27 CHALLENGES IN THE MANAGEMENT OF VIRTUAL ORGANIZATIONS

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Virtual organizations (VOs) are considered to be an answer to tightening requirements of cost-effectiveness, time and quality, especially in a global environment. In addition, it is expected that collaboration within VOs contributes to flexibility, agility, customer orientation and decrease of risks. However, these objectives are not achieved automatically. The management of independent entities with individual, sometimes even contradictory, aims is a difficult task containing uncertainty. The Inter-organizational distribution of processes and activities may lead to high coordination costs, delays in deliveries, quality problems, information leaks and loss of knowledge. To prevent the problems, proactive VO management is needed. The paper discusses the challenges for the development of proactive management. The main experience behind the paper comes from the one-of-a-kind manufacturing.

1. INTRODUCTION

The aim of this paper is to discuss challenges related to the management of Virtual Organizations (VO) and to identify further research needs in the area. The paper relies on definitions related to VOs agreed in the VOSTER-project (VOSTER, 2004), which was a cluster project aggregating together the concepts and experience from mainly European research in the field. Although different terms still exist in parallel, there is a common view that the inter-enterprise organizational forms can be described by using two different concepts:

Network / Source network / Support Network/ Breeding environment (BE) is a more stationary, though not static, group of organizational entities which have developed a preparedness for the creation of a temporary **Virtual organization (VO) or Virtual Enterprise** (VE) as there is a need for a value adding task, for example a product or a service to a customer.

The description is applicable also for inter-enterprise collaboration in one-of-a-kind manufacturing, which is the main base for this paper. In this field, also called "project industry", a temporary endeavor, "a project", is undertaken to create a unique product or service (PMBOK, 1996). In project industry co-operation between

enterprises is a longer tradition than the terms "networking" or "VO". The requirement for co-operation comes from the nature of one-of-a-kind products. Typically the products are unique, complex and large systems, such as industrial plants, large machines or buildings. No company alone is able to deliver them. Different kinds of resources, competences and knowledge are needed to design, market, sell, engineer, manufacture and support the product. Variations in the product scope and configuration lead to variations of the resource, competence and knowledge needs in different deliveries. The temporary nature of deliveries and unstable demand also create instability in the demand of resources and knowledge.

In the global world-wide competition networking has become a strategic issue for one-of-a-kind industry. Taking advantage of the advances in the information and communication technologies, enterprises are increasingly operating in cooperative networked environments. Companies need to develop their capabilities to co-operate efficiently despite of their different infrastructures, business cultures, organizational forms, languages, and legal and fiscal systems. The business networks themselves are dynamic and constantly changing.

The paper considers first the objectives of different organizational entities in the context of VOs. VO management challenges are discussed from different viewpoints. As the problems of VOs cannot be solved by pure reactive management in the VO, proactive management and preparation in the network is needed. As a conclusion further research themes for VO management are proposed.

2. OBJECTIVES OF COMPANIES, NETWORKS AND VOS

In a network each enterprise focuses on its core competence and uses the resources of other enterprises for other tasks, usually based on a long-term relationship. This approach is expected to make the operations more efficient both in proportion to costs and time (scale of economy) and to contribute to knowledge accumulation. Other frequently presented business rationale are e.g. customer orientation, flexibility, agility and decrease of risks. The term "breeding environment" used for the network expresses the idea of creating an environment, where organizations can develop, acquire knowledge and potentially grow in a co-operation (VOSTER, 2004).

However, the objectives of the companies participating in a network are not identical. There are always multiple objectives, part of which may be contradicting. This is the case already inside one organisation, where the objectives of different sectors or departments may be different. In addition short-term and long-term objectives may be conflicting. Though in an ideal network or VO the partners' objectives are inline with each other, in practice the situation is seldom as simple. Typically the view of the network or VO manager is different from the view of a partner. Though all the partners are affected by partly the same objectives, the importance of them is not the same for each organisation. One reason may be that an organisation participates simultaneously in several networks.

