a predefined point, they will exchange some data. There interaction process is shown in Figure 6.
This execution mode can be used for automating the fourth type of cooperation pattern, the parallel collaboration.

- Complete Integration Workflow Parts—CIWP

This mode is the mixture of the front three modes, and its workflow system’s interaction processes is shown in figure 7.

Generally different cooperation process needs different workflow interaction mode for its automation. The more compress the cooperation processes are, the more delicate the execution system will be needed. Although we uses binary interaction as samples, the parallel collaboration pattern and its execution mode can be extended to be multi-sided.
3. A NEW ARCHITECTURE FOR CROSS-ORGANIZATION INTEGRATION

3.1 Analysis of “Business Service” model for B2Bi

Cross-organization integration means to integrate of the data, applications and human resources of different organizations in a controllable way by automating organizations’ cooperation processes (public business process) among organizations. Since different organizations have different interests, different business logic and heterogeneous information system, collaborating these systems to manage the cross-organization business processes efficiently and safely is not an easy task. To meet this end some researchers such as those of IBM \[^{[8,9,1]}\] propose “Business Service” model as the solution for cross-organization business process execution. As is shown in figure 8, it is a purchase order handling service. The service has some operation open for its consumer, and in its internal structure is to enact a business process which includes such tasks as “submit purchase order”, “check credit”, “prep. delivery” and “ship goods”. And some of the sub tasks, such as “ship goods”, may be fulfilled by calling a business service offered by another enterprise.

![Figure 8 Purchase order handling ---a sample of Business Service model](image)

They argue that by nesting the service offered by different organizations, the cross-organization business processes are automated disregarding the heterogeneous information system of different enterprises and not sacrificing their privacy. This model is sound in some cooperation scenes especially in routine cooperation processes, where the interaction among enterprises is simple, for example just an input in a time and an output in a time. But concerning the more compact cooperation scene and more complex cooperation process, the service model is limited. The reasons are:

- Service model cannot describe the enterprise cooperation pattern completely.

As is said there is four types of atomic cooperation process. Service model can serve a good job in describing the front three types while not the fourth one, the parallel collaboration pattern, because classic service model always has a service vender and a service consumer, which means in a time a job is done by just one of them, and no parallel task is taken in its consideration not to mention the synchronization the collaborative task inside a service.

- Problems concerning the granularity of service model

Some people such as those who establish CrossFlow, a cross-organization workflow management system \[^{[1,10]}\] and those who propose using Webservice to realize the automation cross-organization business processes \[^{[9,10]}\] inclines to build fine granular business services, such as those whose consumer only has to submit some input information in a time and get a response in a time, so that they are easy to model, enact and control, but this
service model is too trivial to provide an enroll cooperation blue print. This fine granularly model is fit for routine transaction interoperation. And if we use coarse granular service model, a service may be very complex, which means many times of interaction between both service vendor and the service consumer within a service, this kind of service is not like the classical service with a main actor, all the partners have to take part in the service actively and coequally. This kind of service can offer a full print of a cooperation processes among the business partners, but it is hard to control and the research work in this kind of coarse granular is very few.

- Service model is mostly binate

With a service vendor and a service consumer, the classic service is binate can is not fitted for the multi-sides cooperation scene.

- Service model is not flexible enough

Most service are defined by one enterprise and opened to its cooperators. But with different business partners, the cooperation process maybe special, but the negotiable parameters of a service are very few. So classic one-side service model are more fitted in routine cooperation interaction than the more complex cooperation process in collaborative product design.

3.2 A new architecture for cross-organization business process integration

With the limitations, the business service alone is not sound enough for cross-enterprise business integration of the two types of cooperation scenes, so we propose a new architecture with three layers to meet this end. And the three layers are the agreement management layer on the top, the service management layer in the middle and the local workflow management layer the bottom. And there is a portal agent who will take charge of directory communication with another cooperator. The architecture can be viewed in figure 9.

![Figure 9: A new architecture for cross-enterprise business process integration](image)

1) Service agreement; 2) cooperation process.

**Agreement management layer**

Corresponding to the first layer, a novel cooperation agreement model is presented. In this layer, the following elements are defined: 1) the open services and their specifications, such as execution pattern, access interface etc. The items will servers as parameters guide the execution of services. 2) the shared main
collaboration business process that may be written in XML, and will use such new elements as services and other cooperation tasks, a meeting for example. This cooperation business process can be the PIP (Partner Interface Process) as is defined by RosettaNet\(^2\),\(^3\) and can also be a special cooperation process (public process) defined (through negotiation) by the cooperators. And a public process can be an input for its participants to create their one-side execution process models. The public process and the corresponding on-side execution process model can be viewed in figure 10.

