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FRACTAL MANAGEMENT APPROACH FOR THE MANUFACTURING PROJECTS IN THE COLLABORATIVE NETWORKS OF SME-S.

Nowadays an increasing number of enterprises realize the importance of competitiveness improvement through collaboration. It is obvious that the collaborative network is becoming an effective tool that enables small and medium sized enterprises (SMEs) to survive under the global crisis pressure. It enforces enterprises to focus resources and means on the main activities, and to rebuild the architecture for manufacturing system in effective ways. Therefore, we decided to continue working on research topic of collaborative manufacturing projects management. In this paper we introduce the novel framework for the further development of the existing collaborative network concept in which we combined multiple project management methodology and fractal model of collaborative network of enterprises. The proposed framework enables SME-s to use resources more efficiently, reduce manufacturing costs, rapidly respond to customer demand changes, increase the productivity, reduce total lead time of collaborative projects, improve the products quality, improve the practice of collaboration in multi-project management, improve stability, share the expensive costs and equipment, reduce inventory, raise the accuracy of the forecast, reduce the data entry time, and improve the performance of delivery. In this paper, we will present the project-based fractal collaborative network framework, multiple project management and fractal model framework. We will introduce our vision of information and communication processes in the novel collaborative network, tasks and relationships of collaborative enterprises project managers, external and internal relationships of project managers.

1. INTRODUCTION

A collaborative network include partners (e.g. organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operation environment, culture, social capital and goals, but that collaborates to achieve common or compatible goals, and whose interactions are supported by computer network [7].

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Today manufacturing companies in order to survive under significant competitive pressure companies must increase product portfolio, reduce time to-market, shorten product development cycles and at the same time maintain good product quality and reduce investment costs [11].

The global competitiveness for the small and medium-sized enterprises can be achieved by looking outside of company borders. Today there is no unified system for the collaborative project management. Collaborative partners are working in independent environments. It is not possible to support a partner organization in case if there is the delivery problem, delay or unexpected equipment breakdown.

Therefore Customers, retailers, producers, suppliers and subcontractors set up a cooperative network, and it is reasonable to move the project management functions to the collaborative environment. In our paper we present the new fractal based framework for the collaborative project management in the Network of collaborative SME-s. This research is important for the SME-s, which are working on collaborative projects and interested in long term relationships. This framework enables collaborative enterprises to work in one environment. It is possible to startup the new virtual enterprise, when the business opportunity arises. The proposed framework can be used also by software developers.

In Section 2 we introduce critical aspects of collaborative enterprises, virtual form of enterprises, and fractal manufacturing. In Section 3 we present fractal management framework for collaborative projects. The application case study explains how the new framework could be used in Section 4.

2. LITERATURE REVIEW

2.1. COLLABORATIVE ENTERPRISES

The collaborative network includes independent enterprises with compatible and joint goals. There are different forms of partner relationships between manufacturing enterprises. The networking facilitates communication and information exchange that goes through the coordinated networking, cooperation, up to collaboration. The collaboration form comprises of independent enterprises with compatible and joint goals [2]. In the manufacturing alliances, very often there are phases of intense collaboration, e.g. design and planning phases of a project, intermixed with periods when the participants work on assigned tasks independently. Then from time to time they “come together” (physically or virtually) and integrate their results for the joint problem solving. Therefore, a collaboration process clearly involves periods of cooperation only. The understanding and supporting of collaboration is leads to understanding and supporting the other less demanding forms of interaction. The collaborative enterprises optimize the opportunities in the value-added supply chain. In fact, the involvement of a collaborative network represents not only a survival factor but also a competitive advantage in the face of turbulent market scenarios [5].

Scientific associations play an important role as facilitators and promoters of collaboration among professionals involved in a specific discipline. Some initiatives in this area have been launched in recent years such as the IFIP/SOCOLNET, ESoCEnet, CTS, BASYS [7]. The comprehensive collection of methods and tools for collaborative networks was developed under ECOLEAD project [3]. The THINK creative project was one of the first initiatives to introduce the concept of Collaborative Networked Organization (CNOs) as a more general concept to encompass various collaborative forms such as virtual organization, virtual enterprise, professional virtual community, etc [4].