The long-term objectives of a company typically aim for its viability. The company wants success not only today but also in the future. In addition to profitability of a delivery, customer satisfaction, successful references and continuous product development are necessary. Maintaining profitability requires

the tuning of the delivery and manufacturing processes, co-operation networks, knowledge accumulation and investment risks.

The success of a VO can be considered to be consistent with the objectives of the network or VO manager. To be successful each customer project must take care of:

- the management of costs. In most cases this means keeping the costs within the budget,
- keeping due dates, that is, making the delivery to the customer within the schedule,
- fulfilling the customer requirements (quality) and thus creating good references,
- contributing to development activities by producing data and knowledge and testing new tools and methods in use.

On the other hand, a partner in a VO, values the objectives from its own viewpoint. A partner is typically operating simultaneously in several VOs. The importance of the VO or project for the partner affects the priority that it is given in case of conflicting interests. The importance is based partly on the short-term benefits achieved in the VO or project. However, as the rate of change and uncertainty has increased, the expected future business potential and benefits are currently an important incentive for many partners.

3 VO MANAGEMENT CHALLENGES

3.1 Distribution, dependencies and coordination

In a VO the activities are distributed to different organisations. Also the management of a VO is often distributed in two respects:

- The activities and the partners to be controlled are distributed.
- The management of the project itself may be partly distributed: the subtasks have their own management function.

The duty of VO Management is to take care that the distributed consortium achieves the VO objectives. VO management incorporates different inter-dependent tasks, like planning and monitoring of activities, cost, time and quality management, information management, relationship management, change management, technical integration and risk management.

Having a common value adding goal most often creates dependencies between the different VO partners and their activities. Examples are:

- The "end product" of a VO should be an integrated package of partner results; the contributions must fit together.
- The tasks of partners have input–output –relationships: they create information, material, structures or control orders for each other. These relationships often create temporal conditions: a task can be performed only after another task has given the input for it.
- Allocation of the same resources for different tasks may cause temporal, exclusionary conditions.

The dependencies and absence of power in relation to the decisions of individual partners makes the situation complex. In a system of dependencies the distributed activities do not reach the common goal (the VO objectives) by themselves. This

was claimed by (Lizotte & Chaib-draa, 1997) while discussing the management of concurrent engineering. Coordination is needed in a VO to allocate the objectives to sub-phases, activities or product elements and to monitor and manage their performance. In one-of-a-kind industry project management methodologies, like managing the project through work breakdown structure (WBS) (PMBOK, 1996) are often used.

Despite of the distributed nature of a VO, this work breakdown approach also implicitly assumes that the VO behaves like a single organization. It is assumed to achieve its aims at least as efficiently as one organization. So far, there is little research on the behaviour of the virtual organizations (VOSTER, 2004), (VOmap, 2003), Available solutions are mostly based on experimental approaches, using ad hoc applications of the information and communication technology infrastructure. However, in order to have performance good enough the specific features of virtual organizations have to be taken into account when developing an efficient management.

3.2 Challenges for VO performance

The performance of a VO needs to be considered in relation to its limited time frame. For very short-lived VOs the creation and dissolution phases are critical for the total performance.

In the creation phase, an efficient configuration of the consortium is a key issue. The task can be split into two different, partly related phases. First, well qualified and motivated partners must be identified. Also consideration of the trust effects, independence of partners and the potential existence of conflicts must be considered when recruiting partners for a VO. Secondly, there is a need to establish the collaboration framework with short notice. For both purposes the support of the network/breeding environment is essential. So far, there are very little available services supporting the efficient creation of VOs (VOmap, 2003). Identification, specification and set-up of such general services are research challenges in the field.

