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A MODELING APPROACH FOR DESIGNING VALUE CHAIN OF VE

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As the advent of digital economy changes business environment dramatically, Virtual Enterprise (VE), in general the interactions among business partners in a value chain, has become a key factor to survive under the competitive business environment. VE reveals that more complex and dynamic business processes should be considered as assembled service components in order to integrate the collaborative business processes. Therefore, a formal standard schema for describing and managing the business processes is required. In this paper, we propose a consistent modeling approach that combines enterprise modeling and simulation modeling to design a value chain of a VE. This methodology will provide designers with insight into the business processes of a VE and help identify and resolve unpredictable bottlenecks on the execution of virtual business processes. This paper also illustrates an implemented modeling tool which is based on the generalized model suggested by the working group of ICEIMT and notations by OMG EDOC.

1. INTRODUCTION

Today, in order to achieve mass customisation on a global scale, most of the competitive enterprises focus their core capabilities on their value chain management. It contains the design chain and the supply chain linked with a large number of suppliers and vendors (Messina 1997, Kim 2000). As each enterprise operates as a node in the network of suppliers, customers, engineers, and other specialized service providers, the collaborations between multiple partners are becoming important and VE is emerging as a result (Jagdev 2001, Thoben 2001). Enterprise Engineering (EE) can be used to support the life cycle of a VE (Vernadat 1996). Fundamental of the EE approach is the use of a backbone of modeling concepts that underpin the representation of enterprise activities and objects from different viewpoints, at different levels of granularity, generality and abstraction and during different life phases. Prior to the construction of a VE, a coordinator or a broker must carefully define the business scenario that defines roles, sequences, and interactions between partners, and the business criteria to achieve their coherent business goals. Also, the agile responses to the unexpected changes that may occur during the product life cycle are essential for a VE (Kim 2001). This requires an integrative enterprise engineering approach: ① enterprise modeling at a higher level is needed to provide participants with common understanding of their collaborations, and ② simulation modeling at a lower level is used to evaluate functional capabilities of each partner and to obtain performance metrics for the VE operations. Use of this simulation in the early design stage of a VE helps to reduce the uncertainty throughout the life cycle of it.

This paper presents a modeling methodology and an implemented tool based on the generalized model suggested by the working group of ICEIMT and notations by OMG EDOC. The rest of this paper is organized as follow. Section 2 describes an overview of the proposed modeling approach, and Section 3 shows tool kits to support the proposed approach. Section 4 then explains the interaction between the enterprise modeling and simulation activities. Finally, Section 5 provides the conclusion and future work.

2. OVERVIEW OF MODELING CONCEPT

Business processes of VE involve various processes of different participants. To enable flexible integration of partial processes, the business process models should be based on a meta-model in a standard form that supports dynamic properties of a unit process. To respond to this qualification, a generalized and process-oriented representation of partner businesses (co-operating in the life cycle of a product) was developed by an International Conference on Enterprise Integration Modelling technology 97 working group (Weston 1997). This process-oriented model exemplifies important features of many global multi-partner businesses. First, it emphasises the need to design and realise appropriate "Process Streams" and "Organization Streams". With respect to the process stream, units of enterprise activities need to be logically and temporally ordered to realize the products of an acceptable quality at the right place and time. For the organisation stream, human and technical resources must be systematically and repetitively assigned for the enterprise activities. The proposed modeling approach in this paper is based on this modeling philosophy and is used to design a business scenario and business processes.

The VE considered in this paper belongs to the star-type among diverse types (Thoben 2001). In the star-type, the communications between any two peripheral nodes will be always conducted through the central node called a broker whose roles are ① the registration of an enterprise, ② the formation of a VE, ③ the life cycle support and ④ the replacement of partners (Harbilas 2002). Frequently, the role of the coordinator is taken over by the final assembler.

Figure 1 shows the conceptual modeling approach proposed in this paper. The right side of figure 1 shows that the coordinator composes an enterprise network after receiving an order. The candidate nodes of the enterprise network can be searched from the public registry, such as ebXML Reg/Rep or cognitive communities of the enterprises. Once the enterprise network is composed, the coordinator designs a business process stream according to the business scenario and evaluates it using simulation with respect to the customers' requirements and the global business constraints. Exemplary business constraints include ① product specification, ② due date, ③ order volume and ④ cost. The participants simulate their manufacturing facilities with the conditions provided by the coordinator and send the results back to the coordinator. Then the coordinator analyzes whether some results from the participants conflict with the global constraints. If there is no conflict, the product can be manufactured and delivered to the customer in the next phase called "VE Execution". Otherwise, the coordinator requests the participants to re-arrange their resources to meet the global constraints.

