Virtual Enterprise Architecture and its Supporting Methods/Tools for Managing Supply Chain System Life Cycle

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Abstract In global and competitive business environment, agile virtual enterprise set-up to meet customer needs has become more important. Many companies make a lot of efforts to reengineer their business processes and for example reform existing rigid and inefficient inter-enterprise data interchange to open and efficient supply chain by utilizing advanced information technologies. This paper discusses set-up of virtual enterprise that deliver services of life cycle management of supply chain system.

1 INTRODUCTION

Engineering firms have been accustomed since their origin to organizing a project group involving enterprises concerned, in order to implement Engineering/Procurement/Construction (EPC) for client's one-of-a-kind product, which is often a plant or factory. The engineering industry has long been holding work execution conformation that could serve as the origin of today's Virtual Enterprise (VE). Engineering firms have been concentrating their efforts on project management based on such work execution conformation.

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As telecommunication and information processing technologies developed, this work execution conformation has become accepted by other one-of-a-kind industries, such as shipbuilding, heavy machinery, and building. This work methodology has recently been attracting attention of general machinery industries, as Supply Chain Management (SCM). In the Globeman 21 Project [1][2][3][4] we defined this work execution methodology as Virtual Enterprise (VE) and studied its features.

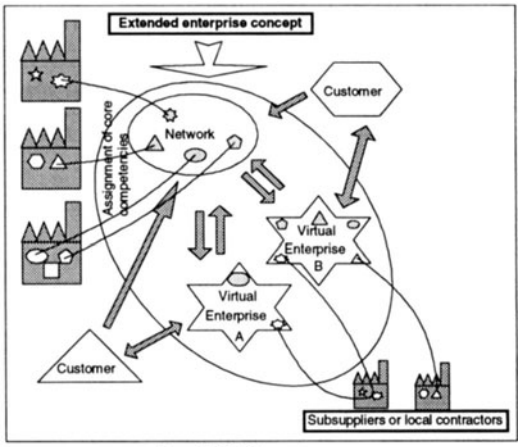

Fig.1 VE Concept

The VE is initiated with consultation for clarifying specifications based on client's specific requirements. As to design, construction, operation, and specific activities, competent enterprise groups are combined to implement the project, as shown in Fig. 1. When an enterprise has completed its role in the project, the enterprise goes out of the VE, leaving technical data about the object. Upon completing the project, the VE is disorganized, while related data is accumulated through the network in the real enterprises that have participated in the project, for use for renewal and maintenance of the project plant or factory. In order to realize such an enterprise entity, information infrastructure and management are needed.

This paper discusses the basic structure of inter-enterprise management as well as infrastructure for constructing the required VE.

2 LIFE CYCLE MANAGEMENT FOR VE

A long-life product, such as plant and factory, serves for 30 to 40 years from the beginning of the project to scrapping, through construction and operation. The project EPC, implemented from the project planning stage to

the start of plant operation, takes only 2-3 years. While conventional engineering work covered the 2-3 years, a new work-type engineering firm should consider Virtual Enterprise (VE) to offer services during the whole product life cycle. The product life cycle covers: sales, consulting, contracting, EPC, delivery, and operation support and maintenance.

Each of these phases requires project management, technical support, special technologies, labour, etc. Since it is almost impossible for any enterprise entity to offer, control, and implement all technologies for all the phases, it has become necessary to organize a temporary team, involving suppliers and other entities having necessary technologies. This report analyses work conformation at individual phases from the viewpoint of VE and on the basis of engineering firm's experience, and summarizes the requirements.

2.1 Consulting Phase

In this phase, the engineering firm, together with the client, analyzes existing business processes and identifies the specifications required for "to-be" systems. This service must be performed for a short period, although it is normally paid. The work requires client's basic information to facilitate the business process analysis. Since confidentiality is crucial, the engineering firm excludes suppliers from the VE team and gathers necessary information without involving suppliers. In other words, from the viewpoint of VE, the client and the engineering firm implement the work, under a **1:1** relationship. It sometimes occurs that the client performs the work in-house using engineering firm's tools and methodology because the client does not want to disclose its own information. In this phase, therefore, an environment appropriate for prompt work support should be built, and temporary lending out of methods and tools may be considered.

The roles of the engineering firm in this phase are (1) providing analysis tools and methodology, (2) providing a concept of the new system, and (3) providing methodology for modelling specifications. In this phase, the engineering firm is not requested to provide management services. The output of this phase is identified product (system) scope, purpose, structure, and components, and serves as the input to the EPC phase.

2.2 EPC Phase

The Engineering/Procurement/Construction (EPC) phase starts on the basis of specifications clarified as a result of the consulting phase. In some

cases, the prime contractor, or engineering firm, serving for the EPC phase may differ from the prime contractor for the consulting phase. The outcome of the consulting phase should be specifications understandable for third parties.

When the EPC phase starts, the organization of enterprises that compose the VE has not yet been completed. The organization is gradually completed as engineering work progresses. That is, the VE group is composed of a few members around the main contractor that manages the progress of the entire project, and the group grows as the project work develops. The main contractor, or engineering firm, coordinates the client and suppliers; the main contractor works with a 1:N relationship.

