ANNALS of the ORADEA UNIVERSITY.

Fascicle of Management and Technological Engineering, Volume VII (XVII), 2008

DECOMPOSITION OF INTEGRATING INFRASTRUCTURE TO SUPPORT VIRTUAL ORGANISATION PROCESSES

Branislav FIDLER, Štefan VALČUHA

Institute of manufacturing systems, environmental technology and quality management
Faculty of Mechanical Engineering, Slovak University of Technology in Bratislava, Slovakia
e-mail: branislav.fidler@stuba.sk, stefan.valcuha@stuba.sk

1. INTRODUCTION

Nowadays dynamicity of industry, due to the progress in technology including ICT, product complexity increasing, market globalization, and customization and so on, has an enormous influence on the behaviour of every single company. Industrial cooperation, mainly among small and medium enterprises (SME) is considered as a business strategy to successfully survive, strengthen and even expand their position. More efficient cooperation and closer customer interface supported by systems integration through the whole product lifecycle is becoming of primary importance.

Implementation of collaborative processes has accelerated recently as a consequence of both the challenges posed to industry and achievements in information technology. Virtual organisation is known as a progressive form of enterprise network focused on loosely coupled cooperation of SMEs. Since 1986, when this term was introduced by Mowshowitz for the first time, the concept has become familiar both in academic and industrial community. Up to now however there exists in practice no implementation which is in complete conformity with the principles of virtual organization. Several attempts were done to group companies for more intense cooperation. Most widely known are Virtuelle Fabrik, Helice, Verko and other examples presented in [2, 5, 6]. These clusters are principally about information exchange and company portfolio presentation to facilitate mutual communication and thus searching for business partners. The higher level of cooperation that is project oriented coordination is missing yet.

Authors consider deficiency of appropriate software as the main obstacle to further advancement. The aim of our research is to contribute to the development of the integrating infrastructure that is composed of proper supporting systems. Partial results concerning essential modelling issues and determination of the subsystems of integrating infrastructure are presented in subsequent chapters. With the provided technological support it is foreseen that the virtual organisation of the future can go far beyond the buy and sell activities, what the state of the art for the current clusters is.

2. INDUSTRIAL COOPERATION IN VIRTUAL ORGANISATION

DEFINITION OF VIRTUAL ORGANISATION

The concept of virtual organization (VO) can be characterized as a business consortium of partners (product designers, manufacturers, component suppliers, service providers, distributors, vendors, etc.) loosely coupled for cooperation under essential support of ICT tools, without any restrictions due to geographical or administrative obstacles. According to the European Commission, as cited in [7], it is a group of mutually independent enterprises that share and interchange their own services and products, but seems externally like one company. The other authors describe this co-operation as a sort of industrial partnership or joint venture where all members contribute their core-competencies.

Such a dynamic multi-enterprise partnership is to be established and managed in conformity with the principles of VO. For the purpose of process analysis and systems

requirements gathering some fundamental principles can be derived with using numerous definitions as follows:

- *Value-creating chain decentralization.* Complementary resources in a number of companies are left in place and integrated to support a particular product effort. This arrangement permits each participant to concentrate on what each does best and to limit its risks and investments to its core competencies (Klein, 1994).
- *Dynamic processes recombination.* Distributed business processes may be owned by one or more organizations acting in partnership. For a specific project, resources are assembled to perform a business process on behalf of project owner(s).
- *Underlying ICT support.* The dynamic grouping of companies, individuals and organizations is possible by computer, software and web technology as facilitating mechanisms. This allows distorting traditional relationships of management and work to time and space (Coates, 1994).
- *Customer-oriented planning.* In order to have a rapid response to the market, companies have to reorganize them around response to customer demand, forging tight relational bonds with core suppliers and long term customers.
- *No superior management.* Equality of the partners leads to a structure without hierarchy. The positive respective effects would be enhancing the efficiency and the responsiveness of the participant, and decreasing the overhead (Bultje et al., 1998).
- *Real-time activity coordination.* Enterprises or individuals can enter and leave the cooperation at any time. Each enterprise has the feeling of a continuous access to the organization and its products.
- *Two-level integration*. According to (Mowshowitz, 1999), logical separation of need from needfulfillment is the foundation of VO. He emphasizes that there, on a managerial level, is a clear distinction between the abstract requirements and the concrete implementation to reach goals. This he also calls “switching principle”.