A VO is supposed to operate efficiently like a single enterprise from the very beginning. The performance is dependent on the performance of the collaboration, i.e. on the inter-organizational activities. The WBS approach (PMBOK, 1996) described in ch. 3.1 defines one methodology to distribute the tasks. The approach is "hierarchical" allowing the measurement and follow-up of performance. However, the aspect of VO is not specifically addressed. The key challenge in the VO-management is still to get the separate entities collaborate towards the aim of the VO. The inter-organizational management has to rely on models of the VOs and their cooperative performance. Modeling is a key-issue for the performance of VO-management.

The dissolution of a VO has not gained much attention so far (VOSTER, 2004), (VOmap, 2003). However, after the disclosure of the VO, its outcome still exists. There may be rights, liabilities, etc related to it. The "heritance" from the VO must be handled and transferred. In many cases it may at some later stage be the input to new VOs as described in the following section (3.3). Also from the innovative point of view the dissolution is an important phase. The knowledge gained and the experience from the collaboration in the VO can remain and be reused only through the partner organizations as described in section 3.3. Means to take care of a proper

dissolution of VOs need to be developed. The network / breeding environment could contain some basic mechanisms for this purpose.

The performance of the VOs needs to be monitored and controlled. Monitoring approaches should follow the used models and the aims described above. The development of performance measures and modeling approaches have to be done in parallel.

3.3 Knowledge and information management challenges

The management of information and its integration over the product life-cycle phases has received a lot of attention during the past years. Standardisation as well as other initiatives have been started to solve related problems. Information adds substantial value to the physical product. In the VO environment the management of this information becomes even more challenging and complex when the life-cycle steps involve interoperability among cooperating organisations. There is an evident danger of information losses between (Salkari, 2002):

- The life-cycle phases, e.g. when handling over information management responsibility from the design organizations to the operation organizations.
- Different VO partners due to non-standard information formats.

A challenge is to select usable communication means and standards for the purpose.

Information and knowledge are created and cumulated during the whole life-time of the delivered product. In general, it involves the accumulation of information on how the equipment or plant has been delivered, and how the equipment or plant has been used. Activities in one phase of the life-cycle usually rely on information from previous phases. However, also feedback of information and knowledge is becoming important. The experience cumulated can be used in subsequent VO life cycles

- in the same phase, e.g. the experience from delivering the product can be used for better future deliveries of same or related type,
- in earlier phases, e.g. the experience can be used to design a better future product.

The main challenge is to have efficient methods and IT-tools in place that can capture this valuable knowledge in the VO and make it available to the organizations in the network. All sensitivity and other information security aspects must of course be satisfied.

3.4 Challenges for VO risk management

Risk is defined as a possibility of losses or unwanted consequences. Business activities, which generate opportunities, also include risks. As companies develop networking with other companies, their risks are also affected. Networking and operation in VOs change the operational processes and the companies may become exposed to new types of deviations. Tighter relationships also mean more dependencies between the companies, which contributes to disturbance propagation in the network.

All companies are not in the same position in the network. The disturbances or unexpected events have different consequences to different companies. Though the

risks of the network partners are inter-dependent, the network does not have only one common risk. The risks must be studied from several different perspectives.

Risks initiate from uncertainty. In (Karvonen et al., 2002) the business risks of enterprises operating in networks were analyzed in four types:

1. Too low or inappropriate demand.
2. Problems in fulfilling customer deliveries.
3. Cost management and pricing.
4. Weaknesses in resources, development and flexibility.

As VOs are built to perform customer deliveries, items 2) and 3) are the most relevant ones for VO management. The view of the network manager can be supported by the project management practices: In (PMBOK, 1996), which may be considered as a standard of project management, risk management is presented as one of the nine sub-processes of project management.

Thus, VO management includes the traditional project risk management. New challenges are coming from the inter-enterprise dimension, sharing of responsibilities and from the increased importance of information and knowledge. While the sharing of information has become easier, also the risks for information unavailability, information leaks or outdated or corrupted information have increased. The distribution of activities and management in the VO also causes the transfer of some risks between the companies, often from the network manager to a partner. This transfer may lead to the increase of the delivery risk, if the party taking the risk is less prepared to manage it than the party transferring it out.

