LOGISTICAL ISSUES IN VIRTUAL ORGANISATIONS' MANAGEMENT

FIDLER Branislav, VALČUHA Štefan
Institute of Manufacturing Systems, Environmental Technology and Quality Management
Faculty of Mechanical Engineering, Slovak University of Technology in Bratislava, Slovakia
branislav.fidler@stuba.sk, stefan.valcuha@stuba.sk

1. INTRODUCTION

Turbulent changes in manufacturing industries, nowadays affected also by ongoing financial crisis and consumer instability, drive companies to search and execute market opportunities more efficiently. Much more intensive collaboration with business partners and closer customer interface through the whole value-creating chain is becoming of primary importance. Mainly small and medium sized enterprises (SME) in their effort to optimize their own production systems tend to benefit from specialisation and outsourcing of production resources.

As a progressive form of business consortia today, virtual organisation (VO) provides environment for flexible partnership, which is loosely coupled under essential ICT support and with no restrictions due to geographical, administrative or technological obstacles. Dynamic value-creating chain should stand for a basic principle of VO's business processes, taking different views on cooperation into consideration: 1. corporate product, 2. distributed manufacturing system, and 3. logistic network of companies. Interenterprise configurations has lots of connectivity costs (Womack, 2003), such as those spent on additional transport and storage, urgent deliveries, industrialization related to new plants, distributing centres, communication with business partners, etc. Seeing that these costs are pertinent especially to the third level above all, VO requires continuously adapting logistics fluxes, from planning to execution, and from suppliers to clients.

The aim of our introductory analysis with reference to research project Inovanet, whose background is shortly presented in chapter 2, was to contribute to procedures and tools that would effectively support management of logistic network. Chapter 2 provides fundamental definitions regarding the domain of production virtual organisations and its operating principles. Underlying logistical issues were investigated from organisation and technology point of view and the following output models are explained in chapter 3: Business model, Functionality model, Domain model.

2. PROJECT INOVANET

Nowadays SMEs, due to strong competitive environment and large progress in technology, are obliged to deal with innovations in order to meet demanding requirements couched in high product complexity, specific customisations, superior quality, on time delivery, various services and so on. General aim of project Inovanet is in overcoming fragmentation of the industrial cooperation through the whole product lifecycle. Research synthesis in form of supporting methodology and applications for business processes automation involve following areas of innovation:

- *Product innovation* – Processes of customer's requirements management, product design engineering, and project management for products development.
- *Production innovation* – Processes of manufacturing technology and system engineering focused on inter-enterprise distribution.
- *Production* management innovation – Logistical processes within value creating chain of the virtual organisation including planning, operation and evaluation.

Conceptual scheme (figure 1) shows the two significant information loops. There is a need on one hand to handle technical and business requirements together with logistical issues

in the beginning of the product lifecycle with regard to distribution and capacity conditions of producers. On the other hand all relevant technical data and specifications from pre production phases have to be transferred to the production management. Hierarchical views on cooperation are considered being the basic principles of dynamic value-creating chain to completely analyze business processes in VO:

- *Corporate product (CP)* – Subject of cooperation specified by detailed technical and business requirements of final customer and suppliers. Reconfigurable CP defines also an output from distributed manufacturing system from project to project.
- *Distributed manufacturing system (DMS)* – System of manufacturing facilities and technology, where some products or their parts are made by one producer, while the rest is outsourced by other producing partners – enterprises or single plants.
- *Logistic network (LN)* – Partnership in which the producers operate as suppliers and eventually customers of intermediate products. Beside the final customer at the end of value-creating chain also independent forwarders can be included if appropriate.

