

Designing the Virtual Enterprise

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Abstract

Much research has been conducted on what a virtual organisation is and how it should work. With this paper we address the question of how a virtual enterprise can be designed to best support two concurrent engineering processes: the product engineering process and the process engineering process. We present a framework for the organisational design and the changing business roles of the 'business architect' who drives the various phases of the life-cycle of the virtual enterprise. We briefly refer to the 'Value System Designer', a set of methods and tools to select partners, reengineer business- and logistics processes and to set up an information and communication platform which have been developed in the TELEflow and the 'Virtuelle Fabrik' project. We focus on the experiences from the many undertaken engineering projects and summarise critical success factors in designing virtual enterprises. Thus the paper contributes insights and applicable know-how for companies and managing engineers that act as the architects of virtual enterprises, for example as leaders of project consortia, leader of joint ventures or as first-tier suppliers co-ordinating supplier (sub-) nets.

Keywords

Virtual Enterprise, Agility, Organisational Design, Value System, Business Architect

1 The need and structure of virtual organisations

The term 'Virtual Organisations' has become a buzz word and is used in many different ways to promise business success. However, the virtue of virtualness is clearly confined to adapted application to its business environment. We therefore set out to clarify our stance on the contingencies of virtual organisations, which will allow managers to anticipate success and failure in their case.

1.1 Virtual organisations are a solution for turbulent business environments

It has become common place to note that firms face an environment changing at an increasingly rapid pace. Market opportunities in particular can arise and disappear again in a short time. However, the speed with which traditional organisations can adapt to changes remains limited. We refer to this situation, where the environment changes more rapidly than organisations can adapt, as a turbulent environment.

Agile behaviour towards market opportunities is the end to which virtual organisations are designed. It is achieved through organisational flexibility, especially the competence to concurrently design a customer's product or service and the processes to produce or deliver it. This flexibility is supported by (but should not be confounded with) the structure of a virtual organisation.

Three basic elements, the customer value, the value system and the network describe the virtual organisation for our purposes (Figure 1) and allow developing answers to the questions:

1. Why is the value system created? The value system is designed to create value in the business opportunity. The value is the force that drives continuous restructuring of the value system.
2. How can the value be created? Value is created with the value system and business processes that are adapted to the requirements of the short-term business opportunity.
3. Who are the potential partners? The potentially participating partners of the network will in most cases be related parties; independent companies, but as well decentralised profit centres or strategic business units of a global holding.

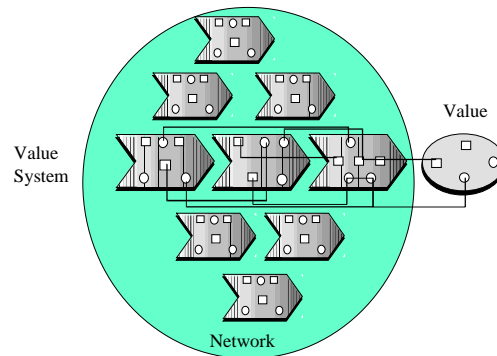


Figure 1: The structure of virtual organisations [Katzy, Schuh, 1997]

1.2 The Value System is a business driven virtual organisation

Competition in the information age will no longer take place among single companies, but among clusters of companies that come together to exploit the value of a business opportunity. The structure of virtual organisations is a useful model to describe this configuration. We call such virtual organisations Value Systems (VS) that are organised actions and interactions bringing together processes from different companies, different sites, suppliers, OEMs, distributors, service providers, etc. that co-operate to provide the customer service [N.N., 1997]. Most popular examples of this kind of co-operations are Nike or Diesel.

With the emerging information society, co-operation on a global scale can be expected to become more intense and will increase in strategic relevance because distance will no longer be a limiting issue [N.N., 1995]. This might turn into a competitive advantage for large multinationals that already today provide the organisational structure of global presence. European companies, however, are smaller in size compared to the US and Asian ones. To share the benefits of the information society, it is therefore often necessary for them to engage in co-operative strategies to achieve global presence.

As smaller companies lack the power of large multinationals, they have to seize the opportunity to substantially improve their competitiveness by creating, leading and sharing win-win constellations with their partners. This in turn requires advanced management competence, or at least the broadening of the domain of interest for managers. They have to leave their turf and actively re-engineer inter-company processes within the VS.