2.2. VIRTUAL FORM OF ENTERPRISES

Virtual organizations (VO) are focused on collaboration among enterprises combining the properties of business-to-customer (B2C) and business-to-business (B2B) [6]. Advanced and highly integrated supply chains, virtual enterprises/virtual organizations, virtual (professional) communities, virtual laboratories/e-science are illustrations of a major trend in which entities seek complementarities and join efforts that allow them to better participate in challenging and competitive opportunities [5]. There is a list of properties that are considered for creation of collaborative virtual organisations in ECOLEAD project: independence and autonomous of enterprises; similarities between running and evolution of the enterprise and CN; life cycle and agility in configuration of CN [3].

The Virtual enterprise (VE) represents a temporary alliance of enterprises that come together to share skills or core competences and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks [7]. The Virtual Organisation (VO) represents a concept similar to a VE comprising a set of independent organizations that share resources and skills to achieve its targets but that are not limited to an alliance of profit enterprises. VE is therefore a particular case of VO [7].

The virtual enterprise management is defined as a goal-oriented design, control, and development of all enterprise activities starting from the material purchase and finishing by the final product. The goal is to establish the relationships with carefully selected cooperation partners and to support the materials and information flows between them.

The virtual Breeding Environment (VBE) represents an association of organizations and a number of related supporting institutions, adhering to a base long term cooperation agreement, and adoption of common operating principles and infrastructures, with the main goal of increasing their preparedness towards rapid configuration of temporary alliances for collaboration in potential VO. Namely, when a business opportunity is identified by one member, a subset of VBE organizations can be selected to form a VE/VO [7].

2.3. FRACTAL MANUFACTURING AND PROJECT MANAGEMENT

The flexible network is made up of autonomous interdependent units. A fractal is generally a unit of a business or recursive pattern which has objectives, achieves results and

acts autonomously. Fractal has been widely applied to describe and model various spatial phenomena, urban morphologies, transportation networks, and complex structures. In the context of manufacturing systems, the fractal concept is embodied in a ‘factory within factory’ and has various manifestations such as fractal factory, basic fractal unit (BFU) model, fractal layout, the fractal manufacturing system (FrMS) and other fractal-like systems including the holonic manufacturing system [18] and the bionic manufacturing system [19]. The objectives are orientated on its contribution in the entire value adding process of an enterprise. This does not necessarily have to be a financial contribution. The Self-organizing and self-optimizing unit characteristics of the fractal company differentiate goal management from resource management in SMEs networking [11].

A project is a temporary entity within the SMEs network. It reaches a certain objective in a limited amount of time [11]. Organizations usually divide each project into several subprojects to provide better management control and to link ongoing operations of the performing organization. The project phases are known as the project life cycle: preliminary estimation of order, order acceptance, works planning, project optimisation, works implementation and acceptance [12].

Accordingly to proposed model all the enterprises are autonomous independent business units which are forming the VO when the business possibility arises. The collaborative project is seen as temporary unit, which is started by the project manager who was initiated new VO. This project manager is called project initiator or father project manager. Each project exhibits fractal characteristics. This highlights the possibility of dynamic reconfiguration in order to exploit business opportunities and event handling [10].

In the project-based fractal enterprise model, both ends (goals) and means (resources) are managed by a project manager. A fractal projects have modular structure and all the projects, starting from father project and up to the lower level of child project, are managed in the same way. [17]. The main responsibilities of a project manager are to achieve the project goal, define the task plan, receive messages and information from managers of its father project (if any), answer requests to its own father project (if appropriate), and negotiate with other project managers playing means-manager role for the allocation of the needed resources. Also, a project manager has to receive messages and information from its child projects, detect and predict abnormal situations, and if it is necessary to repair the project task plan [10].

3. FRACTAL PROJECT MANAGEMENT FOR COLLABORATIVE NETWORK

In this chapter we introduce the framework of fractal collaborative project management, developed for collaborative network of enterprises under IMECC project. This project combines the machine building cluster of industrial enterprises of Estonia, consulting companies and research institutions. The project initiator creates the project plan and divides it into fractal subprojects. The subproject manager can also divide the project into fractal subprojects. All participants are working in the same way. The information about subproject

fulfillment is sent automatically and all the participants can track the project fulfillment in real time. In case of delay the partners can see the source and to support the partner enterprise with materials, resources or information.

Accordingly to framework the enterprises can participate in different forms: project initiator enterprise (Ent1), partner enterprises from the existing collaborative network (example: Ent2, Ent3 and Ent4), and ad-hoc partner enterprises outside of the collaborative network (example: Ent5 and Ent6). In order to improve the quality of collaborative work we propose to include the Intelligent Decision Support System (IDSS) into the framework [12]. The functions of information exchange between enterprises, creation and support of Web pages with User Interfaces for VBE and VE provides the small enterprises, possibility of integration with Enterprise Resource Planning systems (ERP) and support of knowledge base are also included. The role of the project manager is to implement the monitor-analyze-plan-execute (MAPE) loop, which comprises both scheduling and control for a given order or resource Fig. 1 [24].

