

# State-of –the –Art of Virtual Organization Modeling

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**Abstract:** This paper presents the finding of the state-of-the-art of Virtual Organization Modeling in Europe, based on 30 European Virtual Organization research projects. The status of Virtual Organization research can be characterized as having achieved workable solutions on the level of well-defined domains or modules, e.g. modules for planning and control in the IT domain, or management models of broker functions. Nevertheless, The results show that the state of understanding and modeling Virtual Organizations has not yet reached architectural integration. Therefore to develop working solutions that include consistent business, organizational and human architectures for VO should the focus in the upcoming research framework.

## 1. Introduction

Today, globalization, shortening product life cycle, customer oriented product development has transferred the traditional business environment into a more dynamic one. New forms of organizing such as Virtual Organization have become more prevalent to encounter the changing environment. In Europe, estimations of the commission of European Union say, that around 50 Million Euros in research funds have been dedicated into to this domain under the Framework 5 program. Towards the end of this five-year research program it therefore is the objective of a set of three projects, VOSTER, Thinkcreative and VOMap is to baseline the state of research, to develop visions on future organizational forms, and to establish a strategic roadmap for research in the upcoming 6<sup>th</sup> Framework program. The assignment for the VOster project was to extract general findings on the cumulative achievements of more than 30 funded projects of FP5.

Virtual Organization (VO) is a term being used to describe how different organizations come together to explore business opportunities, and collaborating on a temporary basis (Katzy and Obozinski, 1999). Nevertheless, its nature of being dynamic has made Virtual Organization a rather complex system to manage and operate when compared to the traditional hierarchical Enterprise. This paper focuses on modeling approaches and their applicability to capture and structure organizing tasks in VOs. Modeling approaches have been a focus since the very beginning of ESPRIT and are widely used in existing enterprises. We will see that the projects showed that most VO projects do use this technology.

There are numerous existing enterprise modeling approaches and definitions for reference models that support the full range of needs from strategic business management to organizational design, Enterprise Software implementation and software development. An example of a general management model is the St. Gallen Management Model (Ulrich and Krieg 1974), examples for organizational process development is Value System Designer while

GERAM and related initiatives (e.g. VERAM, CIMOSA) address enterprise integration and system design/enactment. Rosettanet, for example has been defined as a standard for technical system collaboration. (Kosanke and Vernadat 1999; Chen and Vallespir, 2002). All these approaches are originally built on the assumptions of the traditional hierarchical firm, which was the prevailing organizational model at the time of their development.

Most of the surveyed research projects on VO explicitly reference one or more modeling approaches and in the last four years have extended and developed those for the specific needs of VO. The objective of this paper is to analyze the evolution of modeling approaches as one core technology for managing virtual organizations and its supporting ICT Infrastructures. We will therefore set out to establish a framework of enterprise modeling approaches from literature review and will then present survey findings of the VOSTER Project on how current projects on VO use existing modeling approaches and in which directions those approaches are extended. The survey covers thirty EU funded Virtual Organization and ten VO projects funded from other sources.

The remainder of the paper is structured as follows. We will start by introducing the VO modeling approach framework positioning key modeling approaches and definitions that have been modified and applied for modeling VOs. We then turn into the research methodology being applied in capturing state-of-the-art of the VO modeling in Europe. We will continue to present the results being collected and conclude with the next steps of the study.

## 2. A framework of VO Modeling Approaches

Enterprise modeling approaches mostly include a definition of a reference model. Chen et al. (2002) observe that modeling approaches can be distinguished first by the distinct theoretical basis of computer science, systems theory, production management, organizational management, or knowledge management on which they are built. And second, modeling approaches can be distinguished by the application areas that they address, be it information system design, business process reengineering, or computer systems design. In short, availability of a range of approaches enables VO researchers and designers to make their choice to model the various aspects of building and operating the VO, which by nature involves more than two independent business entities, sharing or combining operational processes using IST.