3. 5 Challenges for VOs in different phases of one-of-a-kind product lifecycle

Different VOs can be generated for different phases in the one-of-a-kind product lifecycle. The types of virtual enterprises can be categorized in four groups (Jansson et al., 2003). When viewing the one-of-a-kind product delivery the type of VO can more precisely be named **Project Virtual Enterprise.** To support the different phases of the lifecycle also other special forms of VO can be instantiated (figure 1).

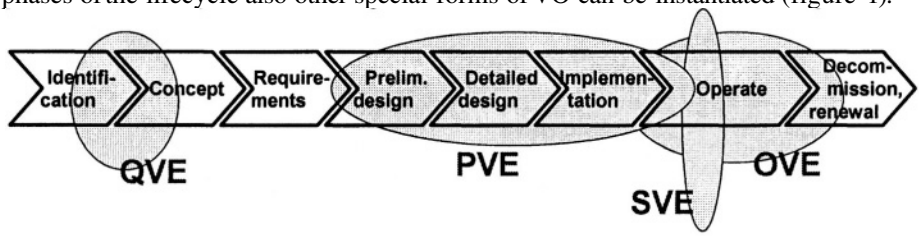

Figure 1, VEs in the One-of-a-kind product life-cycles

The **Quotation Virtual Enterprise (QVE)** investigates the customer's requirements for a product, such as a production facility, provides consultancy so that the requirements are satisfied, and creates a proposal based on a preliminary engineering of the product. The **Project Virtual Enterprise (PVE)** builds the product or the production facility on the basis of the contract. Usually, the customer of these two virtual enterprises is a member company of the **Operation Virtual Enterprise (OVE),** which is the owner of the production facility. This virtual

enterprise uses the product for its purpose, e.g. to produce the planned products. The **Service Virtual Enterprise (SVE)** offers services such as maintenance support, repair, or operation support to each company of the virtual operation enterprise. Despite of being in opposite ends of the life-cycle of the one-of-a-kind product, the management of QVEs and SVEs involves several common challenges. The management challenges of these virtual enterprises are summarized in Table 1.

Table 1: Management challenges of special purpose VOs.

Management Challenge	Quotation Virtual Enterprise	Service Virtual Enterprise
Trigger to set up	Extend to new markets	Time and cost saving
Time required to set-up the VE	Short / medium	Short
Periodical and repetitive need for VE set-up	Small	Medium
Lifetime of the VE	Short / medium	Short or long (depending on the type of service)
Number of network partners	Large	Large
Number of VO partners	Small	Small
Need for local partners	Medium	High
Information and communications technologies	No resources for implementation	No time for implementation
Information flow direction	Down stream	Up and down stream
Information content	Dynamic, uncertain	Complex, large

4. PRO-ACTIVE VO MANAGEMENT

Response to the challenges on VOs requires pro-active management, which aims to foresee possible problems and to act before they arise. To enable fast set-up of a VO in case of a customer request, the first condition is preparation in the network / breeding environment. Additionally pro-active methodologies must be set up for the VO operation phase. These tasks can be carried out at a generic or a specific level.

Generic methods include e.g. following identified best practices for a network and a VO and prevention of typical VO risks.

VO best practices or success factors have been presented in different research projects. Usually they are aimed for specific fields or business processes. Some of them have been aggregated in the VOSTER cluster (VOSTER, 2004). The success factors mentioned include common visions, understanding of objectives of different partners, win-win creation, definition of co-operation processes, trust building and

sharing of information. Following the best practices itself supports the risk prevention but additionally attention can be giving to typical VO risks (Hallikas, 2001).