Last principle obviously distinguishes cooperative processes between the strategic and operational level and thus provide certain approach to analysis (figure 1). In view of organisation structure there are two levels of integration to be analysed separately.

1. *Virtual enterprise (VBE)* – The first level is a long-term cluster of partners that ideally are grouped in stable cooperation. The main activities cover consulting, coordinating, and marketing tasks.
2. *Virtual breeding environment* – At the second level the partners enter into cooperation in response to a specific business opportunity, with their core competencies and resources, taking a respective position in product lifecycle. The particular model of cooperation as well as the number of partners and their tasks is variable.

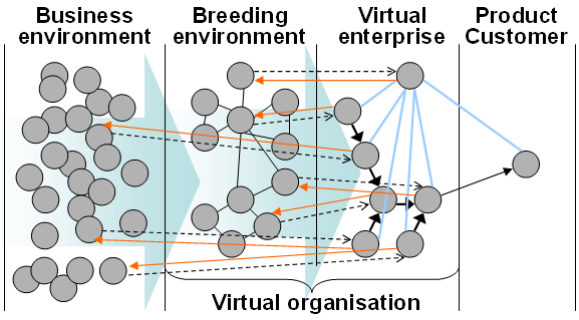

Figure 1: Integration in virtual organisation

RESEARCH ISSUES

Europe is leading the research on the topic of VO, and there is a growing awareness that the developments should be based on contributions of a multidisciplinary nature, from ICT, socio-economic, organizational, business management, legal and social security area.
As mentioned in [1] the complexity of VO would have implications for organization and processes of every enterprise. Currently there are several holistic challenges:

High costs – the main costs are related to investment in ICT and the high operational costs, including training and maintenance. Looking at the general trends in technology costs, this issue is likely to be of reducing significance. *Legal problems* – VEs are established fast and efficiently to respond to market opportunities or tackle specific projects. This can result in complex legal problems as the boundaries between the organizations become vague or fluid. *Trust issues* – This applies both for knowledge sharing and the group dynamics for collaboration. Empirical studies reveal that many companies abandon co-operative arrangements due to problems with trust and control. *Cultural issues* – Co-operation in VO may involve working across cultures. This is a big challenge to managers, and requires them to transfer their policies and culture to work with dispersed business teams – spanning organization, geography, and cultures.

Authors generally consider lack of appropriate software as the main obstacle to further advancement for the implementation of VO. Although the VO could probably exist even without ICT support, its scope and the areas in which it operates would be limited by time and space constraints. In consequence of the achievements in technology, as cited in (Jacobsen, 2004), an organization is enabled to quickly gather, integrate and analyze large amounts of information, and disseminate it accurately to consumers throughout the world. General aim of our research is to contribute to the development of the *integrating infrastructure* composed of reciprocal *supporting systems*. Systems integration through the whole product and organisation lifecycle is currently one of the most important tasks to do.

3. RESEARCH METHODOLOGY

Modelling behind the systems and process analyses (figure 2) provided us with useful information necessary to design the integrating infrastructure in view of functionality.

Having the concept of VO as a basis, an attempt was made to apply unified modelling language (UML) and methodology Grapple (Guidelines for rapid application engineering) to formalize various aspects of integrating infrastructure. The advantage of Grapple is that it was developed with the language in mind, thus making it easier to apply and give attention to its potentials rather than try to see how a methodology fits in. Systems engineering according to Grapple, is divided into six segments each of which includes several actions. Research work that has been finished is associated with the first segment of methodology – requirements gathering. Some deliverables considering process models and roles model are presented in the paper in form of UML diagrams.

Process models are depicted as process hierarchy diagrams, focusing on dynamic courses of events. Generic concepts such as activity and actors, hierarchic and sequential dependencies, and resource-related perspectives were analysed. *Roles model* shows all the organisation roles and their positioning within the network structure. Role model implicitly defines the overall topology of interactions that describes the organisation structure of VO.

