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Forecasting Structural and Functional Aspects of Virtual Organisations

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Abstract: Planning and management of Virtual Organisations (VOs) depends on accurate prognosis of several organisational aspects. This paper examines how structural and functional aspects of such enterprise networks might be forecasted by using systemic methods. The structural aspects cover the partners and their collaborative interactions while the functional aspects describe the value creation processes accompanied by auxiliary processes. Furthermore, an industrial case study is presented and initial expected results from the application of two selected methods are given. The methods analysed in detail are the cross-impact analysis and the collaborative network analysis method.

1. Introduction

Prognosis and forecasting have been discussed several years [1]. They can be seen as important component of all types of strategic planning [2]. In this respect Wild [3, p. 87] pointed out that decision making on the issue prognosis is indeed the most important information, which will be collected and used in the process of enterprise planning. Regarding the strategic management of companies all aspects of enterprise analysis and environment analysis are subject of prognosis and measurements. Trends in the macro environments such as investments in new ICT solutions [4], changes in competitive situation and evolving changes in resource and competence management of companies do call for new forecasting methods and instruments. A classical systematisation of these methods and instruments differentiates quantitative and qualitative approaches [5], [6], [7]. All these approaches have been developed for the usage in companies. Similar to Weber [8], this paper discusses the forecasting of structural and functional aspects in virtual organisations.

Forecasting business developments have a long tradition [9]. Especially within innovation processes it becomes a key competence to better understand upcoming developments. Boutellier et al show that a systematic planning of R&D and innovation processes can support the competitiveness dramatically. The authors discuss altogether 21 case studies of best-in-class companies dealing with the uncertainties of innovation. [10]. Also MCInerney shows that forecasting can play an enormous benefit to better understand customer requirements as for his case Panasonic [11]. They also state a general trend towards decentralization and cooperation towards virtual organisation can be observed [12]. These aspects can be seen as starting point of our investigations.

This paper addresses the forecast and management of such innovation-oriented VOs. First, based on a systemic view, structural and functional forecasting in VOs is introduced. Here the concept of forecasting structure and functional behaviour of VOs will be discussed. Forecasting can be seen as one very important function for those types of networks. Second, a scenario is presented and will be used to demonstrate the forecasting approach. Thirdly business benefits are presented. The results have been tested in the context of the IST-research project ECOLEAD (www.ecolead.org).

2. Structural and Functional Forecasting of a VO

This chapter provides an overview about the conceptual view of structural and functional aspects of Virtual Organisations.

2.1 Structural and Functional Aspects

Camarinha-Matos and Afsarmanesh have developed a first draft for reference model for collaborative networks, which comprises four dimensions: Structural, componential, functional and behavioural [13]. These dimensions have been created to formalise the issues according to design and coordination of Virtual Organisations. Indeed the structural and functional dimension can be easier coordinated as the other two because informal issues such as componential and behavioural are more difficult to influence. Furthermore, the componential aspects describe the equipment of the network which could easily be adapted to structural and functional needs. The behavioural aspects emerge from a concrete design of structure and function. Consequently, the following focuses on the two most important dimensions:

2.1.1 Structural Dimension

This dimension addresses the structure or composition of the VO constituting elements (its participants and their relationships) as well as the roles performed by those elements including other compositional characteristics of the network nodes such as location, time, etc. The structural perspective is used in many disciplines (e.g. systems and software engineering, economy, politics, cognitive sciences, manufacturing), although with different "wording" and associations.

- Actors/relationships – identifying all the participating actors (nodes) in the network as well as their inter-relationships (edges). Actors can be any kind of organisations (e.g. enterprises) or people. Two (or more) actors can be linked through a number of different types of relationships, e.g. client-supplier, sharing, co-authoring.
- Roles – describing and characterising the roles that can be performed by the actors in the network. A role defines an expected behaviour of an actor in a given context. Examples of roles are: Member, coordinator, broker, planner, etc.

2.1.2 Functional Dimension

The functional dimension addresses the basic operational functions available at the network level consisting of time-sequenced flows of executable operations (processes and procedures) related to the different phases of the VO life cycle.