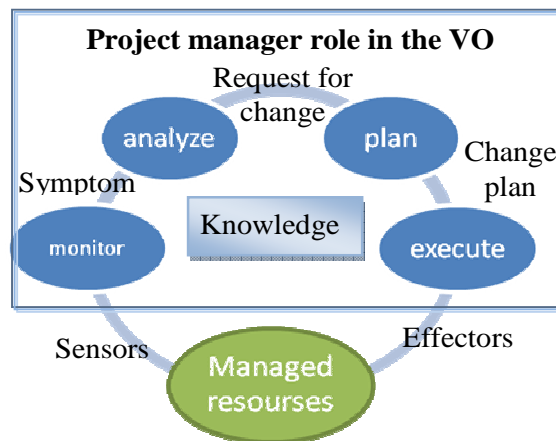


Fig. 1. Role of project manager

In our framework we assume that the enterprise resources are managed by project managers (PM). The Ent1 receives the order accordingly to predefined project portfolio the initiator enterprise creates the new virtual enterprise in e-manufacturing system, and establish the collaborative project plan based on own resources and available resources of partner enterprises that could be received from e-manufacturing system. Then the Intelligent Decision Support System (IDSS) engine of e-manufacturing systems helps to recalculate the manufacturing project in the way that enables the maximum positive cash flow [13].

After that the optimization engine discovers the bottlenecks [15] and uses the partner enterprises available resources to solve the situation. Then the IDSS engine selects the preferred potential partners send out quotations to the ERP systems of collaborative enterprises. When the partner selection is completed the PM 1 sent the invitation to join to the VO for participation to the members of VBE and also can recommend including the stand alone enterprise VE. There is possibility to select partners from existing collaborative

network and also to include the partners outside of the boundaries of collaborative network, or ad-hoc enterprises is added [12]. After the contract is signed the Ent1 startup the father project plan and delegates the parts of the project plan, called fractal projects or child projects, to the partner enterprises Ent2, Ent3 and Ent4. It enables partner enterprises to participate together in the product development process and to optimize the product development and product manufacturing processes.