For the purpose of models analysis educated examines were used to evaluate the process complexity both at the first and at the second integration level. Extensive diagrams enabled to record flow (quantitative analysis) and local (qualitative analysis) characteristics for process areas. The area represents a

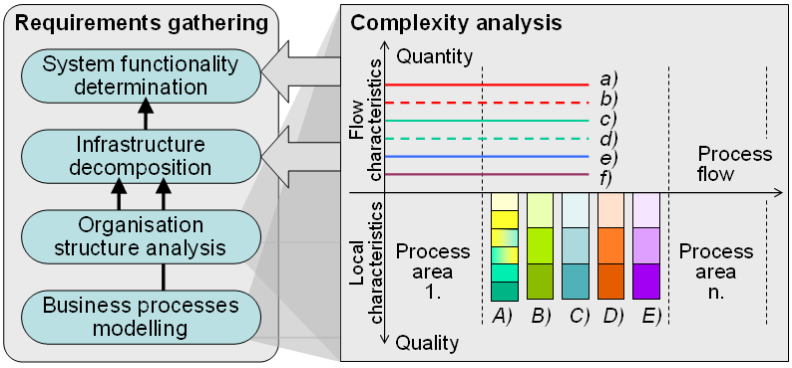

Figure 2: Modelling methodology for systems decomposition

single phase of the network lifecycle, which means that single area may include one or more processes, sub-processes, activities, as well as the respective number of artefacts and roles. Details about the lifecycle of VO are accessible in literature [7].

Seven different categories of local characteristics were used as follows: A) process scope, B) level of organisation, C) process timing, D) extent of interaction, E) level of collaboration. In each of them the process area has to be fully described, i.e. the addition of individual ration values in every characteristic must reach up to 100 %. Flow characteristics were recorded using simple line diagrams across all the process areas. They separately consider other evaluative categories such as a) assumed volume of data, b) data variability, c) volume of metadata, d) metadata variability, e) multiplicity of actors/roles, d) multiplicity of partners/enterprises.

4. REFERENCE MODELS OF VIRTUAL ORGANISATION

Roles model in figure 3 provides a look-in of organisation structure while the models in figure 4 and 5 show how these roles should interact mutually. The models are prepared as a part of the process map of VO at a high level of abstraction.

When looking at the structure, two separate roles have to be described at first – an employee of the enterprise that participates in VO, and an employee of the customer. The possibility has to be taken into consideration when an enterprise as a valid network partner acts also as a customer at the same time. The ordinary role represents all the partner employees that could be somehow affected by inter-enterprise cooperation within the VBE or VE. The other roles arise due to the new principles way of cooperative work and with respect to the principle of no superior management divisions. More information to the organisation structure of VO is accessible in literature [8] and [9].

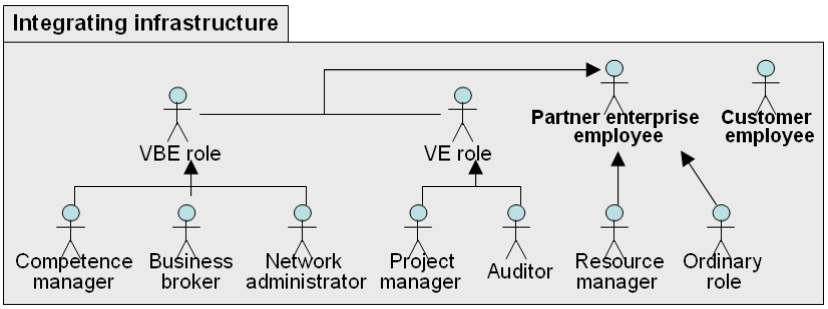

Figure 3: Roles model: Organisation structure of the VO

BUSINESS PROCESSES IN VBE

Outlining of cooperation concept. This process is triggered by detection of an opportunity for long-term cooperation. The initiator as a company representative, most likely employee of the business department, can recognise that the company could win advantages from participation in the network. This process is considered also an innovative intention to build the VBE, at which arguments are associated with improving of the position on the market, production capability, and many others discussed in chapter 2. The initiator introduces the concept supplemented with feasibility study to the management and CEO. The aim of internal approving then is to decide whether the project would be profitable enough to continue. For this purpose internal workshops can be organized, results of which complete and refine the cooperation concept. Within this stage the initial requirements for cooperation should be determined such as product portfolio, scope of business, expectation on partners and their technology, principles of communication and so on.