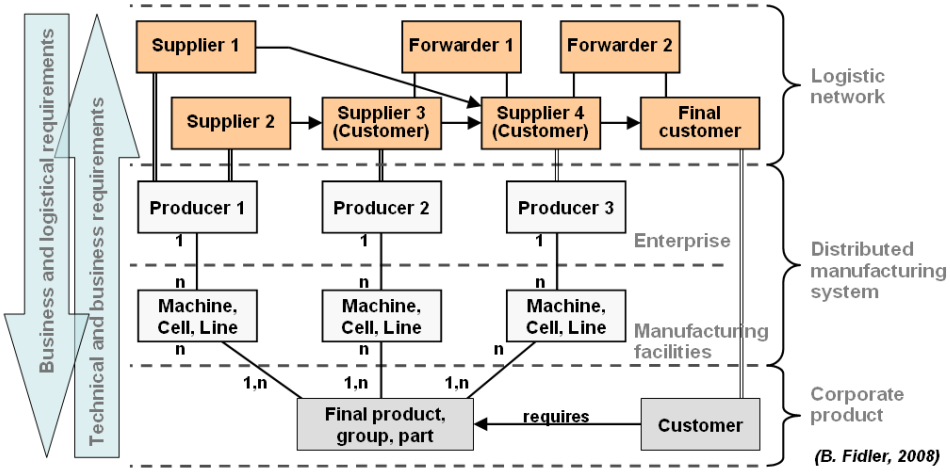

Figure 1: Views on cooperation in virtual enterprise – the 2nd level of virtual organisation

Researchers approach application design and development holistically, tackling tasks arising in manufacturing and software engineering and industrial production management. Methodology GRAPPLE (Guidelines for Rapid Application Engineering) was chosen for the purposes of systems modelling because it is relatively simple, flexible and developed with UML in mind. Object oriented language UML, according to company OMG, is highly recommended by professionals as it enables effective systems' representation both with software and un-software features in miscellaneous areas (Schmuller, 1999).
Deliverables presented in this paper belong to the first segment of the methodology called Information gathering, which covers conceptual understanding of domain, high-level functionality analysis, and initial model of business entities.

3. BUSINESS MODEL: PRODUCTION IN VIRTUAL ORGANISATION

3.1. FUNDAMENTAL DEFINITIONS

Nowadays the concept of VO is widely accepted both in the academic community and in industry. According to the European Commission, it is a group of collaborative, mutually independent enterprises that share and interchange their own services and products, but seems externally like one company (Toelle, 2001).
Such a multi-enterprise partnership has to be in conformity with fundamental principles, as are: digital product model processing, value chain distribution, customer-oriented planning,

real time coordination of activities, decentralization or no superior management divisions, two-level integration, all supported by pervasive ICT and web-technology. Integration on two levels implies quite complex business processes.
The first level is a long-term cluster of partners that are in stable cooperation – *Breeding environment* (BE). In general the reason to build VBE is an effort to support and defend the interests of business environment in a certain branch of industry, economic space or geographical territory. This environment represents the mutual coordination of individual business activities mostly through consulting, coordinating, and marketing tasks.
At the second level in response to a specific business opportunity project-oriented consortium can be established either on short or long-term basis – *Virtual enterprise* (VE). This process is initiated by any subject that has recognized the opportunity for cooperation. Partners take responsibility for the execution of partial tasks based upon the result of negotiation. Companies come from the VBE that is already under operation; nevertheless they may also be third-party subjects where appropriate.
Operation of the VO requires data to be processed and shared among partners interactively, available on time and for the right user with no redundancy. Information flows must be managed by an appropriate *integrating infrastructure* that is compound of supporting subsystems connected through various hardware and software interfaces. Discussed solution should help in exploiting methods and tools for decision making support at all tree cooperation views mentioned above with the highest degree of realism. In light of software functionality automated configuration of logistic network for any proposed DMS or its alternatives is required while providing vital data for high-level production management within planning, operation and evaluation phase of VE's projects.

3.2. STAFF STRUCUTRE

When looking at organisation structure of the VO, individual roles all representing partners' employees that could be somehow influenced by the new way of cooperative work, have to be described (Fidler et al., 2008):

- *Competence manager* – Coordinates product design and production engineering at common VBE level. Is responsible for optimum utilization of resources, technology, knowledge and skills accumulated in the pool. Prepares project proposals including configuration and processes of potential VEs in accordance with DMS principles.
- *Recourses manager* – Promotes business interests of his enterprise on a long-term basis. In case the partner participates in VE he takes responsibility for performing of all the tasks and delivery of products that were agreed in cooperation project.
- *Project manager* – Coordinates tasks that are individually performed by partners, controls their deliverables, costs and times. Collaborates closely with resource managers on planning, controlling and evaluation of the whole cooperation project.
- *Business broker* – Marketing and sales promotion (not affected directly). Is eligible to make necessary changes in VE's configuration and processes under operation.
- *Network coach* – Put in charge of continual management of VO's routine processes and its integrating infrastructure.
- *Ordinary employee* – Every partner's employee whose workload and information exchange is to be connected to the inter-enterprise processes in a straight business line, like design engineer, manufacturing manager, transport supervisor, and so on.
- *Financial auditor* – Responsible for financial commitments controlling inside the cooperation structures. Although with the same rights, he should operate independently from the project manager role.
-