In other words, value systems excel in dynamically changing global markets, because ever-new business opportunities can be identified and addressed with an adapted VS. The value system redesign approach, supports the competence to engineer and re-engineer VS in a systematic and professional way. Real cases (see below) show that this competence of concurrent engineering is a source of sustainable competitive advantage.

Agility describes activity and behaviour, not a structure. Of course the behaviour is backed by the organisational structure, supported or – frequently in traditional organisations –

hindered. In the next section we refer to the ‘Value System Designer’ as the manager, engineer or team that drives the activity of the virtual organisation.

2 The Value System Designer

2.1 A life-cycle based framework for designing virtual enterprises

The Value System life-cycle gives the framework for all concurrent engineering activities in designing the virtual enterprise (Figure 2). In its pre-phase the business concept is defined, which then is engineered into an architecture of the product and co-operation during the configuration phase. Value System processes are engineered during the design phase and consecutively operated. As all Value Systems are by definition temporary, de-briefing and wind-up of the co-operation is requires special attention in the disbandment phase.

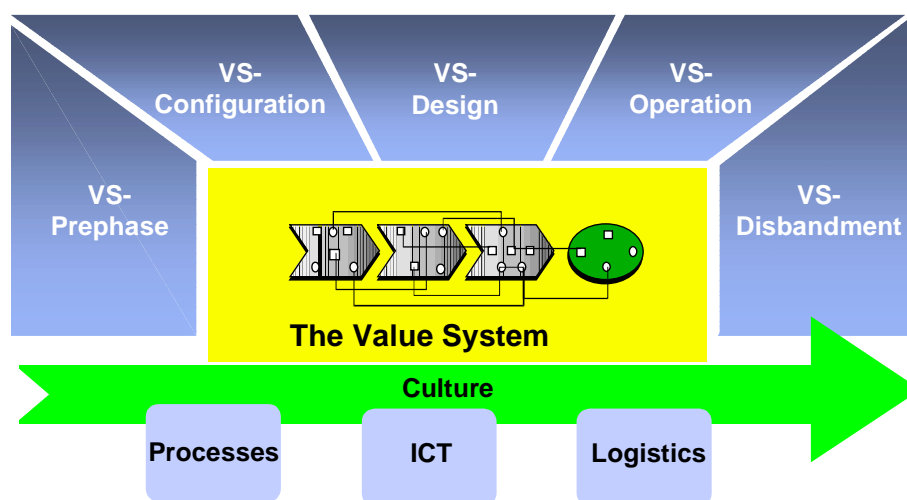


Figure 2: The Life Cycle Approach of the Value System [N.N., 1998]

Tools to support the phases are available, e.g. product specification methods for the pre-phase, a competence database to identify the best partners for the Value System in the configuration phase, a modelling tool for network processes and logistics in the design phase and performance measuring systems for the operations and disbandment phase. Special IT implementation methods are available to rapidly engineer and implement ‘disposable micro workflows’ in the operation phase.

In order to rapidly response to a short window of opportunity in the market, engineering and implementation competencies need to be pre-installed and ready for use. The network of partners, which serves as the platform of such modules that can be accessed and used in each business case. The most critical factor for success proved to be the co-operative culture in the network. Further modules were tested business and work processes, an information and communication platform and a logistics platform [Katzy, Obozinski, 1998].

Concurrent engineering activities in the virtual organisation cannot be based on hierarchical chains of command and control. Instead, what emerged during the years of co-operating in the network were distinct roles and expertise of individual partner for a phase in the lifecycle of the Value System. For the individual firm this meant a shift in their strategic positioning. Before, a strategy was defined around the product or service they delivered to the market and the organisation had to provide support for all phases of its life-cycle. With the virtual organisation strategies were increasingly defined around competencies (e.g. the design of new products, the engineering of processes, the management of operations, the supply of technologies) that are dominant in one phase of the Value System life cycle and the network provided many different business opportunities for it.

2.2 Roles and design tasks in the Virtual Enterprise

From experience six roles were readily observable and can serve to define a genuine strategic position for any partner in a virtual organisation (Figure 3). The broker is responsible for the marketing of the network and for the sale of the competencies of potential virtual factories. She or he is the entrepreneurial person in the early phase of a Value System and acquires new projects for the network. Thus, the broker acts as a facilitator between customers and production.

The competence manager provides the engineering knowledge about available technologies and competencies in the network and supports the application engineering with the customers. For the configuration of the Value System she or he concurrently engineers the Value System processes and selects the best partners. The project manager, supervises the operations Value System. She or he provides project management to keep time and budget restrictions and is able to re-engineer processes, e.g. to replaces partners who do not perform satisfactorily or are not on time.

