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SUPREME: SUPPLY CHAIN INTEGRATION BY RECONFIGURABLE MODULES

Y. Nishioka[1], F. Kasai[2] and Y. Kamio[2]
[1]*Hosei University,*
[2]*Toyo Engineering Corporation, Japan*
Em: nishioka@k.hosei.ac.jp

Abstract: This paper deals with dynamic supply chain configuration problems for one-of-a-kind production (OKP) environment. We propose an architecture named SUPREME, which supports collaborative planning and scheduling for web-based virtual enterprises. In this architecture, each system is located on the site of the network members as well as on the site of the supply chain coordinator, who performs as an agent configuring and managing the supply chain dynamically. A prototype system of SUPREME is developed and illustrated in order to evaluate effectiveness of the proposed architecture.

Key words: SCM, APS, OKP, Collaborative Planning, Scheduling, Web Services, Business Model, PSLX

1. INTRODUCTION

Manufacturing is changing drastically according to the improvement of the information and communication technologies (ICT) infrastructure. Since a manufacturer takes more partial roll in the whole manufacturing process, global supply chain management becomes an important topic. Moreover, to catch up customers' requirement just on the right time at the right place, the supply chain itself should be changed dynamically[1,2]. This paper proposes an architecture in which dynamic supply chains can be managed.

The proposed architecture is named SUPREME: SUPply chain integration by REconfigurable ModulEs. The architecture especially focuses on the APS (Advanced Planning and Scheduling) framework and XML

(Extended Mark-up Language) based communication protocols on the Internet. In this case, the scope of the APS systems is not only inside a factory, but also outside, e.g., logistic firms and supply chain coordinators offices. The interoperability of this distributed systems and their application integration are conducted by PSLX (Planning and Scheduling Language on XML specification) technologies[3].

The organization of this paper is as follows. First, in the section 2, the proposed system architecture is illustrated. Then some applications of the architecture to practical business scenarios are introduced in the section 3. Some of the scenarios are more elaborated and discussed in an experimental study in section 4. Finally, the section 5 describes some concluding remarks.

2. SUPREME ARCHITECTURE

The proposed architecture named SUPREME is designed to apply in a dynamic supply chain business models in an OKP environment. In this environment, each enterprise has to have a function to reconfigure the relationship of partners, because the products ordered by customers are one-of-a-kind so that they need a new supply chain every time. In order to do this, they should be able to select suppliers quickly, and also manage them consistently until the production will be completed. The proposed system architecture supports these business processes using ICT infrastructure and APS technologies.

In this framework, APS performs in planning and scheduling of each partner's activities, so that the throughput of the supply chain will be maximized. Moreover, APS deals with unexpected changes in the reality, adjusting their old schedule to the new environment immediately. Some times, the changes directly affect to the schedules in different enterprises through the supply chain network. In such a case, the system can maintain the consistency of the schedules by using APS systems and Internet technologies.

Features of the proposed architecture are as follows. First, the target of the system is OKP environment. There are many supply chain management systems for repetitive production. However, supply chain management for OKP needs different methods and technologies. Since OKP has to make a supply chain network for each customer's order, a partner selection process is required frequently. To shorten production lead time, the system should flexibly support the configuration and re-configuration of the network.

Second feature is that the system can support collaboration of planning and scheduling processes among different enterprises. The selection of partners is evaluated not only by the quality and cost of the products, but

also by the total delivery date estimated by the APS module. Temporal relationship of delivery dates dynamically affects the lead time of the whole process of the supply chain. Therefore, the supply chain coordinator should manage the delivery date in order to synchronize the network. The APS modules in this framework provide re-configuration or re-scheduling functions. These functions will take a very important roll of the OKP environment.

The final feature is addressed on the communication protocols used in this framework. We use HTTP for data transportation on the Internet. Using this protocol, two different ways of communication are involved in this architecture. The first is a typical communication using a web server and an application server combination. This has an advantage that client side does not need any particular system except for a web browser. The other is a communication using a PSLX interface module, in which XML-SOAP technologies are used for implementing web-services. The detail specification of the PSLX interface is published in recommendations of the PSLX consortium[4].

In the SUPREME architecture, members candidate for the supply chain have a distributed system. Each distributed system is connected to the production planning system in the manufacturer. Operations in the production processes are managed by APSTOMIZER, which is an APS system developed in HOSEI University. On the other hand, the supply chain coordinator has another system, which deals with synchronization among the distributed system located in each manufacturer. This system concerns a virtual supply chain, calculating some recommendations of supply chain networks.

Communications among supply chain members and the coordinator are executed in two ways. One is web-based client-server communications, in which an enterprise gets another enterprise's information via a server-side system located in the coordinator. The second type is peer-to-peer communications that the supply chain members directly send their information each other. When communication processes are critical in terms of time constraint, the second type might be necessary in practice in order to establish synchronization of the business process.