3.3. PROCESSES OVERVIEW

Processes were defined in line with business requirements for simple synchronization of projects and tasks, flexible information flows in terms of reconfigurable logistic network, and accurate and rapid data exchange. Those processes and partial activities in table 1 that are marked with asterisk are the primary candidates for software automation.

Table 1: Business processes – Management of logistic network

Processes	Inputs	Activities	Outputs	
• *Network configuration** (Planning)	Design & Assembly drawings, BOM, Final customer and partners requirements, Register of prospective partners	• *Selection of partners** • *Tasks assignment** • *Product definitions** • *Volume determination** • *Contracts negotiation*	Production project specification, VE's logistic network structure, Business contracts and subcontracts	Work breakdown structure
• *Production scheduling** (Planning)	Production volumes and repeatability, Required times to delivery	• *Project dates definition** • *Tasks dates definition** • *Determination of batch sizes** (Top down approach)	Detailed production schedules, Delivery plans and transportation schedules	
• *Production costing** (Planning)	Man. equipment and technology, Material and quality properties	• *Tasks cost definition** • *Project costs definition** (Bottom-up approach)	Detailed cost budget	
• *Production* (Operation)	Detailed production orders, Product specification and production processes specifications	• *Project initiation** • *Task initiation** • *Task performing** • *Task conclusion** • *Production costs recording** • *Production times recording** • *Internal product development* • *Inside manufacturing process*	Resources requests, Batch control sheet, Statements of tasks performance, Conformity declarations, Sales invoice details	Products (goods or | and services)
• *Product transportation* (Operation)	Delivery plans and schedules, Transportation orders	• *Transporting costs recording** • *Transporting times recording** • *Interplant handling*	Statements of tasks performance, Transportation invoice details, Shipping documentation	
• *Provision of product* (Operation)	Product to delivery Final customer order	• *Provision costs recording** *(costs of sales, installations, services, etc.)* • *Project conclusion**	Acceptance test and service documentation, Acceptance certificate, Sales invoice details	
• *Production monitoring* (Evaluation)	Records of products, cost and times – plans vs. reality	• *Ad-hoc analysis** • *Project reporting**	Statement of cash flows, Report on tasks and project performance (Productivity, effectivity, efficiency parameters)	
• *Network dissolution* (Evaluation)		• *Closure of the virtual enterprise** • *Agreement on IPR*	Final report of cooperation Free production, transportation and knowledge resources	

3.4. FUNCIONALITY MODEL

List of use cases in figure 2 describe what the software system should do and what functionalities should the users access to.

As the competence manager is responsible for key decisions in configuration, he must have all the information about resources at his disposition. This role access to the list and profiles of VEs and enterprises those are available in VBE with a possibility to register new enterprise (company) or partnership. Project manager, who should be deputed by competence manager along with the formation of VE, have access to list of the VE's partners, projects, and project tasks at the inter-enterprise level. This role is capable to register and manage new projects and integral tasks assigned to partners. He has to define product, partial deliverables, costs and time constraints for project and each task.

Having the frame definitions of common project both the project and competence manager use cooperation modelling for planning purposes. With functionality of ad-hoc analysis they are capable to simulate different cooperation scenarios depending upon variable inputs, as for example reconfigurations of product and work breakdown structure, changes in production volumes, delays in tasks, cost overruns, etc.

Another system-embedded functionality includes tracking of project events (recording of costs and time consumed, products or other deliverables delivered), continual cash flow computation, early alerting and notifications of users.

Resource manager has an overview of all projects and tasks which his enterprise participate in. Besides, this role is capable to register and manage subtasks and assign them to ordinary employees. These subtasks and their stakeholders are hidden for the project and competence manager.