Feasibility study execution. If the concept appears to be real in the future the initiator or larger workgroup should be charged with making the preliminary feasibility study. As the study provides information for all subsequent processes following points should be contained at least: 1. strategic plan, 2. objectives in respective cooperation fields, 3. assumed investments, 4. frame work structure and project schedule.

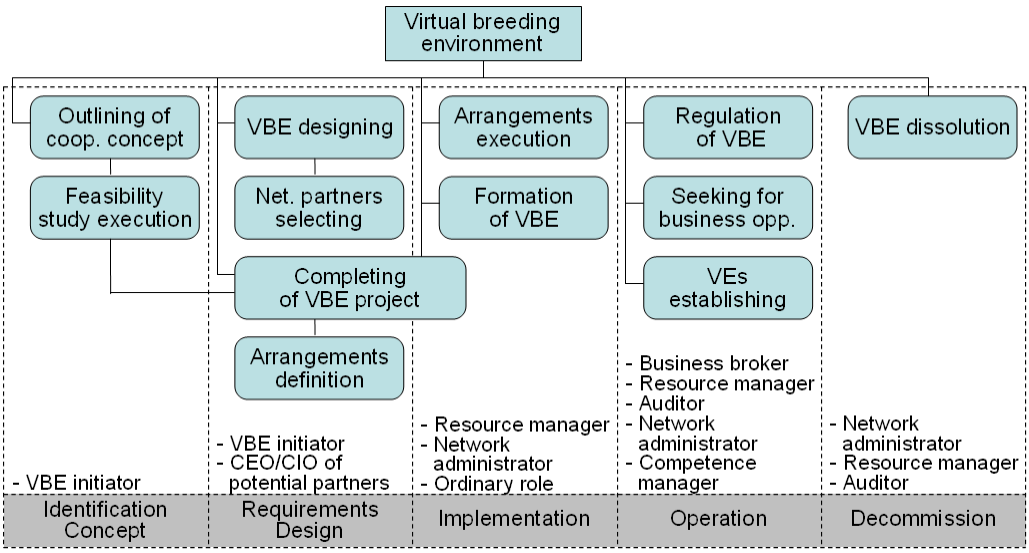

Figure 4: Process hierarchy diagram1: Process map of the VBE

Virtual breeding environment designing. Network partners selecting. The key task within this process area is to select the group of enterprises for future cooperation. Besides the initial visions and the cooperation concept also business relations are significant. These moreover may be the determining factor of decision-making. After the concept is ratified the initiating enterprise may start contacting potential partners. Appropriate enterprises should have production capability (development, manufacturing or product maintenance) as well as cooperation competence (ability to take cooperative responsibility). For this purpose several workshops can be organized where necessary.

Completing of VBE project. Enterprises interested in cooperation have to create the network workgroup that takes responsibility for coordination and project management activities in course of building of the VBE. To avoid any future conflicts when a hierarchy of common goals should be defined and approved. During the workshops the cooperation concept is gradually refined, added and accepted. At this point the feasibility study should repeat again with using new and more specific information.

Arrangements definition. The VBE project document must also include definition of all the arrangements that have to be done before putting the network into operation. There can be considered for example harmonization of business rules, principles of contracting, intellectual property rights, implementation of ICT tools, cooperation procedures and etc.

Arrangements execution. If the target level of preparedness of the network is known, and the project was approved, implementation of decisions and reference models can be started. This process may include installation or configuration of information systems, staff training, and business processes reorganisation, introduction of new rules regarding quality management, environmental principles, and standardisation and so on.

Formation of the VBE. After all the arrangements are finished the network is ready to come to routine operation. All the partners take responsibility for tasks associated with their individual participation. At this point the mission of network group is changed from management of the VBE project to long-term management of organisation. Its function is rather in coordination of mutual cooperation than in making directive decisions for enterprises that constantly remain their own subjectivity.

Seeking for business opportunities. The primary task under the VBE operation is marketing and promotion of common product portfolio that is available in the network. This includes several integral processes, e.g. purposive market research, active searching for customers, response to demand, business dealings, and so on.