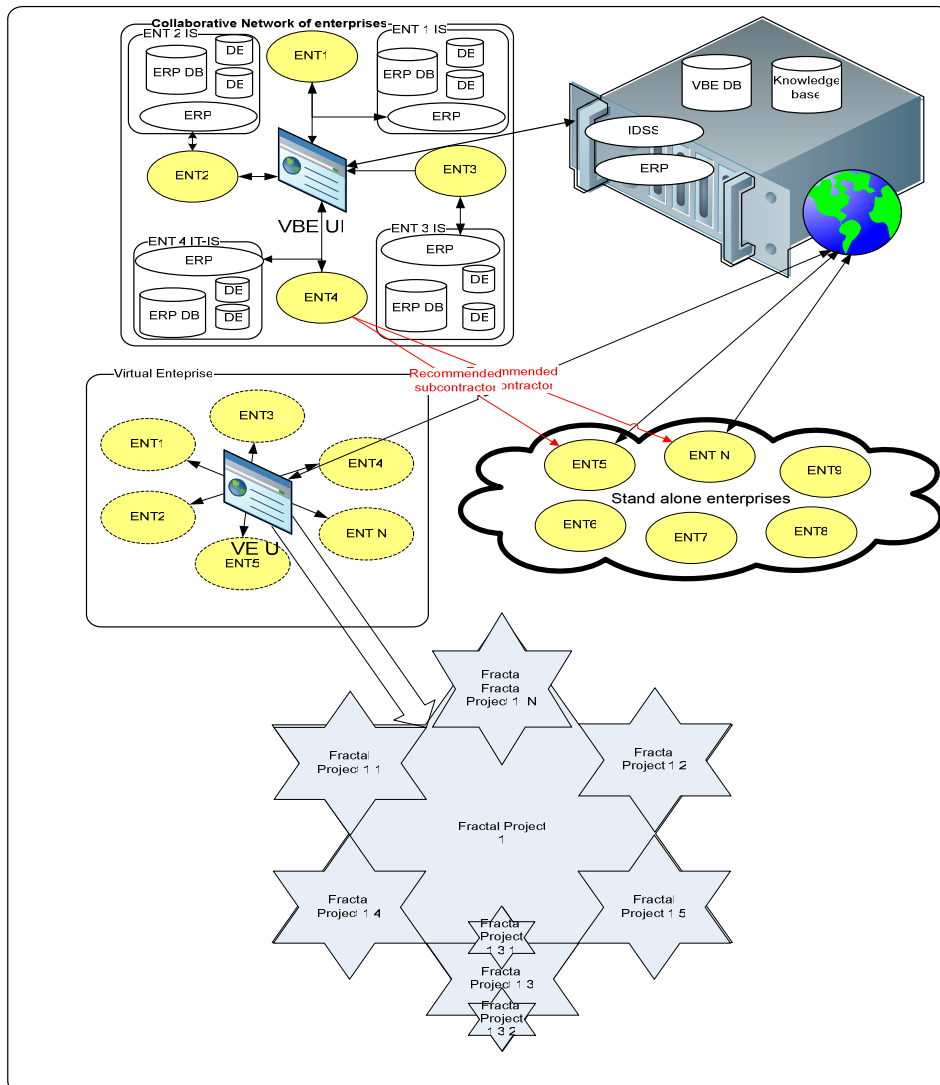


Fig. 2. The structure of the fractal project management for the Collaborative Network

For every fractal project management is used an e-manufacturing system. The system sent the preliminary requirement and deadlines to the partner enterprises and receives back the child project plans. It is the responsibility of the child project managers to provide required resources that are stated as available in the VBE collaborative environment. The child enterprises can also use subcontracting and to search, select, accept and invite new partners to join the VE. E-manufacturing system manages the project as one whole, at the

same time the projects managers of child projects have enough freedom and act in the role of independent manufacturing enterprises. For example the part of the fractal project 1.3 is outsourced by PM 4 to subcontractor enterprises which are not members of the CN, or so called standalone enterprises. The child project PM4 will recommend to the management of VO to include Ent5 and Ent6 into VE, which enables them to exchange the information with VE participants. The information exchange can be done manually through the upload of required information to the web portal on VO. Then the fractal Projects 1.2.1 and 1.3.2 are formed and managed by child projects PM 5 and PM N respectively.

The project management phases are known as the project life cycle: preliminary estimation of order, order acceptance, work planning, project optimisation, works implementation and work acceptance [12]. Fractal project management ensures that partners manage the child projects in the same way. This enables to optimize the total cost of the whole project, minimize the project cycle time and improve quality, due to improved control and information exchange between partner enterprises is given in Fig. 2.

The disadvantage is that ERP systems should be modified to be able to exchange data. The e-manufacturing system enables to collect required data and track the situation supported by IDSS system monitoring function [14]. If there was a delay in one of the fractal projects, the child project managers solve the problem together with the VE project managers to minimize the whole project delay. The e-manufacturing system enables the transparency of the whole VE. The partners can directly exchange required information within the VE. The advantage of e-manufacturing system is the ability to receive the information from different sources and to combine it into the whole project plan. The traceability of data is enabled by the help of agents [15], which responds in on-line manner to any change made by any participant of the VO.

4. CASE STUDY IN FRACTAL MANAGEMENT OF COLLABORATIVE MANUFACTURING PROJECTS

The case study is based on the project that was carried out by using the traditional, sequential project management approach. It is introduced how to implement fractal management approach into project management concept, which could minimize manufacturing cost and production time, enable to improve the quality of the product, improve information availability, and improve the shipment reliability [20]. The fulfilling of those aims could not be done without the production system support by Intelligent Decision Support system (IDSS).

4.1. "BIG-BAG FILLING STATION COMPLEX" PROJECT MANAGEMENT.

In general, the project management has six main steps of production chain. There are the preliminary estimation of order, order acceptance, work planning, project optimization,

works implementation and work acceptance (Fig.3) that are necessary to successfully produce desired outputs or outcomes [21]:



Fig. 3. Sequence sequential order of project processing

The project management processes by project initiator enterprise. In this context of sequential order processing the ready design documents were sent to internal and external suppliers and subcontractors after the product development was finished. The suppliers and subcontractors had the function to design and manufacture the product without being able to exert genuine influence on the product oriented design. The advantage of clearly separated and hardly networked processes was thus opposed by serious disadvantages. If production engineering began after the product development is finished, the total lead time between the product development process and manufacturing process start-up increased. In addition, the cost of sequential order processing is higher, due to the reason that during the production development process the know-how of production companies cannot be integrated into the design parts, it results also in production cost increase.