In the construction phase, a number of subcontractors participate. At this stage, while information about the VE flows in two ways between VE members, technical information and managerial information should be concentrated at the engineering firm. The roles of the engineering firm at this phase are: (1) splitting work, (2) securing resources, (3) managing the progress, (4) managing the functions of the entire system, (5) managing technical information, and (6) managing information flow inside the project. That is, while an **N:N** relationship is constructed in the VE, all information should be concentrated at the engineering firm.

2.3 Operation Support and Renewal Phase

Previously, engineering firms were not active in the phases after the delivery of product. Engineering firms participated in the Operation Support and Renewal (OSR) by, for example, bidding for revamping etc. Individual suppliers also participated in OSR by supporting operation and maintenance of their equipment. In this paper we define the OSR phase as a stage where client needs can be well understood and client-oriented services can be offered. Based on this understanding we provide "OSR Community Environment" as illustrated in Fig. 2. In this community, the client and suppliers are combined with **N:N** relationship, and a VE is organized of most suitable members to provide services on the basis of the contract with the client (monitoring, diagnosis, training, preventive maintenance, revamping, etc.).

It is necessary to reorganized design information produced in the EPC phase so that the information can be used in the OSR phase. The roles of the engineering firm in this phase are: (1) monitoring the entire system, which is the product, (2) providing tools and methodology required for solving problems, and (3) providing necessary resources.

Fig. 3 summarizes the changes in VE at various phases in accordance with the life cycle.

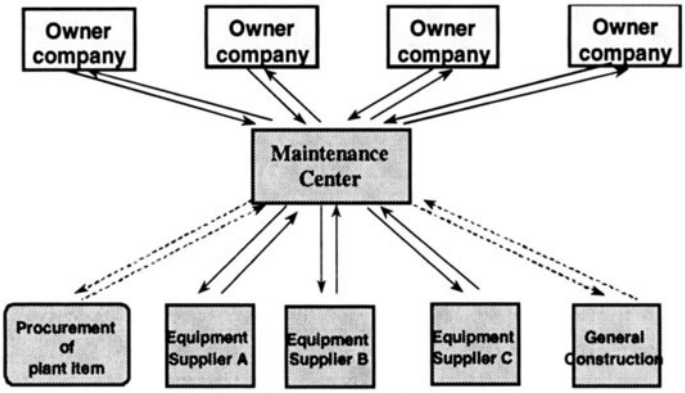

Fig.2 OSR Community Environment

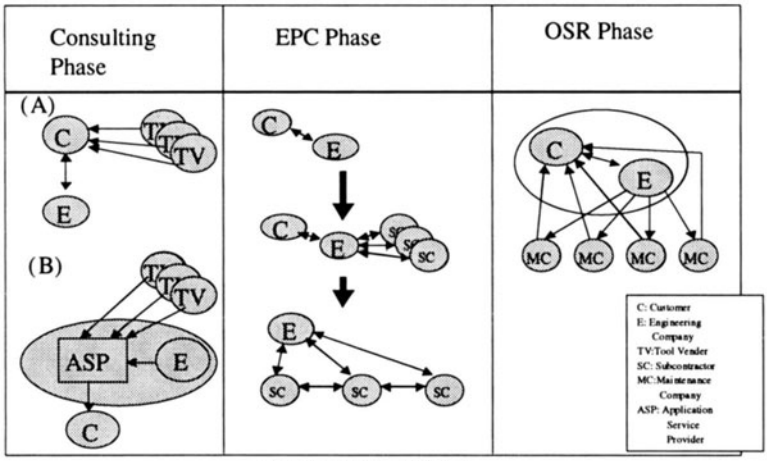

Fig.3 Structure of VE

3 REQUIREMENTS FOR VE LIFE CYCLE

TEC implements engineering activities to create SCM, in addition to conventional engineering firm's activities. With regard to SCM, TEC's activities are focused on the consulting phase. Based on such experience, we have analyzed the VE activities in the entire lifecycle activities, and have revealed the following major requirements. In order to realize VE:

1) VE should assure free, open participation.
2) VE should be able to combine special capabilities.
3) Each VE member should be able to identify his or her roles in the VE.

4) VE should allow information to be exchanged freely.
5) VE should not depend on OS and other specialty.
6) VE should allow VE Technical data and models of the object system to be transferred when the phase changes.
7) VE should be able to guarantee data to be interchangeable during the life of equipment and other hardware.
8) VE should be able to change the basic composition of VE from phase to phase.

Items 1), 2) and 3) relate to organizational problems, 1), 4), 5) and 6) to information infrastructure problems, and 6), 7) and 8) to project lifecycle problems. With regard to project organizational problems, project functions through phases should be broken down and described clearly. For this purpose, the domain of each function and input/output specifications should be defined at least. To satisfy this requirement, techniques for modelling of objects should be utilized. As a tool for modelling, IDEF for example is available for description. For SCM in which the objects are known to a certain extent, modelling techniques with templates such as SCOR are used.