In one-side execution model, the tasks that are fulfilled by other participants will be replaced by the pair of output interface and input interface. Additionally this sample public process is of “nested workflow part” mode, and if the public process is of “parallel workflow parts with synchronization” mode, the input and output interfaces of the corresponding one-side execution model will have synchronization properties. And the task elements in a one-side process can be a a service as is shown if figure 10. This one-side execution model will be imported in WFMS to be enacted, and moreover its enactment operation will be encapsulated as a service and open for other enterprises. And corresponding to one cooperation process there is one service in each participant’s system, which executes its own one-side process model, these services are linked by the input and output interfaces defined in the process. We can see that this type of service is not like the classic service with very few interactions between the service vendor and consumer, in that firstly it can be multi-sided with some synchronization elements, secondly it need all cooperators to actively participate in the service because some parts of the cooperation process needs to be executed by him, and this means that its execution entity must have at list a listening message interface and a sending message interface.

- **Service management layer**

And service manage level will take charge of local service definition, enactment administration, and remote service monitoring. Corresponding to this layer there is a portal agent, who will take charge of communication with the outside entity and scheduling the execution of services. A service will offer some operation for its applicant and in its internal part, there may be one or more business process which will be executed by WFMS. According to the service level agreements, an enterprise can remotely call an atomic business process offered by
another enterprise directly and get the result.

As is said, the service in this architecture is extended, besides the atomic service with the classic request-respond mode, some services are corresponding to a cooperation process and may be multi-sided and may need many times of operations among its participant and require the service participants to actively take part in its execution. This execution of this types of service depend on three elements: 1) the creation of the one-side process model depending on the public operation process model offered by the agreement layer; 2) execution of this one-side process in the WFMS layer; 3) the work of portal service agent to send and receive control and data message from outer environment and transform it to WFMS layer.

Although WFMS can communicate directly, service layer is needed, because on one hand it can shield the difference of different enterprises’ WFMS and offer standard operations, and on the other hand it will screen some confidential information and operations.

- The WFMS layer

The third layer, WFMS layer, also plays an important role in that it will take charge of executing a business process and record its trail. WFMS will offer API for its upper layers, and more over, in order to communicate with the outer environment the WFMS will have a message-listening module and a message-sending module. So the WFMS will have two types of interfaces the API and the message channel.

With these three layers, our architecture can enable correct modeling, executing and managing the cross-organization cooperation processes of different types, not only the routine cooperation processes but also the more complex cooperation processes in inter-enterprise product design and manufactures.

4. RELATED WORK

Cross-enterprise business process integration is a hot topic in B2Bi (Business to Business integration). Ref. [1,10] proposes a contracted based cross-organization workflow system to control the execution of business services offered by different organizations. As the services are routine, this extended WFMS is mainly to support standard cooperation in supply chain. And in Ref. [2,3], RosettaNet, a global business consortium, defines almost all the atomic standard cooperation process, the PIP (Partner Interface Process) and the corresponding exchanged data format. Again this standard and its implement framework are to support the standard transaction in supply chain. In Ref. [8,9], some researchers from IBM propose web service technology to support the execution the business service among different enterprise. They also put forward WSFL, a web service flow language to link these services together and construct a more complex business service. Their work improve the flexibility to the service model, still has the limitation of service model its own. Ref [6] discusses a peer-to-peer inter-enterprise business process execution mode. And Ref. [12] studies the agent-based business process management system, they also uses services model, but the business is restricted in one enterprise.

5. SUMMARY

In this paper after a survey into the cross-organization cooperation scene, the atomic cooperation process pattern and their execution mode, we make an analysis of the prevailing “business service” model for cross-organization, and find that service model really work in some parts especially in automating the routine business process among different enterprises, but concerning the more compact cooperation scene and more complex cooperation process, it is limited. To meet this end we propose a new architecture with three layers, the agreement layer, the service layer and the WFMS layer. And a novel agreement mode is also addressed. This architecture can enable the automation and management of the cross-organization processes in both of the two types of cooperation scene, the trades in supply train and the more compact cooperation in product design and
manufacture. This architecture is already used as a part of guideline of IPP-SYS, a national 985 project.

Considering the implementation of this architecture, there is still a lot of work to do. For example, the XML-based public business process model, the mapping algorithm from public cooperation process to one-side execution process model, the construction of business service based on WFMSs API and message channel, the internal structure of portal agent service, and the extended function of classic WFMS to support B2Bi, these topics will be included in the project IPP-SYS.

6. REFERENCES