- Processes – this sub-dimension is concerned with the processes involved in the main line of activities of the network. Processes represent the structured part of operational activities of the network. Examples are distributed business processes in a VO.
- Auxiliary processes – including those processes that are designed to assist the VO in terms of its maintenance and improvement of operations. Examples include performance monitoring, competencies management, etc.
- Methodologies – typically less formalised than processes, represent the body of practices, procedures and rules used by human actors in VO. Often, they are represented as a semi-structured set of steps (informal enumeration of activities) combined with some structured representation of input/output information. An example is the methodology followed by a broker to announce a business opportunity to VO members.

The following chapter provides a system-oriented view on VOs to further narrow the concept of structure and function in Virtual Organisations.

2.2 System Oriented View on Virtual Organisations

A VO can be considered as a system, which is composed of nodes and edges [14]. Then, the dimensions can be characterised in the following way:

- Structural Dimension: Network nodes are represented by system elements and edges describe the relations among the nodes. A number of elements that are connected by relations describe a system. A subgroup of elements and relations can be a sub-system, if all elements and relations also belong to the system. Finally, a system is embedded in a super-system, which creates a framework for the bigger picture. The actors and their relationships are supplemented by roles – both together is characterised by the structural dimension (see Figure 1).

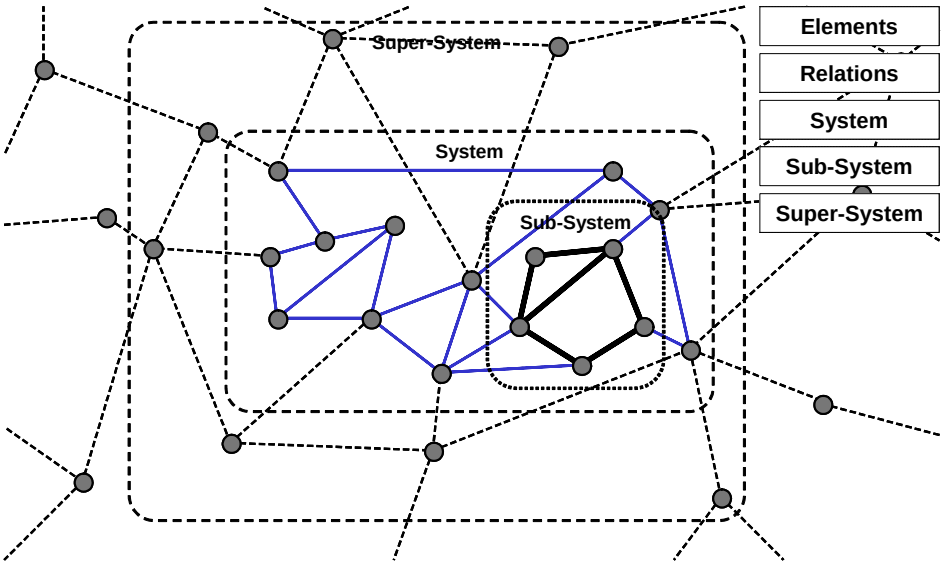

Figure 1: System-Oriented View on Networks like VOs

- Functional Dimension: The functional dimension is described in Figure 3. The VO life cycle is illustrated by the terms VO formation, VO set-up, VO operation and VO dissolution. Indeed, the VO preparation phase is in the focus of the functional dimension, because it is characterised by (distributed) processes and auxiliary processes.

3. Forecasting in Virtual Organisations

3.1 Quantitative and Qualitative Forecasting Approaches

Quantitative forecasting methods deliver on the basis of mathematical and statistical operations results regarding to the intended result. A short overview about the quantitative methods and instruments, including a short characteristic and application fields is shown in several publications [15].

The second group is called qualitative forecasting methods. Those methods have been highlighted in strategic management due to the high uncertainty which continuously increases in companies. They are suited for application in enterprise and network contexts in which either past data is not available or in which data cannot be easily quantified. Simon [16] differentiates quantitative from qualitative forecasting methods with the help of the following characteristics:

- The application is limited on worse structured situations, which are labelled by imperfect information.
- They deliver no guarantee for solutions, but they can be used to reduce the complexity by focusing on a view on most suitable solutions.

- Qualitative methods imply subjective assumptions on individuals or groups.

To summarise, qualitative methods shall be seen as forecasting approaches which are based on a subjective evaluation of the respective prognosis issue.

Both, qualitative and quantitative methods have been developed for the usage in enterprises. As an addition, this paper shows how two approaches can be applied in the dynamic context of smart and virtual organisations. These two methods have been developed towards demonstration of forecasting in VOs.