VEs establishing. Within the VBE operation the partners are provided with support of virtual enterprises establishing when a specific business opportunity arises. The activities are especially about methodical support and project management of preparations.
Regulation of VBE. This process covers all the management activities necessary to keep the network under routine operation – planning, auditing, and decision-making. These are to coordinate the partners to optimally utilize all their resources and core competencies in cooperation. There may be decisions concerned about incorporation of new enterprises, or changing of the concept, etc.

VBE dissolution. The VBE according to one of the fundamental principles is operated on a long term basis, at which number and structure of enterprises can be changed dynamically. In the case of network dissolution legal issues have to be solved above all.

BUSINESS PROCESSES IN VE

Business opportunity evaluation. This process is triggered by specific business opportunity for cooperation that may arise from straight order, or product offer forwarded by the VBE representative or by any of the partners. After the first contact to the customer the aim of business dealings is to make a qualified decision considering all the resources available in the network. Customer requirements are essential input of this process.
Customer requirements specification. Requirements analysis is necessary in order to specify information about characteristics of the product as well as specific requirements for production. The aim is to describe the required product in light of product structure (if it is already developed) and functionality (if there is a need for development or innovation), as well as requirements regarding times and costs of production.

Virtual enterprise designing. Business partners selecting. Enterprises that possibly could participate in the VE have to be analysed and select under their current capability for cooperation, i.e. availability of their resources in the required time. Although the business partners are primarily selected from the VBE, they may also be third party enterprises if there is a need.
Completing of VE project. Within the completing of the project personal constitution including project management team and chief project manager designation have to be arranged upon the consensus. Along with the work break down structure also the work responsibility is defined for project partners. This is decomposition of the overall output into partial results with respect to the work deliverables of business partners.

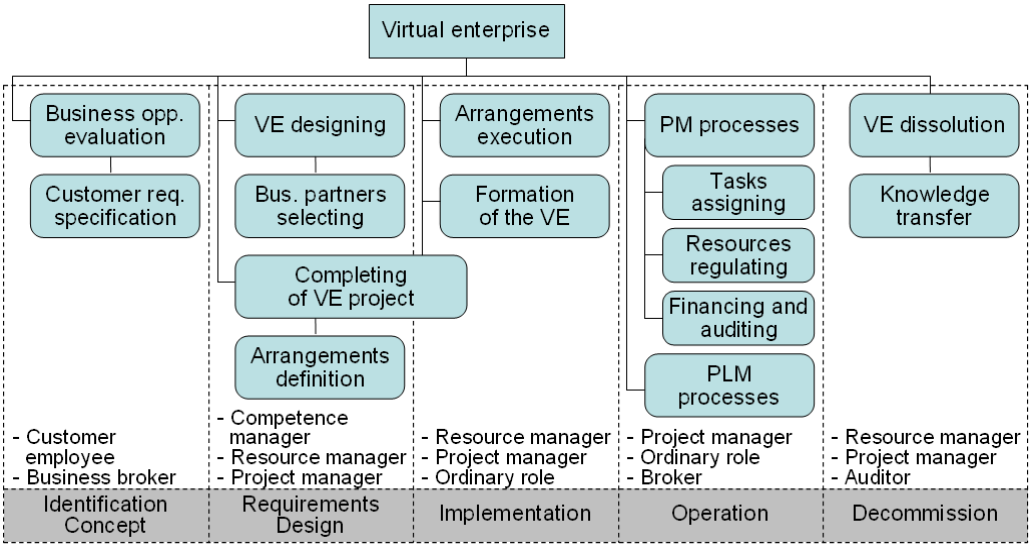

Figure 5: Process hierarchy diagram2: Process map of the VE

Arrangements definition. Preparedness for cooperation in the VE is highly affected by the level of preparedness that was achieved in course of the VBE building. The extent of preparation can vary depending upon the specific conditions of cooperation project: 1. technology and systems integration, 2. legal and contractual issues, e.g. using of standard form contract, 3. cooperative organisation structure, 4. production facilities, and 5. business processes. All the arrangements should become integral part of the VE project.

Arrangements execution. Network management team coordinate one or several preparatory projects focused on individual areas of common infrastructure in compliance with reference models, which is similarly to the arrangements at the first level of the VBE.

Formation of the VE. Cooperation among partner enterprises is initiated according to the VE project, which was proposed and approved in previous processes.