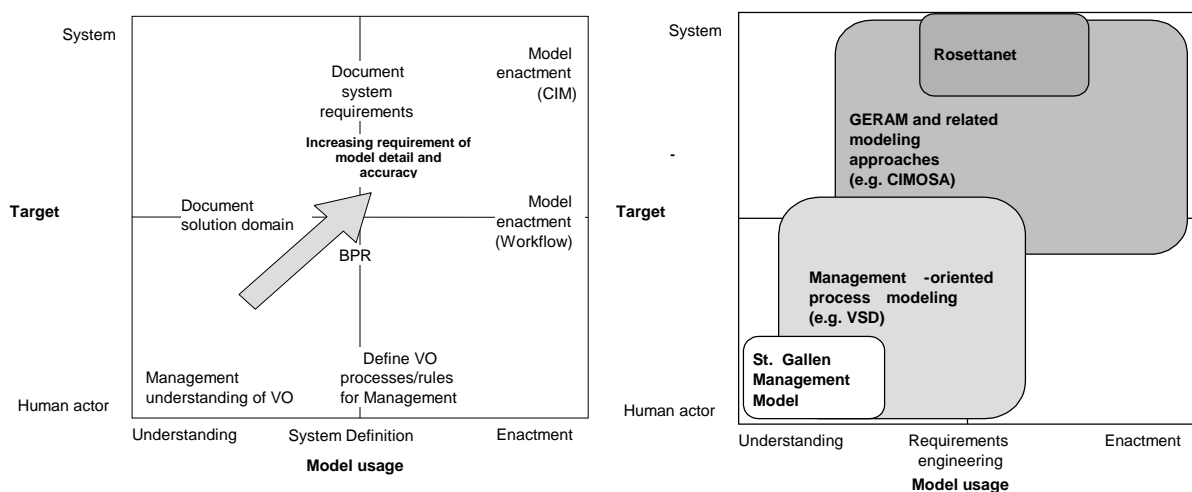


Figure 1: Framework to position modeling approaches

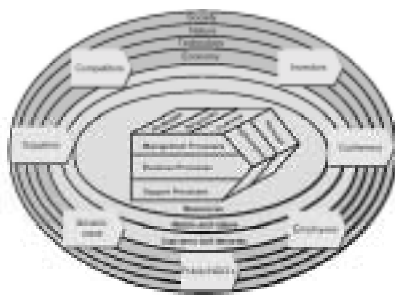
Figure 1 establishes the here used framework for positioning modeling approaches with regard to their inherent modeling purposes. It is populated with some examples of wide-

used contemporary modeling approaches. Two dimensions span a matrix with one dimension being the target user (human actors use the model or it is targeted to be used in the context of computer system) and the second being the type of usage (understanding the enterprise or enacting it). The lower and further left the objective for the modeling is positioned, the simpler and easier to understand the models should be. On the other hand, the further the objective is placed in the upper and right corner, the more detailed and accurate the models must be. Correspondingly, the effort for modeling will increase, while the flexibility to change the models decreases.

Furthermore, this chapter intends to provide a broad perspective on enterprise modeling and discuss some exemplary methodologies and definitions: the St. Gallen Management Model as representative for understanding enterprises from an organizational management perspective, VSD (Value System Designer) as a management-oriented business process reengineering approach, GERAM and related initiatives (e.g. VERAM, CIMOSA) for enterprise integration and system design/enactment, and Rosettanet as a standard for system collaboration.

### 2.1. Contemporary Modeling Approaches and Definitions

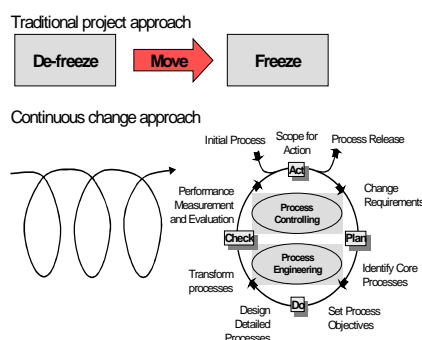
The **St. Gallen Management Model** was first developed by (Ulrich 1968; Ulrich and Krieg



1974) and further refined by (Rüegg-Stürm 1998; Rüegg-Stürm 2001). It structures the enterprise into different important elements as depicted in the left hand diagram. The purpose is to understand the enterprise and its behavior better through observing, describing and analyzing it according to this structure. Every firm would be a specific combination of the different elements, which could be described verbally or through different diagrams. However he approach has taken the following assumptions:

- Manifold and not immediately apparent relationships and interactions exist between the system's elements.
- Due to the “idiosyncrasies” of the system's elements, and various feedback effects between them, these relationships and interactions are in a state of continuous and only marginally predictable development.
- Results “emerge” from these relationships and interactions (i.e. the systems behavior), which means that they cannot be traced back to the behavior of individual elements in any way, but originate in the interaction of the system elements and depend principally on particular patterns of ongoing interaction (Rüegg-Stürm 2001).
- The dynamics make it impossible to examine any given complex system from a single, central standpoint, to describe it fully and “objectively” and to depict it “accurately” within a model (von Hayek 1972).