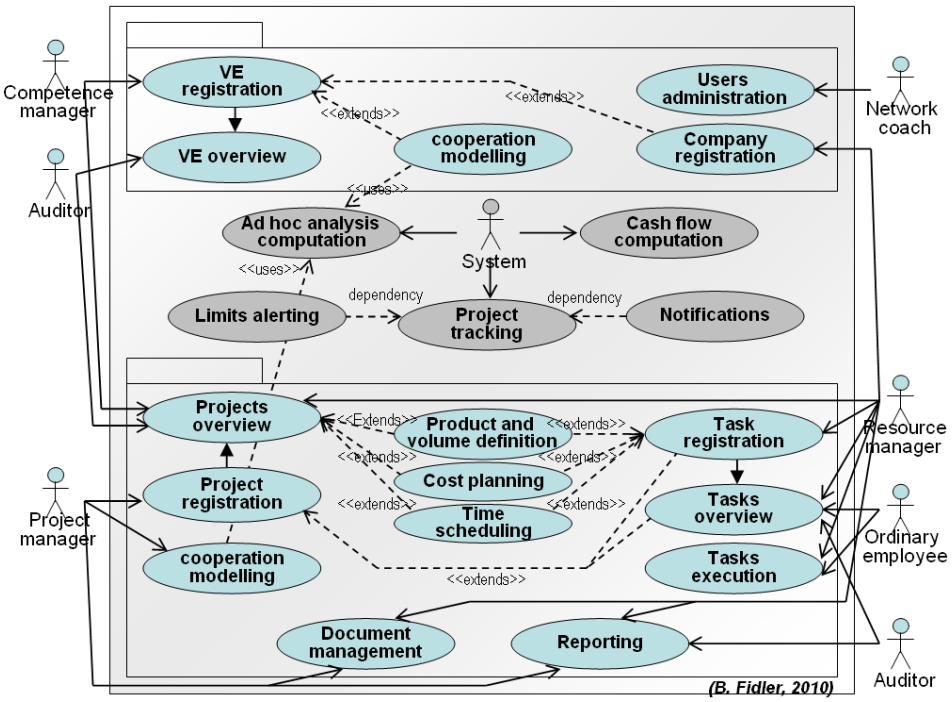

Figure 2: Functionality use cases – Management of logistic network

3.5. DOMAIN MODEL

The objective during the process and functionality analysis was to identify entities, their properties and associations, thus to improve systematic understanding of the domain.

High-level diagram (figure 3) contains building blocks each one with set of entities interacting in different ways to execute use cases.

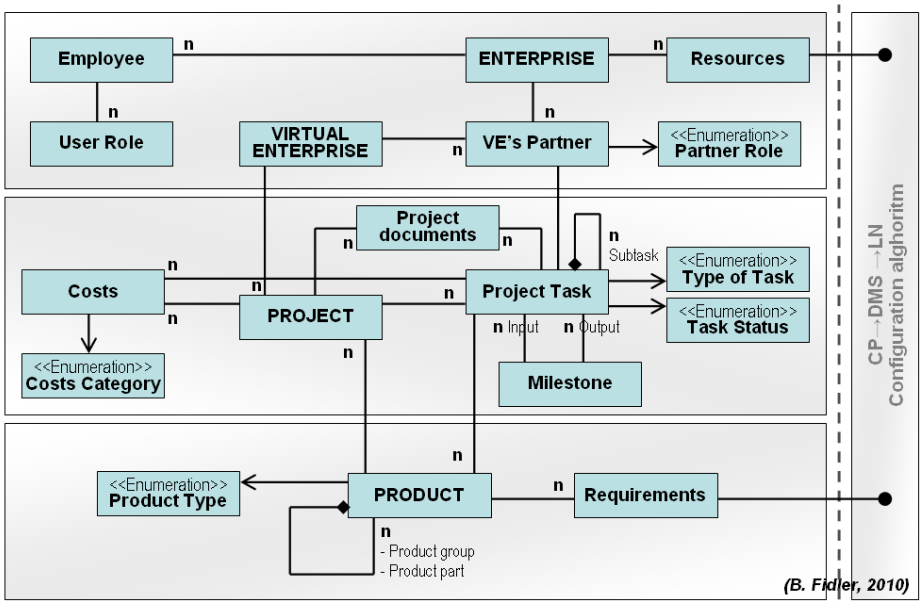

Figure 3: Entities and associations – Management of logistic network

Rectangle on the right side of diagram shows another core component of the integrating infrastructure that is a subsystem for computer-aided VE configuration.
According to (Henderson, 1990) the structure of manufacturing system and organisation is reflected from a structural decomposition of the product. Moreover the product structure significantly influences the manner in which company knowledge and information are processed. Accepting this matter of fact, outputs from the CP→DMS→LN configuration algorithm should help to answer questions on the subject of product manufacturability, expected manufacturing costs and delivery time. In this manner potential partners can be provided with the information they need to select an optimal logistic network.