3.2 Forecasting Approach

The forecasting approach shall improve the planning and management of VOs. One of the main objectives is to reduce the complexity. Figure 2 shows precisely that the approach shall be used to do two things: First, providing information about the structural and functional dimension, and second, to forecast developments of the real world by decomposing it into structural models and further into a rough model. These three layers are presented in Figure 2. By forecasting the "real world" detailed information about structure and processes can be determined.

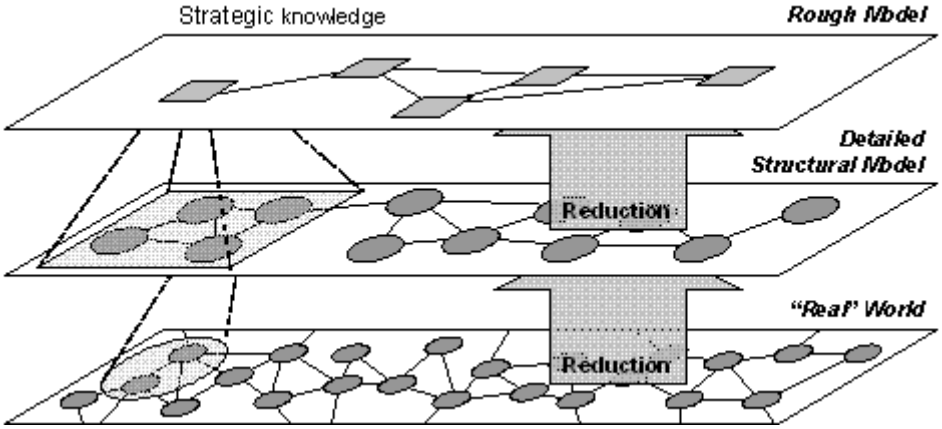

Figure 2: Reduction of Complexity by Modelling

Figure 3 integrates the view of nodes and edges, VO life-cycle and functional and structural dimensions with the ideas of an accurate forecast. Here, the forecast includes not only the estimation about the number of nodes and their edges but also an assumption of the intensity of the collaboration among partners.

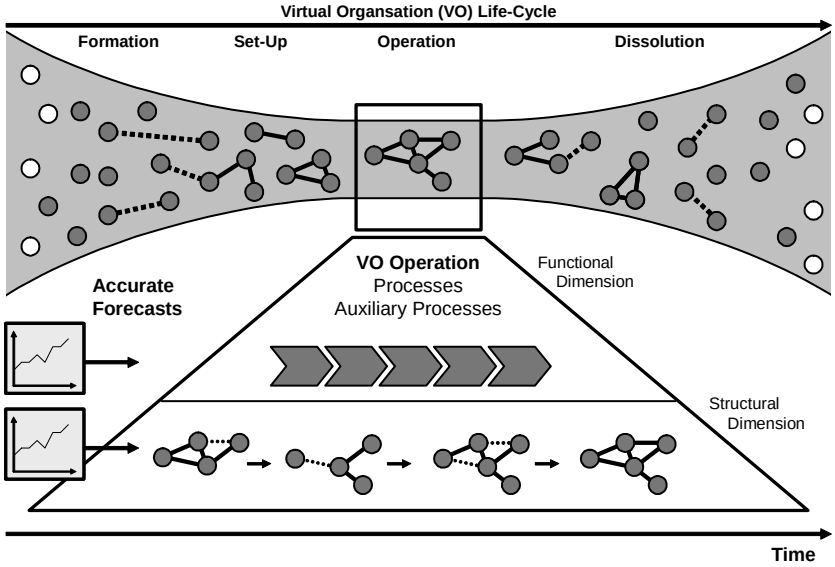

Figure 3: Forecasting Structural and Functional Dimensions

Forecasting of the structural and functional dimensions of the VO should be done using methods based on a systemic approach. As a first attempt, causal cross-impact analysis and network analysis has been chosen for this task.

The next section presents a case study to illustrate the forecasting approach.

4. Scenario Discussion

In European IST research projects such as TRUSTCOM (www.eu-trustcom.com), ECOLEAD (www.ecolead.org), DBE (www.digital-ecosystem.org) and Intelligrid (intelligrid.info) structure, processes, needs, requirements and IT-Systems for VOs have been analysed. The main focus was constantly on the development and usage of ICT. For some reason the analysis of forecasting methods were only subject in the ECOLEAD project, where the following descriptions are based on.