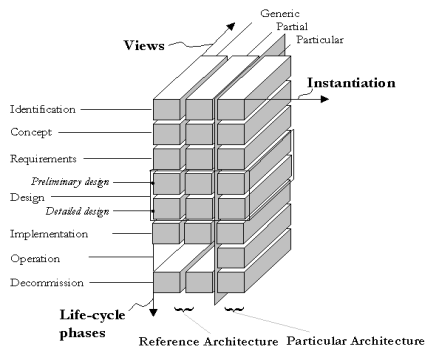
**Value System Designer (VSD)** is a typical example for a management-oriented business



process modeling approach. It is an end product from the EU-project TELEflow and further improved in the Business Architect and Genesis Project (also analyzed in this report). Its main application is designing the processes for new businesses (Value Systems) such as in virtual organizations and for business process engineering. Reference models according to this approach are blueprints for business processes, which

depict their generic elements without the idiosyncrasies of the individual firm, such as an additional department integrated for agreement or the usage of a specific computer tool. Since the effort to generate specific models is limited, the primary usage of reference models is to educate the user about typical process flows and to provide a type of checklist that important process elements have not been forgotten in adopted modeling efforts.

**The Generalized Enterprise Reference Architecture and Methodology (GERAM)** was



developed by a joint task force of IFIP and IFAC on the basis mainly of PERA, CIMOSA, and GIM, which in turn were influenced in their development by GERAM ((Bernus 2002)). It provides a framework or meta-model for enterprise integration and enterprise system design and implementation. Reference models within GERA are defined as generic or partial models. These are modules depicting certain aspects of the enterprise, such as a process or part of a process, objects, organizational

set-ups or resource configurations. The idea is by having many such reference models available to be much more efficient in modeling, since then adaptation and configuration is required, sometimes even only plugging together such models, instead of new model development.

**Rosettanet ([www.rosettanet.org](http://www.rosettanet.org))** is one of the largest standardization projects. It covers B2B e-business processes within the information technology, electronic components, and semiconductor manufacturing industries. Some 400 companies from around the world have joined Rosettanet since its start in February 1998. Rosettanet’s main deliverables are definitions for so called partner interface processes (PIP). These PIPs cover many different areas from transactions to administration, joint forecasting or quality management. PIPs standardise only the data exchange between different companies, they do not provide any models for company internal processes, or even on ways how the often rather rich information exchanged can best be used internally. They are embedded in an implementation framework (RNIF) based on XML-messages across HTTP-type networks. In Rosettanet, the different standard processes with their definitions are the reference models. A system based on Rosettanet has to adhere exactly to these reference models, which is tested and certified by a validation process. Rosettanet is a very interesting case study for defining models for open virtual organizations and can provide a reference point for future research and development initiatives in the area of reference models.

**3. Research Methodology**

Since emphasis was on reporting the status and future direction of VO research in Europe we have chosen the survey methods to be the research method.

The different projects used their proprietary definition of modeling and reference models derived from their perspective and purpose. In a first step therefore, projects with relevant modeling approaches were selected and mapped into the above-presented framework. Models and related information was extracted along these lines, analyzed, and preliminary conclusions were drawn..

However, due to the fact that some of the requested information was not available or restricted for public release, a second iteration was necessary. The second stage of this two-stage data collection/analysis methodology was dedicated to more detailed information was

gathered on each modeling approach. Therefore, a more targeted survey for capturing the core results of the modeling, were designed. However, the structuring according to the relevant aspects of VOs was continued to allow easy comparison between the different projects. 30 European wide Virtual Organization related projects were targeted. The collected information was further analyzed and later turned into a survey questionnaire, which was then distributed to each project contact persons for further data collection.

The collected data was analyzed and synthesized according to the purpose of the modeling approach; VO characteristics related to modeling; operation, management & support process of the VO; source network, operation, governance model; and management roles modeling. The outcomes of the findings were discussed in the results chapter of this paper.