Pro-active management in one-of-a-kind manufacturing has been discussed in (Karvonen, 2000). From the VO management point of view, one good practice is to plan the VO to be inherently operable and reliable, not a system requiring complex and effective control. One way to attain the goal is to use as simple VO and activity structures as possible. Complex internal dependencies should be avoided. However, as they cannot completely be eliminated, the interfaces between the distributed tasks should be clear and the distribution should not create unnecessary interdependencies between the activities.

Additionally special methods to set up pro-active management may be considered:

- Identification of deviations before their appearance, e.g. by hierarchical or feed forward control,
- Identification of "weak links" and additional monitoring or check-points in the critical activities, aiming at early detection of symptoms of deviations.
- Ensuring easy retrieval of the main information, e.g. near-by due dates for the VO management.

In addition to the generic practices, it is useful to analyze each specific VO case and to plan the VO operations and set up actions based on this analysis. Some methods of project management, like critical path method or project risk management methods (PMBOK Guide, 1996) could be used. However, systematic analysis is seldom performed and more usable methods would be needed to support VO planning taking into account the different objectives and perspectives. These methods could be supported by VO performance measurement processes (VOSTER, 2004).

5. GAINING ADDITIONAL EFFICIENCY FOR VO, DEMANDS FOR SOURCE NETWORK / BE

The distinction between the Virtual Organization (VO) and the Network or Breeding Environment (BE) concepts made in chapter 1 emphasizes the accumulation of experiences and development ideas related to the product, production process and organization. The challenge is to employ the accumulated information and take necessary actions to turn ideas and experiences into innovations that promote continuous success of the network. According to (Roberts, 1988, p 13), innovation is the invention and its exploitation. Consequently, mechanisms supporting a holistic exploitation of the accumulated experiences are key factors for the competitiveness and efficiency of VOs. In the holistic exploitation the view of an entire network is taken. Issues that promote effectiveness in the network scale may be unfavorable from one partner's viewpoint. For instance, the exploitation of accumulated experiences in all kinds of networks is a critical issue. Mechanisms, practices and organization to forward and evaluate ideas for further action must be introduced and agreed upon.

The BE is in a central position to develop and utilize mechanisms for exploiting the accumulated experience. Ideas and experiences from previous collaboration in a VO can be implemented in advance to support collaboration in future VOs or projects. Prerequisites for efficient VOs are a continuous development of the BE including practices for collection of ideas, evaluating them and putting them forward for implementation. Similar aims exist also internally in companies.

Saren (1984, p. 11) has classified product development models according to the following taxonomy: departmental-stage models, activity-stage models, decision-stage modes, conversion process models and response models. When studying models in these classes it is noticed that many of them are built to fulfill mainly internal needs of companies. The existing models, however, recognize on generic level issues, such as interaction between interest groups and contacts to customers that are relevant also in a networked environment. Therefore, they can form the basis for constructing a model for innovation process in virtual organizations. The special characteristics of the VO/BE may prerequisite different logic from the model and the model may essentially be a mix of classes that Saren had recognized. Thus, to really get the innovation process work in virtual organizations, a network specific model needs to be developed. Such a model should support the special characteristics of the VO/BE environment and use appropriate taxonomy and modeling methods.

When developing models for turning ideas into innovations (either radical or incremental) in a networked business environment, the following aspects need to be considered:

- In a holistic development process the underlying dilemma is the possible contradiction between the benefit for the network and the benefit for individual companies. Issues like sharing benefit, liabilities and work may be emphasized.
- A project manager or a temporary manager in a VO may not have the same power as a line manager (e.g. CEO) in a company, who may ultimately make decisions from a holistic viewpoint despite of possible contradictory objectives. The responsibility of the project manager after the dissolution of the VO (project) is also an issue, like the management of the BE.
- Due to the dynamic nature of VOs the organization changes over time. This may set challenges for classifying ideas and accumulated experiences. It may be that ideas turn successfully into innovations only in some specific kinds of VOs that e.g. involve certain company types. Therefore, the model may need to emphasize the definition of the environment in which the idea can be implemented.
- The interaction and distribution of tasks between the VO and BE is not necessarily always clear. The development of both parts requires close collaboration and exchange of knowledge.
- Agreement and legislation issues need to be developed, especially in a global setting. Issues related to e.g. intellectual property rights, like liabilities and responsibilities, are a part of these.