One of the ECOLEAD cases, the CeBeNetwork scenario, is described in full length in [17]. This case is used for relevant aspects for this paper.

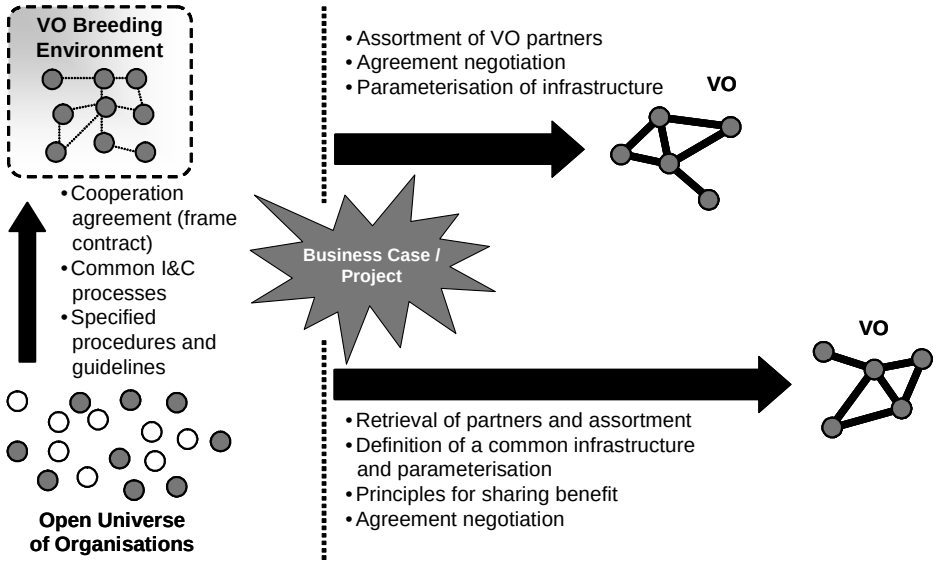

Figure 4: From VBE to the VO in the CeBeNetwork Case (ECOLEAD 2005)

4.1 Collaborative Engineering Scenario

The "CeBeNetwork cooperation group" exists and is proven since November 2002 as an international aerospace subcontractor network of more than 20 partners with over 20 years of experience in aerospace. It provides competitive services for the aviation sector in France, Germany, UK and Spain and additionally in some low-cost countries. It is trying to create new business in automotive and other industries. Figure 4 shows the transformation from the open universe to the CeBeNetwork VBE. Out of this VBE a real VO is created.

4.2 Scenario Specification

Figure 5 shows the ECOLEAD demonstration case scenario. In the cloud a number of new companies (not member of the CeBeNetwork VBE) and new partners (new members of the VBE) are trying to initiate a cooperation. Additionally freelancer's form a Professional virtual community (PVC) which could be freelancers or programming experts are selected which both together create the CeBeNETwork collaborative engineering VO. This dynamic VO is coordinated by CeBeNetwork as VO coordinator that creates the interface to the customer.

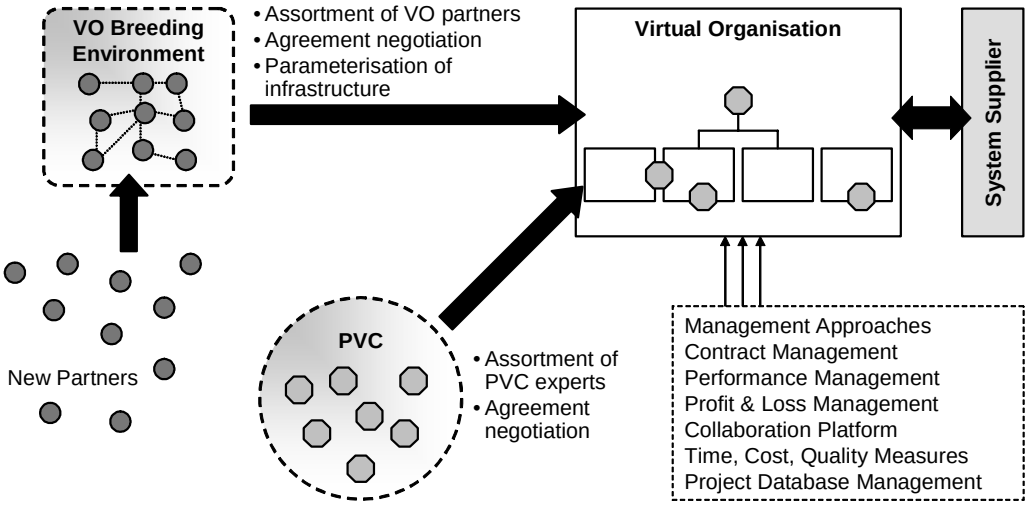

Figure 5: Demonstration Case Scenario

The grey box indicates that all VO functions identified in Figure 5 do play a role in the collaborative engineering case of CeBeNetwork.