#### 4. Results

Most of the projects used modeling to design IT systems supporting virtual organizations. Almost half of the projects applied modeling to define the system specifications. Comparably, only a small number of projects exploited modeling to clarify the issues of Virtual Organization as system human interaction. (Figure 2)

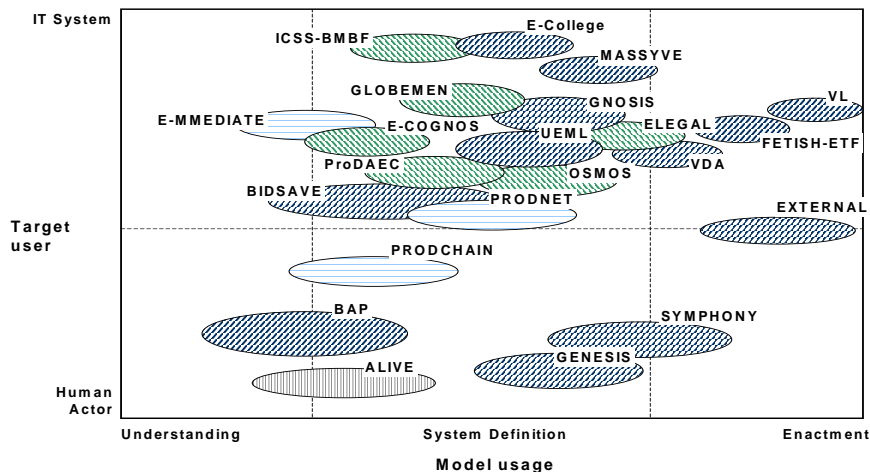


Figure 2: Purpose of Modeling of The Surveyed Projects

##### 4.1. VO Characteristics Related to Modeling

About 70% of the projects assume the existence of a stable source network from which short-term cooperation in a VO emerges, but only few actually model it. Yet, there are clearly observable pattern of three network topologies, as a chain or supply-chain configuration, a hub & spoke or star topology, for example in construction industry, and third, a peer to peer network, for example in engineering networks. By comparing supply chain topology with star consortia topology networks, we can realize that the former source network typically is more stable and has an inherent long-term orientation. Among peer-to-peer topology networks, there are some, but existing for only short periods, while others can exist long term, or be even permanent.

Most projects are focused on the operation phase of VO, sometimes also including the VO creation, but pay little attention to issues of the source network. Therefore, few projects make any proposition for the degree of change in the source network configuration over time. In terms VO composition during the operation phase, changes happened in 60% of the peer-to-peer and star/consortia types of reported VOs. Factors such as: size of the project,

nature of VO activities, complexity of the process or product were indicated to influence the changes. While supply chain type of VOs, don't allow any changes during any single project or order. For the accountability of dynamic configuration and adoption, the majority of the reported projects used the IT platform and/or specially defined management roles like network -coordinator or project- manager.

All projects presume, that firms can be members of several VO projects at the same time. Thus multi-project involvement could be considered as one of the typical characteristics of Virtual Organizations. About 75 % of the projects also suggest that firms could be members of more than one source network. It is however not clear, how this multi-membership is accounted for in the related IT systems and their usage, as systems from different networks might try to coordinate the same resources.

#### 4.2. Overall view of VO Modeling

<b>Modeling Aspects</b>	<b>Findings /Outcomes</b>
Models for Management Process in VO Source Network	The processes developed for managing the source network can be divided into three types: <ul style="list-style-type: none"> <li>- Participation management (Integrate new partner, remove partner)</li> <li>- Management of the IT platform</li> <li>- Contract/rules definition management</li> </ul>
Models for Management Process in Operational VO	More than 60% of the reported projects (30% didn't cover this issue) focus on VO creation or configuration activities. The project (or contract) management during VO operation and the VO dissolution get less attention, and only one project has reported the modeling for all three processes.
Models for Operational Process in VO	The spectrum of processes modeled for operational VO is approximately similar to the processes in a traditional enterprise.
Models for VO Support Process	Comparable to the operational processes, the support process models reflect a wide scope of activities, which includes human resource management, financial controlling, performance measurement, configuration and management of IT platforms etc.
VO Source Network Model	Most of the reported projects have not provided information on the source network model even when the source network was considered an important factor for the VO. One reason might be that most projects have only focused on the operational phases of the VO, even though it seems difficult to develop suitable VO support systems without good understanding of the underlying source network.
VO Operational Model	Not all projects have reflected on the operational model underlying the VO, i.e. the type and structure of the links between the entities in the network. This could be a sign of the limited management orientation and understanding in some projects. However, peer-to-peer topologies and star-topologies seem to be most prevalent for virtual organizations, while supply chain topologies might not require the special relationships between companies.