4. CONCLUSSION

Afore described models belong to the complex framework of VO offering a nomenclature, and set of key principles and requirements for software applications development independently of industries' specifics. With the provided system support it is foreseen that the VO of the future can go far beyond the only buy and sell activities, what the state of the art for the current consortia is.
Research issues in further phases the project will be centred on the development of software capable of modelling and optimizing of logistics networks and parameters, by implementing discrete event simulation based modelling along with multi-objective optimization using multi-objective evolutionary algorithms (MOEAs) in an easily adaptable tool. Thus, the software will combine the capability of managing complex logistic network with the aptitude of obtaining optimal solutions that show MOEAs.

ACKNOWLEDGEMENT

Presented results were developed in the context of project "*Research and development of designing methodology for engineering innovations of new generation represented by digitally networked mechanical plants (Inovanet)*", which is funded by the Slovak Ministry

of Education under Applied Research framework from 2009 to 2011. Research partners: Faculty of Mechanical Engineering SUT in Bratislava, Slovakia; Mondragon Goi Eskola Politeknikoa S. Coop, Spain; ZTS VVÚ Košice, a.s., Slovakia – Industrial partner.

REFERENCES

[1] VALČUHA, Š. – FIDLER, B. – SOMORA, D. – PODMAJERSKÝ, P. and SABÁČEK, Ľ.: Research and implementation of Virtual Organisation in European research and production area. Final report. SUT in Bratislava. Slovakia, 2008. Funded by the Slovak Ministry of Education under "Programme of Applied Research"

[2] CAMARINHA-MATOS, L.M. – OLIVEIRA, A.I. and JARIMO, T., et al.: Requirements and mechanisms for VO planning and launching. Project ECOLEAD, Uninova +partners. Portugal, 2005.

[3] URBAN. G.: Logistik braucht ein fortschrittliches PDM (Logistic needs an advanced PDM). IPRI – International Performance Research Institute gGmbH. Germany, 2003.

[4] FIDLER, B. and VALČUHA, B.: Decomposition of integrating infrastructure to support Virtual Organisation's processes. ANNALS of the Oradea University. Romania, 2008.

[5] Toelle, M.: Management and Engineering of Virtual Enterprises. Ph.D. Dissertation, Technical University of Denmark, Denmark, 2004. pp. 391.

[6] SCHMULLER, J.: We think in the UML language: Programmer's bookcase. Grada Publishing a.s., Czech Republic, 2001. pp. 359.

[7] HENDERSON, R.M. and CLARK, B.: Architectural Innovation: The Reconfiguration of Existing product Technologies and the Failure of Established Firms. In: Administrative Science Quarterly, Vol.35 No.1. NY, 1990. pp. 9-30

[8] FIDLER, B. – VALČUHA, Š. and GUNIŠ, A.: Systems modeling for Visrtual Enterprise configuration. Proceedings of the 9th Biennial ASME Conference on Engineering Systems Design and Analysis ESDA08. Israel, 2008.

[9] CAMARINHA-MATOS, L. Collaborative Networks in industry – trends and foundation. In: Proceedings of the 3rd Int. CIRP sponsored conference on Digital Enterprise Technology, Portugal, 2006.

[10] CAMARINHA-MATOS, L. - AFSARMANESH, H. Virtual Organisations: Systems and Practices; 1.6 Collaborative networks: A new scientific discipline. SpringerScience + BusinessMedia, USA, 2005.

[11] KARVONEN, I. – v.d. BERG, R. – BERNUS, P. et al. Global Engineering and Manufacturing in Enterprise Networks. VTT Symposium 224, Technical Research Centre of Finland. Finland, 2003. ISSN 1455–0873.