Project management processes. Management of cooperation in the VE is close to project management issues and includes several subprocesses of organisational nature. The aim is to coordinate all the activities that are individually performed and to control the deliverables of partners.

Tasks assigning – Detailed planning and controlling of work deliverables in collaboration with managers of the partner enterprises. *Resources regulating* – Acquisition of material and non material resources for cooperation. *Financing and auditing* – Decision and control in light of common cash flow, date and budget plan monitoring according to the VE project.

Product lifecycle management processes. PLM processes were identified based on product lifecycle analysis. When looking at specific activities performed at the partner enterprises several lines of businesses of engineering nature can be recognised: *Product requirements specification, Product development, Production process preparation (product, technology and facilities designing), Material preparation, Production (raw materials preparation, parts manufacturing, product assembly), Product distribution, Product installation, Product service and maintenance, Product disposal and shutdown.*

VE dissolution. Operation of the VE generally stops when the common project is completed. In the case of ongoing demand however the operation should not be limited by definite date. The event triggering this process is delivery of the product and related services to the customer. Activities are associated with administrative and legal issues. After the project is completed all the partners, their resources and core competencies have to return to the VBE pool to be available for next business opportunities. Sharing of common achievements and knowledge transfer must be solved beforehand.

Knowledge transfer. The aim is to collect all the knowledge obtained in cooperation and to negotiate terms and conditions for their sharing and using in the future. Urgent questions within this process are such as: What have we learned? Could it be done in better way in the future? Is it necessary to rebuild or to enhance the VBE? The outputs here are likely to initiate modification of existing reference models, procedures and principles to improve the efficiency of the processes of virtual organisation.

5. IMPLICATIONS FOR INTEGRATING INFRASTRUCTURE

Information derived from the models above was sufficient for process complexity analysis both from quality and quantity point of view. Results of the trough analysis helped us to determine several supporting subsystems. Decomposition of the integrating infrastructure in light of functionality was made with following assumptions in view:

- Virtual Organization is primarily characterized as being a network of independent, geographically and culturally dispersed enterprises. There is a clear distinction between a strategic and an operational level. A partner can step out once its goals have been met. The relations in the network are less formal and less permanent.

- The cooperation inside the network is built on semistable relations and based on sharing information and knowledge. There must be a high amount of trust among the partners supported with high level data security.
- The relations create dependencies among the partners, but the partners can also survive without them. Success of the network is based on market opportunities, and the essential element is the corresponding responsiveness.
- Every employee of every partner in the network must identify themselves with the VO and at the same time with their own company. VE can be disbanded in the event of project completion, but can also have an undetermined duration for as long as demands exist and/or the participants find the collaboration to be beneficial.
- Partners that do business outside of the network, in addition to the work within the alliance, are considered having partial mission-overlap. While partners performing all business within the organizational context, have complete mission-overlap.
- The products and services provided by the network are dependent on innovation and are strongly customer-based.

The properties and expectations on the integral subsystems are briefly described in table 1 as follows:

Subsystem 1. *Supporting system for the VE operation* – web-application with product lifecycle management functionality; necessarily: document management, product structure and data management, Job-order or project management.

Subsystem 2. Configuration system of virtual enterprises - a decision support system considered also as a core of the infrastructure to allow, facilitate and shorten the process of VE configuration for any specific demand or product.

Subsystem 3. *Supporting system for the VBE operation* – digital communication channel close to e-business commerce providing participators with functions to cover mutual consulting, coordinating, and marketing activities.

Subsystem 4. *Subsystem of enterprise applications* – Multi-applications environment composed of all the inherited software systems of cooperative partners that need to be maintained under routine operation concurrently.

Table 1: Subsystems of integrating infrastructure

	Business processes	Organisation roles	Technology
Subsystem 1.	- PLM processes - PM processes - Knowledge transfer	- Project manager - Business broker - Resource manager - Ordinary role	Shared infrastructure Repository of shared data (databases, groupware, WANs, remote computing)
Subsystem 2.	- Business opp. evaluation - Customer req. specification - VE designing - Business partners selecting	- Customer employee - Business broker - Competence manager - Resource manager	Channel for marketing and distribution, replacing physical infrastructure connectivity, sharing embedded knowledge, United data model for both of subsystems (email, Web, databases, Intranet, group technology)
Subsystem 3.	- Network partners selecting - Seeking for business opp. - Regulation of VBE	- CEO/CIO of partners - Network administrator - Ordinary role - Resource manager - Business broker	
Subsystem 4.	- PLM processes	- Project manager - CEO/CIO of partners - Resource manager - Ordinary role	Respective enterprise applications (CAD/CAM/CAE, office system, accounting applications, etc.)