As to information infrastructure, communication functions and information interchange is a problem. This problem can be coped with by the combination of the Internet and browser functions; however, the solution is applicable mainly to documents and screen images prepared in advance. In project execution, real-time information exchange and decision-making through conference are important, and this requires particular infrastructure. In the case of VE, the problem of information exchange is wider, covering documents, drawings, images, applications, etc. Since information exchange is needed throughout the entire product lifecycle, information exchange viewing future prospect is needed. This requires not only exchange of applications that is presently made, but also information exchange intermediate form such as XML, which is independent of applications. Where the applications to be used are known to a certain extent, use of Application Service Provider (ASP) is available. In this case, at least data should be independent.

The problem of lifecycle is important for project management although it has been little aware of. Depending on the lifecycle, resources including organization, application and tool are different. The prime contractor (engineering firm) may be different depending on the lifecycle, so the model must be described in advance. The description can be made with GERAM etc.

Table 1 shows the result of organizing functions needed for supporting the construction and operation of VE and for managing inter-enterprise

processes. Fig.4 shows the summary of specific methodology referring to building supply chain system.

Table.1 Methods/Tools for VE and IEM

VE set-up & operation	Open network environment	Internet/Extranet, WEB
	VE & business process Modelling	IDEF, GERAM, ARIS, SCOR
	Application interoperability	Java, CORBA, ASP
	Document exchange	XML, SGML, STEP
	Security management	
Inter-enterprise management	Database management	OODB
	Schedule/Cost/Quality control	PMS tools
	Progress monitoring & control	PMS tools
	Scheduling & coordination	APSTMIZER, PSL

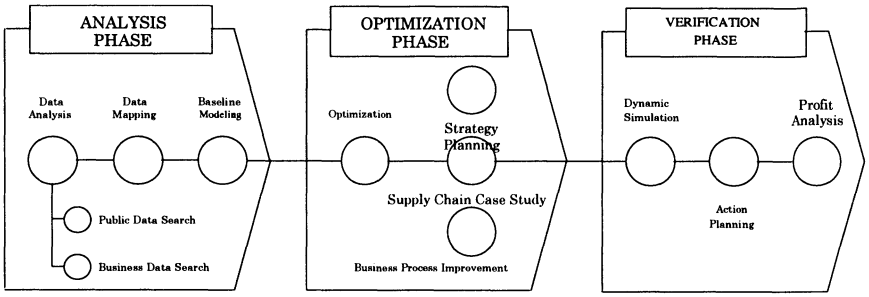

Fig.4 SCP methodology

GLOBEMEN-Japan intends to realize the whole picture of project management as shown in Fig. 5 in accordance with the VE features described in Chapter 2 and the requirements described in Chapter 3, in order to expand the project management in whole.

4 CONCLUSION

This paper summarizes architectures necessary for realizing OKP engineering activities using VE and proposes architecture based on the experience in engineering activities. This architecture will be realised as industrial prototype in GLOBEMEN project [5].

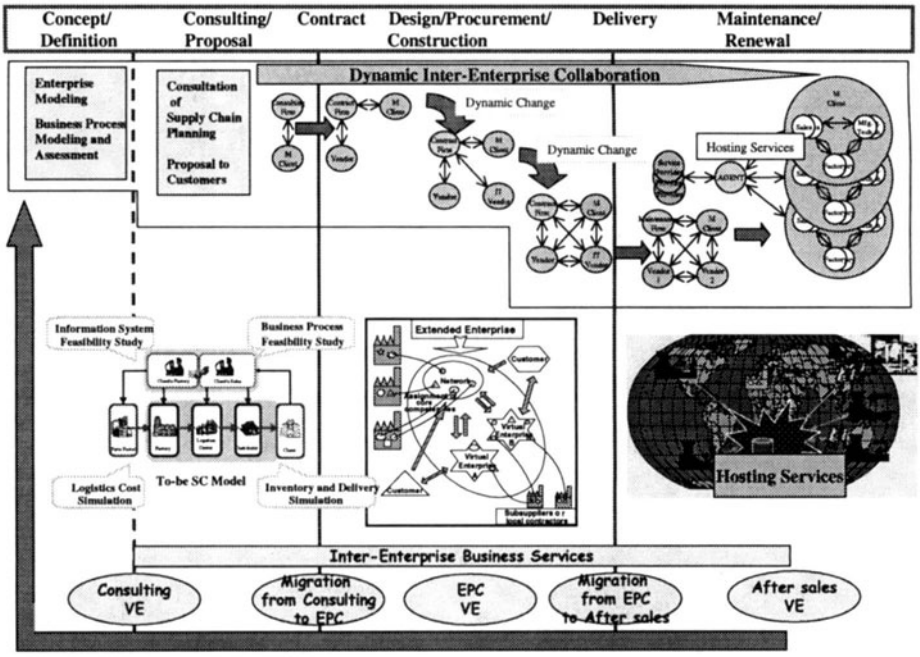

Fig.5 Life Cycle Structure for VE

5 ACKNOWLEGEMENT

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