3. BUSINESS SCENARIOS

Considering an OKP environment, there are various benefits if different enterprises can share their production information and make collaborative decisions on the SUPREME architecture. In those cases, planning and scheduling problems are important to catch up with the changing market

environment. This section shows some business scenarios in which the SUPREME architecture will play an important role. Actors of the scenarios include customers, manufacturing enterprises and third-party-logistic (3PL) companies. Since these actors perform on the different decision-making systems, a supply chain coordinator, which is another actor proposed within the architecture, is due to establish synchronization for a win-win partnership.

3.1 Supply chain agent

The first scenario is that a customer, who requires an OKP from scratch, accesses the SUPREME coordinator in order to make a quotation and choose the best supply chain recommended by the system. In a quotation process, the customer puts his/her request in a form of process plan sheets. Then the coordinator asks the corresponding partners' manufacturing capability and also the availability to meet the schedule. Once the suppliers have registered their manufacturing capability to carry on some of the predefined manufacturing process candidates, the coordinator can select an appropriate supplier for each process, which is part of the input for the customer's request. Finally, the APS module calculates feasible plans and schedules, in which all temporal constraints such as precedence relations and lead time are satisfactory.

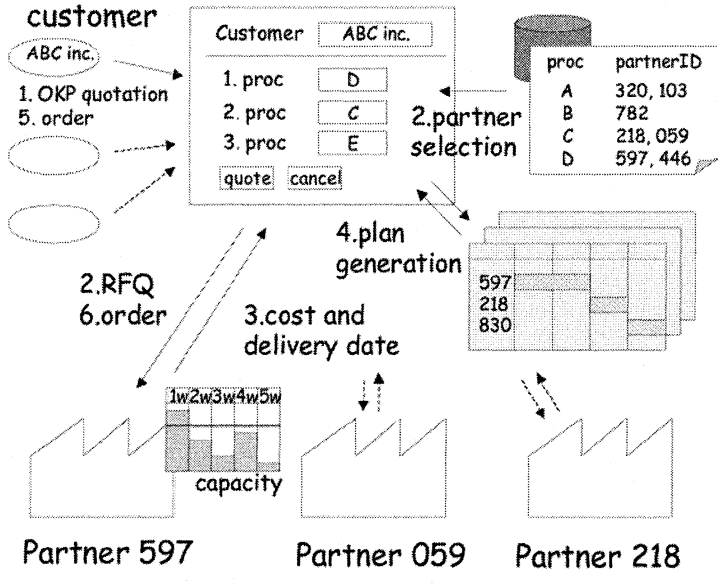

Figure 1. Supply chain configuration agent

In this case, the SUPREME coordinator performs as an agent who arranges the best plan to fulfill the customer's order of OKP. One of the differences between the agent and a supply chain planning staff is that former can be automatically executed on the Internet. Furthermore, after a supply chain is established, the members of the supply chain can be cooperated each other on the Internet until the supply chain network is dismissed. The coordination is managed in the SUPREME architecture. Figure 1 demonstrates this scenario.

3.2 Delivery process integration

The second scenario focuses on integration of a manufacturing process and a delivery process. While a 3PL partner manages delivery processes ordered by several manufacturers, connecting the customer's manufacturing processes with the supplier's manufacturing processes plays a very important role. This will be achieved by process integration between logistic enterprises and manufacturing enterprises. For instance, a truck driver has an accident and the estimated arrival time would be behind the schedule. Or a supplier's shipping process was delayed and excepted production volume would be shortage. In those situations, the scenario shows that a revised logistic schedule is sent to the coordinator, and manufactures relative to the change are informed to rearrange their current schedules.

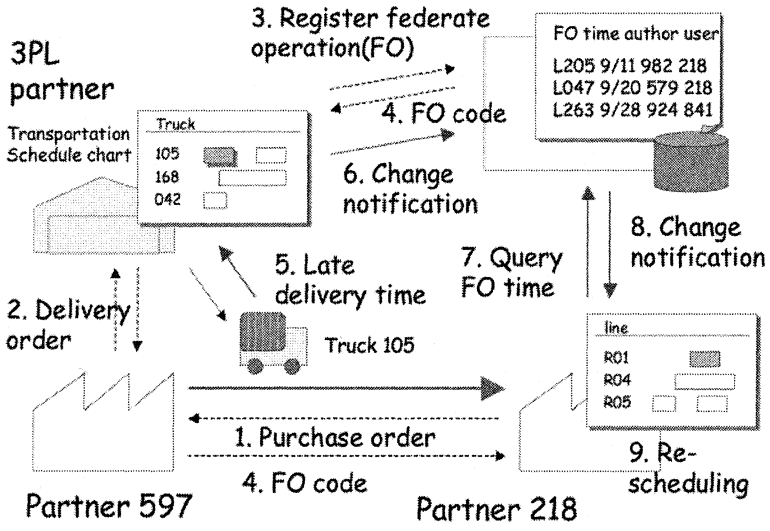

Figure 2. Delivery process integration

Detail of the collaboration is shown in Figure 2. A manufacturing enterprise sends purchase order to a supplier, who then asks a 3PL company to deliver the products. Regarding that both the customer and the supplier have their production schedule, the delivery schedule is uploaded to the SUPREME server in order to synchronize the production schedules. The customer frequently checks the delivery process as well as the supplier's production process. When some serious changes are occurred, the SUPREME suggests making reschedule the customer's plan.