For judging the success of collaboration there must be agreed principles and indicators for measuring the achievement of different VOs. By analyzing successful VOs, some success factors that promote efficient operation may be identified. These success factors may be useful in the configuration of new VOs, but they may also need to be considered in the qualification of partners for a BE. To become operable, the identified success factors may need to be implemented as innovations in the BE.

6. CONCLUSIONS – FURTHER RESEARCH TASKS

Inter-enterprise cooperation is necessary in several industrial fields because of extensive and varying resource requirements in customer deliveries. As VO is often designed and created separately for each customer order, VO management is also different from one case to another. Lessons learnt from experience or from available practices can indicate working principles and approaches. Recently, there have been attempts to collect such information based on experience from emerging VOs.

The main challenges for VO management come from the heterogeneous, independent, potentially conflicting organisations and at the same time the hardening business requirements and future uncertainties. If the challenges are not solved, the inter-enterprise distribution of operations may lead to the increase of management costs, quality problems and/ or delays in deliveries. More understanding is needed about:

- Processes and methodologies to support VO management. Key issues are the creation of effective incentives for the partners and trust building.
- Appropriate performance measures supporting the VO management also proactively.
- Management of the knowledge accumulation and inheritance between VOs over the full life time of the product developed.

As all the VO management challenges cannot be solved effectively in the VO itself, the identified methods must be developed in the network or breeding environment. The preparation in the network can be seen as an investment, which is paid back with more efficient operations in the product delivery. This investment needs to be balanced according to the expected benefits.

7. REFERENCES

1. Hallikas, J., Karvonen, I., Lehtinen, E., Ojala, M., Pulkkinen, U., Tuominen, M., Uusi-Rauva, E., Virolainen, V-M.. Risk Management in Business Networks (in Finnish), No. 14/2001, Metalliteollisuuden Kustannus Oy 2001.
2. Jansson, K., Karvonen, I., Ollus, M., Hartel, I., Burger, G. & Kamio, Y. "Virtual organisations in the Sales and Service Life-cycle Phases of a One-of-a-kind Product", in Karvonen et al. Global Engineering and Manufacturing in Enterprise Networks (GLOBEMEN), VTT Symposium 224, 2003.
3. Karvonen, Iris. Management of one-of-a-kind manufacturing projects in a distributed environment. VTT Research notes 2044, 2000.
4. Lizotte, S. & Chaib-draa, B. Coordination in CE systems: An approach based on management of dependencies between activities. Concurrent Engineering: Research and Applications, 1997, Vol. 5 No 4 pp. 367–377.
5. PMBOK Guide. PMI Standards Committee. A guide to the project management body of knowledge. Upper Darby, PA, USA: Project Management Institute. 1996.
6. Roberts E.B. "Managing Invention and Innovation", Research – Technology Management, 1998, July – August. Pp. 34-41.
7. Salkari, I., Jansson, K. & Karvonen, I. "Process plant information integration in three dimensions " 5th International Conference on Design of Information Infrastructure Systems for Manufacturing 2002. Osaka, JP, 18 - 20 Nov. 2002 (2002), 157 –164.
8. Saren M. A. "A Classification and Review of Models of the Intra-Firm Innnovation Process", R&D Management, 1984, Vol. 4, No. 1. Pp 11-24.
9. VOmap. http://www.vomap.org, 2003.
10. VOSTER, Virtual Organizations Cluster, IST-2001-32031, http://voster.vtt.fi 2004.