4.2. THE PROTOTYPE DEVELOPMENT FOR “BIG-BAG FILLING STATION COMPLEX” PROJECT MANAGEMENT.

Based on the virtual enterprise (VE), Virtual organisation (VO) and VO Breeding environment (VBE) approaches, collaborative network for Big-Bag Filling Station complex will be developed. The experience of several projects in applying has revealed a number of disadvantages in sequence project management structure (Fig. 6). The most considerable disadvantages are: non-efficient usage of resources, high manufacturing costs, slowly respond to customer demand changes, low productivity, the high total lead time of projects. We assume that the web based environment for VBE has already worked out. The project initiator enterprise creates a new virtual organization and new project within the VO. It includes all enterprises which participate in production process Fig. 4.

When the virtual organisation is created, the project initiator enterprise establishes the collaborative project plan based on own resources and available resources of partner enterprises that could be received from e-manufacturing system. The companies inside the VO are able to track the project execution plan in the web environment. They are able to make suggestions, corrections in the execution plan accordingly to their needs. The information will be available for each enterprise in the real-time operation mode. It allows project manager to respond in fast manner to the changed situation, to interact immediately with other managers and to correct the utilization of resources regarding to the project needs. The participants of the VO can recommend and invite to join the project also the

companies outside of the VBE, for the duration of the project. If the proposed company is accepted by partners the new account will be opened in e-manufacturing system. The information related to the joint outsourcing company accomplishment of its commitments will be available to VO members.

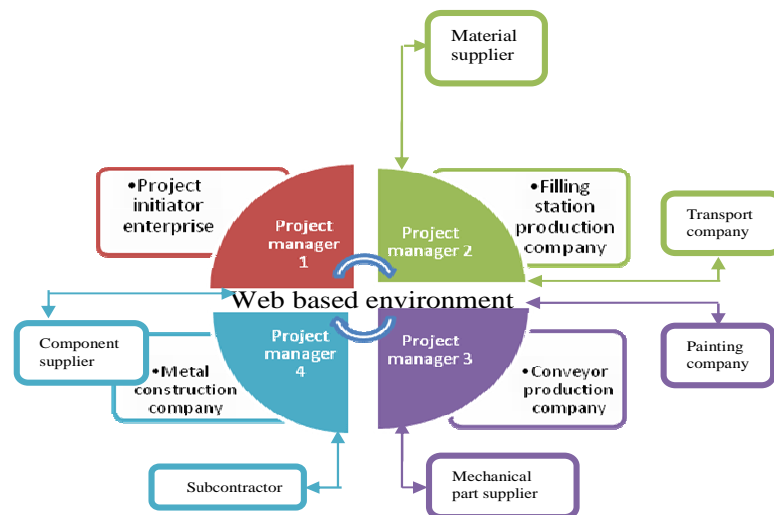


Fig. 4. Virtual organization with the companies outside of the VBE boundaries

4.3. APPLICATION OF THE FRACTAL STRUCTURE FOR PROJECT MANAGEMENT

The application of fractal project management has to be integrated into proposed case study. This step favours to establish the project management and gives an opportunity for future management of multi-projects. It is an important requirement on the way to production project development. The method of fractal project management for the realization of parallel processes between product development and process design, where the IDSS supports the different activities of project management with up to date information and optimisation feature is developed Fig. 5.

The “BIG-BAG station” design project is divided into sub-projects. The sub-projects are independent self organising units, but have the same management structure with estimation of order, order acceptance; work planning, project optimization; works implementation and work acceptance steps included Fig. 6. Each sub-project is managed by project manager [25]. Active projects consume resources in order to perform the project accordingly to the projects tasks plan. The required resources are internal or external resources of a production plants that are doing: the metal construction, conveyors production and stations production. Those companies are small or multipurpose plants: the batch production companies for the components, design companies, etc. A production VE lifecycle may extend up to 10 years and to have several important milestones when the project owner must decide if the project should be continued or not. So, the resource sharing and sub-

project delegations between project managers are conditioned by successful project evolution.