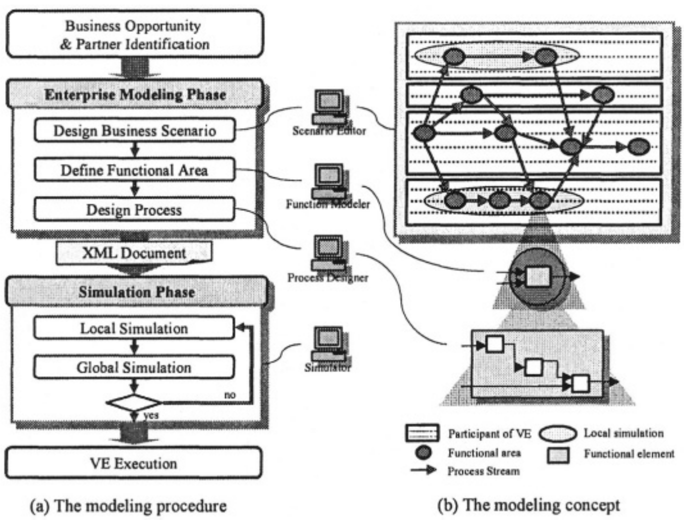

Figure 1 – Proposed modeling approach

3. ENTERPRISE MODELING APPROACH

The purpose of the proposed modeling approach for VE is to extend the capability of the existing public domain architectures and methodologies as well as our methodology of the previous research, IMEE (Kim 2001), with respect to partnership enterprises. As shown in figure 1, the modeling approach starts with "Design Business Scenario". In this step, we select some functional areas and organizations of each participant using the function-organization matrix that describes the process stream and the organizational stream of the VE. To improve understanding about the functionalities available to each organization in a partnership enterprise, the top-down analysis is facilitated to reveal the primary functional capabilities of partners. The functional model of this approach is a kind of "CompoundTask" of the UML profile for EDOC-BP (OMG 2002). For the bottom-up object-oriented modeling to systematically describe information and function as a single object view, the object components and their relationships are described through a meta-model of the UML profile for EDOC-BP. To support this modeling approach, we developed three kinds of modeling tool kits: Business Scenario Editor, Function Modeler and Process Designer.

3.1 Business Scenario Editor

Figure 2 shows screen captures that illustrate how to create organizations and business areas of participants. In the "Department" tree-view, we create organizations using the pop-up menu, while functions are created in the "Operation" tree-view. Through the iterative process for the creation of the functions and organization, the function-organization matrix can be constructed.

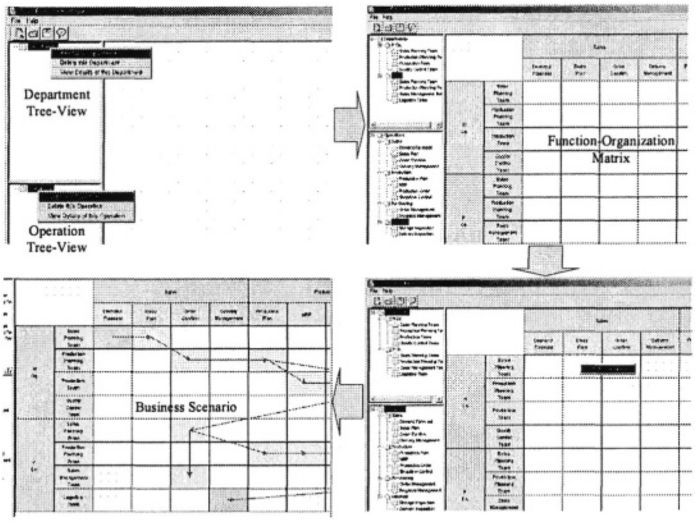

Figure 2 – Design of a business scenario

From this matrix, we can design a business scenario by selecting and connecting cells that represent a function of an organization. A business scenario depicts 'What to do' rather than 'How to do'. We can connect two cells and add "Spit" or "Join" operators according to the business context.

3.2 Function Modeler

Since a collaborative business process is widely distributed across several enterprises, a formal and common schema is required for the participants to understand their roles and relationship with the business process. To support this schema, a common definition of the function is needed. The modeler provides a dialog box for the description of the function. An XML document obtained from the function description (see figure 3) is stored into a repository. In the next step, we connect these identified functional elements to constitute a business process of VE. The products of the functional elements, that is an XML document, will be transmitted to the simulation package and will be discussed in detail later in this paper.