The in-/outsourcing manager of each network partner provides a dedicated interface towards the network and interacts with Value Systems. She or he offers technological know how, resources and the technology of his or her enterprise towards the network. While operating a Value System he or she is responsible for a step in the value chain of the Value System and represents the interest of his firm to the other partners. The auditor serves the network as a neutral financial auditor providing financial solidity towards the business environment through his or her independent status. This is crucial in cases where no track record can be presented for the customised, on demand engineered Value System.

The network-coach is not related to a business opportunity but constantly serves as a coach to the network. Governance in the network, business rules and routines for co-operation as well as the provision of technological infrastructures in the network, and the management of the relationships (and conflicts) aim for creating the indispensable co-operative culture in the network.

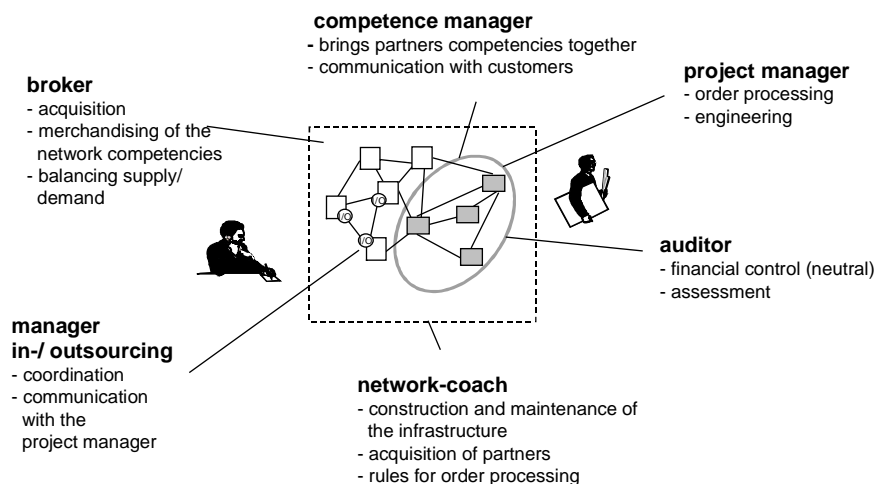


Figure 3: Roles in the Virtual Factory [Katzky, Schuh, Millarg, 1996]

3 Lessons learned from business practice cases in designing virtual enterprise

The Value System Designer is the result of more than four years of industrial co-operative R&D. Today, the 'Value System Designer' is a modular package of business solutions combining concepts, methods and tools to support the design of virtual organisations. Table 1 gives an overview of business practice cases, which have been undertaken to validate the 'Value System Designer' solutions.

Manufacturing Project	Description of Product	Description of concurrent engineering process
1 Mechanism to electrically retract a car steering wheel	The mechanism targets a market of less than 10.000 items a year and is therefore not interesting to auto suppliers used to lot sizes of hundreds of thousands. It is technically challenging, as it has to meet safety standards of auto industry at competitive manufacturing cost.	The network was prepared to face such opportunities, responding within two days to the customer request To engineer the process from the best competencies, ten potential technologies were identified. In a co-operative effort with the customer engineering changes of the product were implemented and prototypes manufactured.
2 Large precision base for tool machine	The base was a 20-mm sheet metal, roughly 1m x 1.5-m in size. More than 300 holes were needed for the assembly of all mechanisms of the tool machine. Placement of the holes de-fined the tool machine's precision. The piece was too big for most machines.	Alternative technologies such as drilling, laser drilling, and water drilling were identified and compared. During process engineering a large dimension tool machine was identified, on which the piece could be machined in one fixing. Value created was quality improvement (because of one fixing), and 75 % cost reduction.
3 Module for a letter sorting machine	The manufacturing of a module of an industrial postal letter sorting machines that was fully engineered. To meet short delivery deadlines, the manufacturer needed additional manufacturing capacity. The module was structured in mechanical and electrical subassemblies, and painted sheet metal as the cover and stand.	Competencies from the network. E.g. controller manufacturing for textile machines, and sheet metal manufacturing and painting from furniture industry were brought together to engineer the specific process for the customer project.
4 Air-conditioning unit	The concept of an air-conditioning unit, fitting a demand pocket in the upper range of the market was engineered and manufactured as a project lasting about two years.	During a presentation of the project 'Virtuelle Fabrik' an engineer in the audience revealed having a product concept and asked the necessary competencies to engineer the production process from the network. On stage, project members analyzed the idea and proposed an initial architecture of contributions from three partners. Business was agreed, in a cooperative effort with the customer the unit was engineered, prototyped and 50 copies manufactured after 18 month, further orders are pending.
5 Fifteen end of life-cycle industrial products such as slides, fans, necks and nozzles	At the beginning of the project, old, simple to manufacture and fully specified products with a low known annual demand were given to the network, because these were assumed to best fit a spot market for idle capacity.	The production processes were partially more efficient where direct cost effects were achievable with resources better fitting the manufacturing task. Due to already assumed learning effects in the long life cycle, effects however remained small. Indirect effects were observed where outsourcing opened dis-investment opportunities of constantly underutilized resources.
6 Re-engineering stability of a large sun-umbrella	Finite element simulation competency of an engineering firm in the network was used to improve wind stability of large restaurant umbrellas marketed by a textile manufacturer.	The network was prepared to face market opportunities from outside its companies' core-businesses. The network's brokers channeled a customer request from textile industry to highly specialized competencies available in a firm from the mechanical industry.