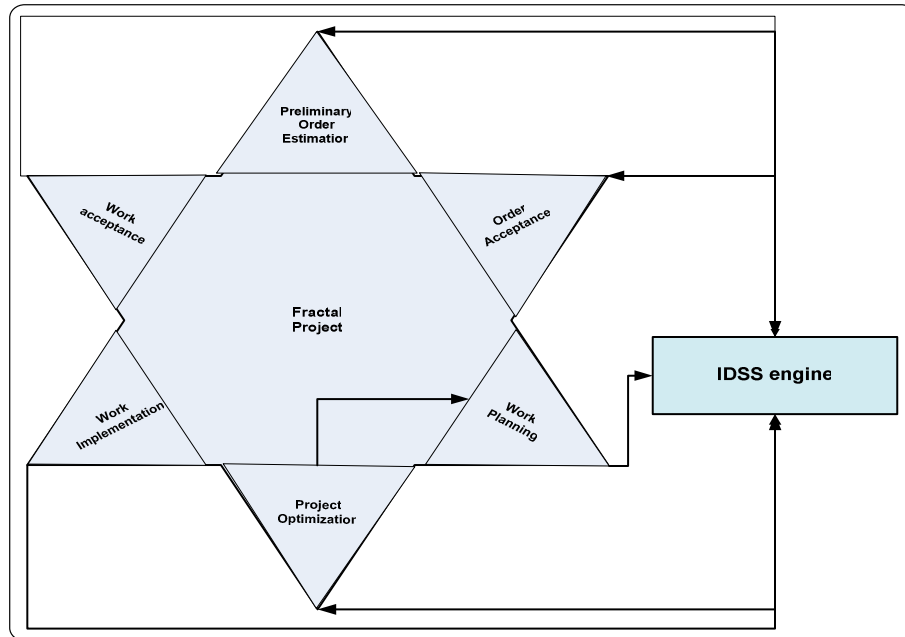


Fig. 5. Structure of a project as a fractal management unit supported by IDSS



Fig. 6. Virtual organization with the companies outside of the VBE boundaries

The fractal order processing has the following distinctive features: transfer of information in real time; production industry as production facility supplier, early integration of production companies into customizing process; production company is an active partner in the process chain. Compared with sequential order processing, the fractal order processing enables a substantial project lead time and setup time reduction. By the use of the fractal based framework for collaborative project management it is expected to achieve the reduction of the total project expenses and production time up to 20%. The time required for the confirmation of changes is reduced from several days up to one day and the probability of error making during the project fulfilment is eliminated.

The spreading of incomplete or questionable information gives producers the possibility to intervene and to promote process-oriented production design. However the advantages of this approach are partially outweighed by disadvantages of strongly networked operational sequences, which lead to increased difficulty of control [22]. The fractal project management approach eliminates the main disadvantages of old structure, as well it improves the products quality, improves the practice of collaboration in multi-project management, improves stability the sharing of the expensive costs and equipment, reduces the inventory, raises the accuracy of the forecast, reduces the data entry time, improves the performance of delivery consumes time for project development.

5. CONCLUSIONS

In this paper we created a new model which integrates collaborative systems requirements, concepts of virtual enterprises, IDSS methodology, project management and fractal structure.

The existing sequential order of project processing is time consuming. Today the company has a lot of problems related with the on-time delivery or orders. The pittance of time has an impact for the quality and affected to relation with customers. We have proved that the introduced fractal project management approach will have a positive effect on the future project implementation, which is the reason of this research project initiation.

We estimate that implementation of presented concept will give the following advantages for the collaborative networks of enterprises. It will enable to reduce: inventory, cycle time, the data input time, manufacturing costs and total lead time. In addition, the system will enable to use resources more efficiently, raise the accuracy of forecast and the delivery and the effectiveness of collaborative multi-project management will be improved. Partners will be able rapidly respond to customer demand changes, share the expensive costs and equipment and improve the products quality.

The disadvantages of the proposed framework are the full traceability of the collaborative project. Partners are able to see the all participants of virtual enterprise but the project managers are required to follow the accepted methodology for the fractal project management. In case if any of the partners is not sending information on time the information about total project fulfillment will be misleading. In proposed framework the project manager need more time to check if the data was properly sent. The partners

have more responsibility inside of the virtual organization and there should be done audit of stand alone partner enterprises. The enterprise data structure should be adjusted accordingly to the requirements of the Virtual Breeding environment. Company also requires additional expenses for some applications or software to successfully work in the virtual system. The enterprise data structure and the existing applications should be adjusted accordingly to VE requirements. The training should be provided for the labor before the enterprise can be connected to virtual enterprise. The new approach application consumes an addition time of project manager. An experience is also required before the new system will be work properly. In future work we are planning to continue work in the direction of IDSS system development for collaborative network of enterprises.

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