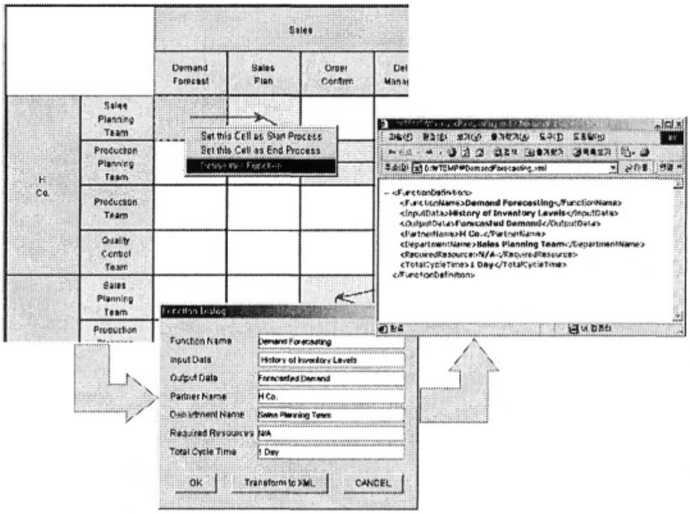

Figure 3 – Generation of an XML document

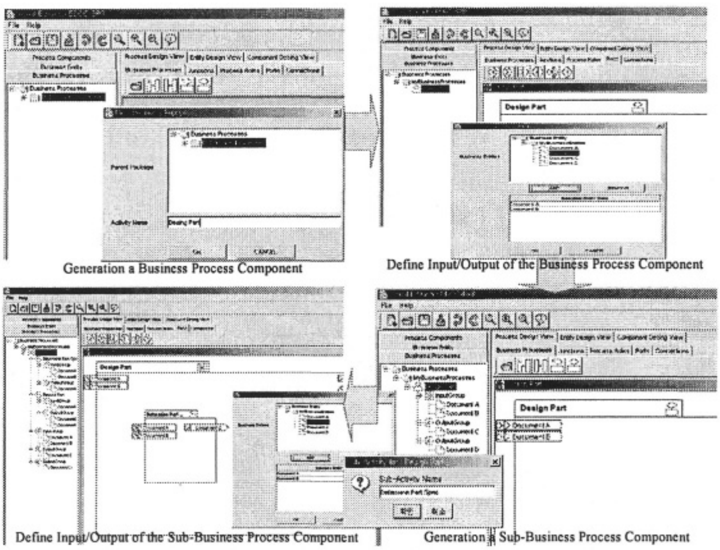

Figure 4 – Modeling of a business process component

Functional decomposition of the top-down approach can be extended to design a system where the consistency between system design and analysis should be assured. Although this approach provides flexibilities to develop enterprise systems, the interoperability problems among business components based on diverse middleware platforms cannot be resolved. To remove this bottleneck, OMG suggests MDA (Model Driven Architecture) concept and the UML profile for EDOC (Enterprise Distributed Object Computing) to improve the productivity, quality and reusability of a model (OMG 2001, OMG 2002). For these reasons, the function modeler developed in this paper is based on the UML profile for EDOC. A business area can be defined as a business process component that has an input and output port which are characterized by “Synchronous” or “Asynchronous”. The business process component is decomposed into sub-business process components. At first, we create a “Package” and a business process component. The generated component is registered in the left tree-view of the window. From the business process component, sub-business process components are created based on the procedure as shown in figure 4. Sub-business process components can be newly generated or imported from other business process components.

3.3 Process Designer

As shown in figure 5, the process designer has a tree-view and a diagram-view. In order to define a business process model, we select business process components and their ports. Then, we connect them using the “Data Flow” button. If two or more components are connected, we use a “Junction” component (AND/OR/XOR Split or Join). A business process can be created through these iterative procedures. The lower screen of figure 5 shows an example of a complete business process modeled via the process designer.