6. CONCLUSSION

Camarinha-Matos in his works [15, 16] argues the various advantages that a company could potentially win from participation in the business of virtual organisation. These are complementary advantages from scale, new knowledge and technology acquisition, competitiveness and innovations improving, increasing of market access, sharing of entrepreneurial risks, common achievements, and more. The core competencies of a partner are usually not the whole company, unless it is a small company that has specialized its own operations within a niche. The smaller size of partners leads to more flexibility and makes it easier for the organization to take advantage of opportunities in the market. Several authors point to the fact that larger companies often are slower in decision making and innovation, which are essential factors in responding to opportunities.

We have attempted to shed light on the integrating infrastructure that could be helpful for SMEs in their effort to shift the progressive concept from pure theory to practice. With the provided technological support it is foreseen that the virtual organisation of the future can go far beyond the buy and sell activities, what the state of the art for the current clusters is. The infrastructure must be easy applicable in light of technology and investments. Robust solutions are not required, at which all the inherited applications have to be remained and the original operation of the partner enterprises cannot be disturbed.

REFERENCES

[1] JACOBSEN, K. A Study of Virtual Organizations - in mobile computing environments -. Norwegian University of Science and Technology, NTNU. Norway/Trondheim, 2004.

[2] AFSARMANESH, H. Characterizations of Key Components, Features, and Operating Principles of the VBE. Ecolead, project FP6. IP506958. [on-line] 06/2006. http://www.ecolead.org

[3] MOWSHOWITZ, A. Social dimensions of office automation. In: Advances in Computers. Vol. 25 Academic Press. USA/NY, 1986. pp. 335-404.

[4] PELS, H.J. Product data management for co-engineering. In: Proceedings of TMCE 2008 Symposium. Delft University of Technology. Turkey/Izmir, 2008. pp. 457-466.

[5] FIDLER, B. Virtuálne organizácie a PLM – Výskum a vývoj referenčných modelov pre strojársky priemysel. Písomná práca k dizertačnej skúške. Strojnícka fakulta STU v Bratislave. Slovakia, 2005.

[6] ESCHENBAECHER, J. – JANSSON, K. – KARVONEN, I. et al. Challenges in Virtual Organisations Management. Report on methods for distributed business process management. ECOLEAD project FP6 IP506958. [on-line] 09/2006 http://www.ve-forum.org/projects/

[7] TOELLE, M. Management and Engineering of Virtual Enterprises. Ph.D. Dissertation, Technical University of Denmark, Denmark/Lyngby, pp. 391. 2004.

[8] FIDLER, M. – FIDLER, B. Implementation possibility CMMI Model's parts in Virtual Organization. Proceedings of the 10th International conference: Mechanical Engineering 2006. Slovak University of Technology in Bratislava. Slovakia, 2006. pp. 731-736.

[9] 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.

[10] MOWSHOWITZ, A. The Switching Principle in Virtual Organization. In: Proceedings of the 2nd international VoNET Workshop. Simova Verlag. Germany/Bern, 1999.

[11] BULTJE, R. – VAN WIJK, J. Taxonomy of Virtual Organisations, based on definitions, characteristics and typology. VoNet: The Newsletter 1998. pp. 7-20. [on-line] http://www.virtual-organization.net

[12] KLEIN, M. M. The Virtue of being a virtual corporation. In: Best's Review, Vol.95, No.6, 89-94, 1994.

[13] COATES, J. F. Managing scientists in the virtual corporation, In: Research - Technology Management, Vol.37, No.6, 7-8, 1994.

[14] VALČUHA, Š. – FIDLER, B. – PODMAJERSKÝ, P. – SOMORA, D. Applied research program of mechanical engineering automation. ANNALS of the Oradea University. 2007.

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

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