Table 1: Business practice case of designing virtual enterprises

3.1 Lessons learned for the Product Engineering Process

Three lessons learned concern the pro-active role of application engineers that sum up to more agile behaviour of the virtual organisation.

1. The projects created value for their member firms through identifying market opportunities outside their core-business. This points to conditions of turbulent environments, where market opportunities emerge unpredictably and markets change an order of magnitude faster than the organisation can adapt. Clearly, this case of making business in non-related industries is not covered by traditional marketing analysis, where a firm's conduct and the requirements of for products are derived from the structure of the industry it is in [Bain, 1959]. Similarly, in turbulent environments the identification of dominant players, suppliers, customers, or competitors becomes difficult. As we have seen, firms change the roles they play to the extent that they simultaneously assume multiple roles in parallel Value Systems. Consequently, with increasing turbulence it becomes more difficult to identify the competitive forces [Porter, 1979] that these players create in the industry, rendering this framework a less valuable basis for marketing decisions.
2. Concurrent Engineering with the customer gained importance in the virtual organisation. Initially pure market access has been recognised as an important element of networks, where not all companies are equally situated in terms of access to profitable opportunities. In Prato, for example, many of the small textile-manufacturing firms are not in a position to access world-wide customers. In this industrial district, merchants, "impannatores", provide access to market opportunities for the entire district [Kumar, Bielle, van Dissel, 1996]. The impannatore brings "an overview of external markets" and markets the services of other firms to "compete on the basis of price, innovation and service" (p. 207). In the construction industry, market access is provided by specialised project managers, who hire those crafts that are needed for a custom-designed building [Piore, Sabel, 1984]. In fact, the construction industry was discussed as a model for Value Systems. However, it turned out that virtual organisations implies a more active search for opportunities than simple market access. In construction, project managers organise the response to a customer request, but do not actively encourage or seek out new work. As it turned out, this was the motivation for a project launched by the Swiss construction industry to adapt the concept.
3. Market opportunities do not present themselves neatly labelled as such. Instead, it is necessary for application engineers to be able and willing to create opportunities and to stretch competencies beyond their primary business. Pümpin [1986] refers to the concept of value potential, which he defines as value that is embodied—but not yet exploited—in constellations of the environment. He makes the point that it is the active role of a promoter to develop and multiply a market opportunity through interaction with involved stakeholders. Unfortunately, not much is known about the process by which promoters develop new market opportunities. Innovation models, such as Abernathy and Utterbeck's concept of dominant design [1974], focus on describing the lifecycle of an industry, which has only limited value for the engineer.

In summary, identification of market opportunities provided member companies with access to applications for their competencies in businesses beyond their traditional industry boundaries. Membership in the network exposed the firms to ideas and demands they would otherwise not have seen. As a reservoir of market opportunities the network is specifically adapted to turbulent environments, where we have perceived market opportunities as short-term windows, emerging and disappearing again in an order of magnitude faster than the organisation can adapt to it. Selecting from business opportunities requires more than simple picking of the shelf. Instead, to accommodate short-term market opportunities required

extensive concurrent engineering activities by the partner firms as well as on the level of the network.