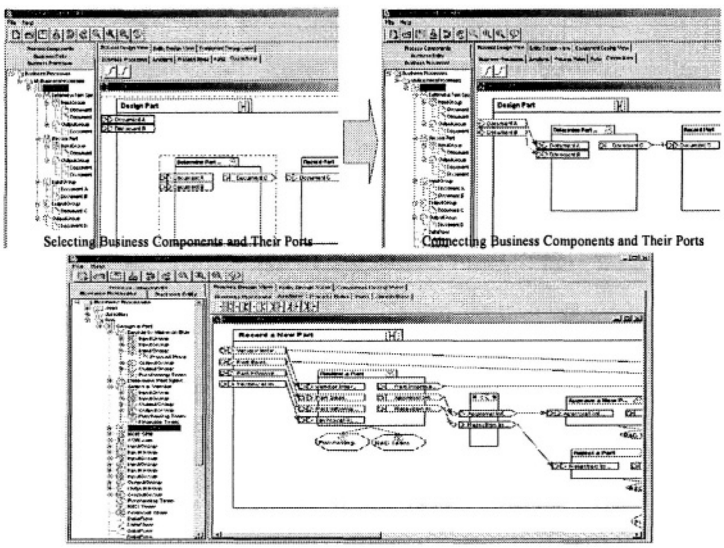

Figure 5 – Design of a business process

4. SIMULATION MODELING

While an enterprise model focuses on the interactions among participating companies of VE, a simulation technique is employed to evaluate each partner’s functional capability with local simulations as well as the coordinator’s business process feasibility with global simulations. Two types of interactions are described in this section: ① interaction between an enterprise model and a simulation model and ② a close loop interaction between the local simulations and the global simulation.

The products of the functional elements constituting a process stream of a VE are first translated into the XML document as shown in figure 2, and then translated into the required inputs for each simulation package. The partial information of the functional elements is used to construct a series of pre-defined events for each individual simulation. In addition, the partial information of the functional elements is used to specify the data associated with those events. For example, when the assembler sends a message related with an order to a supplier, both parties must have the same understanding of what is meant by "Order". Some of those elements are: ① order, ② product, ③ transporter order, ④ supplier details, ⑤ assembly details, and ⑥ transporter details. Partial attributes of these elements will be used as business constraints such as ① product specification, ② due date, ③ order volume, and ④ cost. Elements related with simulation results also must be defined. Since the functional elements will contain information on resources, a partial simulation model can be automatically generated. Shop floor resources (R) include equipment (E), tools (T), fixtures (F), instruction sets (I), connectivity graph (CG), and more. The simulation generation method interacts with E, CG, T, and F. A connectivity graph (CG) is a graph showing the connections between the equipment in the facilities. Each node is associated with a physical equipment entity. Each arc is associated with an equipment interaction -- an origination node and a destination node. In this paper, a preliminary resource model has been developed using the XML document, whose instances will provide input information for the simulation model generator.

To construct a global simulation model, a system dynamics (SD) simulation technique is normally used. SD simulation is normally used to build models using aggregated data for system wide dynamic flow analysis of managerial decisions. On the other hand, a discrete event simulation (DES) technique is normally used to construct a local simulation model. DES is used to model a system in detail to comprehend the actual behavior of the individual components. When each simulation run is requested, the simulation must capture the commitments that have already been made in addition to the new commitment that has initiated the current simulation run. Synchronization of information must detail as to ① what information needs to be exchanged between the local DES and the global SD simulation models, ② when the exchange must take place, ③ how information is transformed, and ④ how the information is utilized by the models. When stochastic input data are used for simulation, simulation results, such as machine utilization, mean tardiness, and cost, will be represented in the form of ranges (e.g., confidence interval).

To enable communications between simulation models, each simulation model is broadly classified into two parts: ① the interface module and ② the actual model. One entity is created at zero time and is in charge of interface with the external events. It is noted that these events must have been determined on the basis of the enterprise model (functional elements). It is noted that if a company belongs to multiple virtual enterprises, the associated simulation model interacts with multiple external events. The interface module can be implemented in Visual Basic for Arena™ and in C++ for ProModel™ and AutoMod™. The actual model of each simulation is the representation of a physical facility (e.g., final assembly plant, component supplier, and transporter). The benefits of a simulation model compared with an enterprise model include the high modeling fidelity and an ability to model constrained capacities of resources. A parametric and data-driven simulation model will be designed and constructed to enable for the same simulation model to be used to evaluate different set of parameters without any modification.

5. CONCLUSION

In this paper, we proposed a new modeling approach combining the enterprise modeling and the simulation modeling. Although the enterprise model of a VE has diverse views such as function, information, organization and resource, we focused on the functional aspect for the design and evaluation of the collaborative business processes. The proposed methodology is useful to rapidly define functional elements and evaluate functional capabilities. In this work, a distributed simulation is used for the evaluation of the business processes.

Future work will be conducted to apply the proposed concept to the real world cases, including the SAMEX (Samsung Mexico Electronic Complex) composed of Samsung Electronics, Samsung Electro-Magnetics, Samsung Corning, Samsung SDI, and their suppliers.

6. ACKNOWLEDGMENTS

This work was partially supported by grant No. R05-2003-000-10080-0 and No. R01-2003-000-10171-0 from the Basic Research Program of the Korea Science & Engineering Foundation

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