4.3 Application of the Forecasting Approach

Baseline of this paper is the conceptual business case of an aeronautical supplier. Actually this supplier is transforming the value chain in a more virtual, smart supply chain. The case has been conducted by using a system analysis point of view (see chapter 2).

The subject of forecasting virtual organisations implies an enormous complexity. This complexity can be structured into three different levels which show a rough model (we call it birds eye view, representing strategic knowledge), detailed model (we call it system model level) and the picture of the real world which includes all the complexity (see Figure 2). Our approach is to use the rough model – the birds eye view – to understand the most important structural elements of the system and to forecast the tendencies within its functional behaviour.

5. Results

Forecasting methods play a prominent role in enterprise management. They can be used to better understand future trends [18] and developments in order to prepare answers towards the organisation of inter-organizational business processes. The case example has shown that the two presented approaches clearly add value to the prognoses of organizational developments including collaborative networks. Especially virtual organisations need a strong strategic planning to better understand their own structure and behaviour.

5.1 Contributions of Methods

Table 1 gives an overview on the single contributions the two chosen methods provides for the structural and functional dimension.

	Causal Cross-Impact Analysis [20]	Collaboration Network Analysis [19]
Structural Dimension	*Actors relationships*	
	Strategic planning; Assessment of market niche / business opportunity; Competition	Short-term / mid term planning of actors and their relationships; Network structure; Specification of necessary relationships
	Roles	
	Consortium balance; Network size	Roles of VO partners; Value chain structure
Functional Dimension	*Processes*	
	Efficiency and effectiveness; Best competence fit; Process performance	Design of distributed business process by using Porter Value chain model; Stage-Gate-Process; Collaboration intensity
	Auxiliary processes	
	Adequacy of auxiliary processes	Understanding of secondary value chain processes

Table 1: Contributions of Methods to Structural and Functional Dimension

5.2 Expected Business Benefits

Collaborative networks are going to become the major driver for European industry (ECOLEAD 2008, COIN IP 2008). So far the dissemination of such organisational forms are still lacking far behind expectations [22]. The authors claim that one reason is the missing knowledge and understanding about accurate forecast and planning. By using the two approaches the following business benefits can be summarised:

- Better strategic understanding of the potential actors relationships and / or roles with the Virtual Organisation –leads to improvements,
- Better definition of partner roles before starting the operation phase,
- More efficient business process management.

5.3 Feasible results

The application of the Causal Cross-Impact Analysis [20] and the Collaboration Network Analysis at CeBeNetwork shows remarkable results. Regarding the collaboration Network Analysis the following points can be summarised:

- The partners of the Virtual Organisation can a transparent view of the early phase of the innovation process,
- Secondly a structure for collaboration is proposed by the methodology and
- Finally, the CeBeNetwork Case shows the enormous problem to understand the upcoming processes. It happens many times that the future has not been properly understood. This leads to misallocation of resources, late deliveries and so forth. Thanks to the collaboration network analysis these issues can be identified earlier.

The application of the cross impact analysis shows the following results:

- The main strategic developments within innovation processes can be forecasted. Fore CeBeNetwork the careful analysis of the Power 8 program of Airbus indicated dramatic chances within the aeronautical industry.
- The demonstration on alternative scenarios showed CeBeNetwork different alternative routes for the behaviour of the collaboration which provided important support the decision making.

To summarise: The application of the two forecasting methods provided a decision support for the CeBeNetwork cooperation which gained into future business benefits.

6. Conclusions

The paper has discussed how the cross-impact analysis and the collaborative network analysis can be used to support the forecasting in Virtual Organisations. The methodologies have been conceptually applied in an aeronautical case study. The business benefits clearly show the importance of such approaches in everyday business.

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