3.3 Outsourcing management

The final scenario is addressed in outsourcing processes. When a manufacture makes production plan by loading and leveling the resource capacities, a part of the orders would be asked to some suppliers that have free capacity of resources for the corresponding production processes. In OKP, however, the selection of suitable suppliers takes a long time, because most of cases are the first time in its experiments. Like the first scenario, this partner selection for outsourcing can be supported by the SUPREME architecture.

The SUPREME also copes with the collaboration processes after the supplier selection is finished. As shown in the figure 3, the customer's production processes and supplier's production processes can be synchronized by peer-to-peer communication between them. This

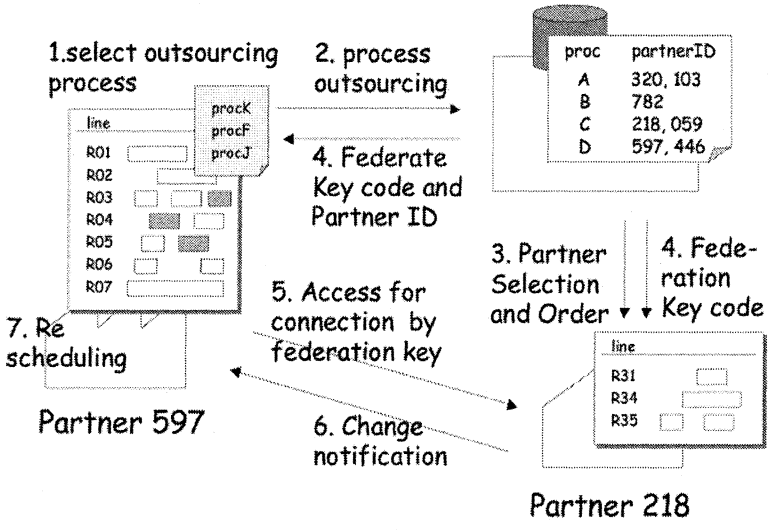

Figure 3. Outsourcing management

communication process has an advantage if changes in one partner's manufacturing processes immediately make a negative effect to the other. In this case, the SUPREME is a kind of broker, who only initiates a secure communication by "federation keys" for identifying their partner. By means of this peer-to-peer communication and APS modules, distributed processes in different enterprises can be synchronized.

4. DISCUSSION

Since SUPREME has defined as a system architecture for a supply chain management of OKP, particular systems implemented for each business environment would have different forms. In this study, a prototype system of SUPREME is developed for further discussions. The system performs pretty well on the first scenario and partially on the third. Some graphical user interfaces of the system are briefly described.

First of all, the *partner registration* form is used for new members who want to join the virtual enterprise network. In this form, each one registers its information of the company profiles and also describes its production capability, which will be used by the network members as a partial production processes in a future supply chain. Then the *order entry form* can be shown for the customer who is also a member of the network. In the order entry form, the customer can design by input any manufacturing processes in order to produce the appropriate products.

This information is sent to the SUPREME agent, who then gathers corresponding partner's manufacturing capacity. After the APS module calculates some supply chain configuration plans, the *plan recommendation form* shows them for the customer as selection candidates. If there is more than one plan, each plan is recommended with its cost, delivery date, and quality information. Furthermore, the *Gantt chart* that represents the whole supply chain production schedule can be shown for each candidate.

The user interface forms descried above are in the front end of the communication processes between an OKP customer and a supply chain coordinator. On the other hand, back end of the system is implemented on web-applications, web-services client/server modules, a RDB system, APS modules, and so on. The prototype system also has a function of peer-to-peer communication.

5. CONCLUSION

This paper deals with a dynamic supply chain for OKP environment. ICT support is necessary for current economical situation, because the supply chain setup time should be managed shorter and shorter. In the emerging supply chain, each collaboration scheme also has to change in accordance with the dynamics of the real environment.

SUPREME is a system architecture that has web-based collaborative planning and scheduling system for virtual enterprises. Therefore, the architecture has an APS modules and PSLX interfaces modules as well as the other technologies. These components are addressed both on a supply chain coordinator site and each member's local site in the supply chain network. Then the coordinator performs as an agent that dynamically configures and maintains the suitable supply chain.

A prototype system is developed and demonstrated for evaluation of the architecture. We show three business scenarios, both of which represent typical scenes of a strategic supply chain management in OKP. After the prototype system is briefly demonstrated, the experimental results shows that APS modules and PSLX interface modules play a very important role in the proposed system.

In conclusion, the SUPREME architecture, which has capability to re-configure and manage supply chains dynamically, is one of the most suitable solutions to achieve the goal of the supply chain management in OKP. In addition, the communication and collaboration methods in such an open network platform are required, so that PSLX interface and collaborative APS will be the important research topics in the future.

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