3.2 Lessons learned for the process engineering process

Three lessons learned concern the role of concurrent processes engineering as a core element of more agile behaviour of the virtual organisation.

1. The conception of resources gradually evolved and expanded in the Value System. Initially, the view was quite limited: resources were machines. Descriptions of these machines across the industries was based on the generally accepted classification scheme and terminology from the DIN 8580 standard, which defines all possible machining operations. For example, cutting machines are described by how they cut metal (with a defined edge, by grinding, etc.); assembly machines by how they bind parts together (temporarily e.g. by screwing, permanently e.g. by welding, etc.). The manufacturing resources available in different companies were identified in this way and listed in the “technology capacity bourse” database. Similarly, in Prato, the function performed by each of the small textile companies is well defined based on the steps required for clothing production. Thus, dying, weaving, cutting or sewing a particular order can be allocated to a firm providing this function [Ritaine, 1990].
2. Experiences of Value Systems revealed engineering services to be independent competencies that were not linked to machine tools but which were equally important for successful projects. These engineering capabilities were needed to back the network’s competency to design and engineer complete customer solutions. Examples in the business practice cases included assembly competency, quality inspection and testing capabilities, project management or certification for ISO conformity. These capabilities required complex combinations of information technology (for CAD, CAE), testing devices, skilled engineers or accreditation. Chiesa and Barbeschi [1994] similarly point out that resources are not simple factors, but rather represent complex combinations of factors that give them a distinct and unique character.
3. As well as within the individual member companies, competencies were developed at the level of the network as a whole. Valuable competencies could include factors from multiple partner companies, enabling the network as a whole to respond to demands from the turbulent environment. From experiences from Value Systems, more stable sub-networks of partners emerged, which as a group proved to have competencies for applications, for example, in medical technology or precision machinery. Similar empirical evidence of developing competencies is reported from Norway, where a learning cycle was implemented in a regional learning network [Hanssen-Bauer, Snow, 1996]. Since these network competencies were even harder to describe, the ‘competency manager’ was needed as someone who knew what competencies were available across the various partner companies and which might be applied to a particular customer’s problem.

4 Conclusions

We conclude from applying the concepts, methods and tools of the ‘Value System Designer’ three critical success factors for the design of virtual enterprises.

First, virtual enterprises proved to be most favourable when 80% customer-specified requests allowed for 20% engineering improvements to make best use of the network competencies. Fully specified products often created rigid constraints to the engineering of processes, while vague customer requirements gave no guideline for an effective concurrent engineering process.

Second, virtual organisations require a fundamental change in the co-operative culture of most firms. Individual co-operation and teamwork are essential pre-requisites for successful virtual organisations. Even more difficult to change will be the decision and planning systems (e.g. MRP, ERP, Accounting, Strategic Planning) that are efficient for stable business but prevent fast reaction through local decision making in the virtual organisation.

Third, the success of a virtual enterprise is dependent on the balanced provision of all engineering roles in all phases. Virtual enterprises are constrained in their performance by the 'weakest link in the chain', the weakest role or phase in the Value System. Again, the advantage of virtual enterprises is to involve the best supplier for each service needed to deliver a customer specific solution.

In turbulent environments, where the configuration of Value Systems rapidly changes with the short window of opportunity in the market, can virtual enterprises be expected to outbeat traditional firms.

4.1 Designing Value Systems in the 5th Framework Program

New ways of co-operatively working between self supporting companies are emerging for the information society. Under the 5th Framework Program for research & Technological Development (1998-2002) the Information Society Technology Program will focus its Key Action II (New Methods of Works and Electronic Commerce) on addressing the above issues in particular.

4.2 Cross-project co-operation in the electronic discussion forum on virtual enterprises

More than 40 projects in the different areas of European RTD programmes address the issue of virtual enterprises, virtual organisations, virtual teams or closely related topics. Due to existing structures however, experts frequently ignore parallel work. At least, exchange of knowledge or combination of complementary results remains rare. The virtual enterprise forum (contact bernhard.katzy@unibw-muenchen.de) uses web based technologies to improve cross project knowledge creation and what are the critical success factors for implementing it. Results of the Web based discussion forum on virtual organisations hosted by the NECTAR project (<http://www.nectar.org>) and since 1997 a series of physical workshops include the initiation of a cluster of 25 European active projects working on virtual organisations and a consolidated contribution to the elaboration of a key part in the work plan for the IST programme under the 5th F.P.

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