VO Governance Model	The General VO Governance model is following more or less the same trend as the VO operational model. Most of the star/consortia topology reported projects - 3 out of 5 - show co-existing of supply chain and star/consortia governance behaviors, while the remaining two projects exhibit purely star/consortia governance structure. A mixture of star/consortia and peer-to-peer topology co-exists within the peer-to-peer topology projects. No information on supply chain topology was given.
VO Management Role Modeling	Network coach / VE coordinator was indicated by majority of the reported supply chain topology projects, as the key management roles. While the Broker/Integrator was the dominating management role being reported by both peer-to-peer and star/consortia type of VO. This outcome, directly reflect the operation and governance models. Nevertheless, some projects also indicated that these management roles might changed according to the specific activities within the projects, i.e. product development, software application development, which might somehow missed interpreted the actual roles.

Additionally, research in Virtual Organization engineering seems to face a barrier in adopting proven modeling methods from traditional enterprise engineering. For process modeling in networks, for example, only 40% of the projects relied on formal methods like IDEF 0 and UML, while more than 60% were using Visio, PowerPoint and verbal descriptions in MS Word. Interesting enough is that a high number of projects that worked towards management models developed special modeling tools, e.g. VSD, Grade and Adonis. These kinds of tools allows presentation of process information in easy-to-understand way.

## 5. Conclusion

The survey results, show that the state of understanding and modeling Virtual Organization has not yet reached architectural integration. The status of Virtual Organization research can be characterized as having achieved workable solutions on the level of well-defined domains or modules, e.g. modules for planning and control in the IT domain, or management models of broker functions. All projects are well focuses on of the functions, where good progress is made. Real-life pilots, however, that show practically working solutions in all their dimensions are still lacking. This clearly reflects that, in the previous research framework (FP5), IT systems for supporting the VO were being addressed with greater emphasis. A necessary next step for VO take-up will certainly be to develop working solutions that include consistent business, organizational and human architectures for VO, thus need to be addressed further in the upcoming research framework. This research, however, does not yet provide consistent life cycle spanning support, which enterprise engineering has achieved for traditional hierarchies. In a nutshell, the following will be future focus of work in this area:

- There is a need to develop a strategy for model development and usage in future VO-projects: A future strategy should thus define objectives for the modeling, assessing the true potential of different modeling approaches and their limitations – or how limitations can be overcome.
- The modeling has so far concentrated on systems requirements and engineering, very limited on human understanding of VOs and organizational reference models:

Therefore more projects in these areas could be included to provide better understanding on these issues.

- Important aspects of virtual organizations cannot be modelled through enterprise engineering because these models tend to be directive and deterministic.

## 6. References

- [1] Bacquet, J. (2002). Plug and Do Business" and the European R&D Programmes, L. Camarinha-Matos, Kluwer Publisher.
- [2] Bernus, P. (2002). "IFIP IFAC Task Force on Architectures for Enterprise Integration."
- [3] Bernus, P. and R. Baltrusch (2002). Fast Tracking ICT Infrastructure Requirements and Design Based on Enterprise Reference Architecture and Matching Reference Models, L. Camarinha-Matos, Kluwer Publisher.
- [4] Chen, D. and B. Vallespir (2002). Developing an Unified Enterprise Modeling Language (UEML) - Requirements and Roadmap, L. Camarinha-Matos, Kluwer Publisher.
- [5] D. Reid, D. Bussiere, et al. (2001). "Alliance formation issues for knowledge-based enterprises." International Journal of Management Reviews 3(1): 79-100.
- [6] Jackson, P. J., J. V. D. Wielen, et al. (1998). Teleworking: International Perspectives: From Telecommuting to the Virtual Organization (The Management of Technology and Innovation), Routledge.
- [7] Jarillo, J. C. (1988). "On Strategic Network." Strategic Management Journal 9: 31-41.
- [8] Katzy, R. B. and G. Schuh (1998). The Virtual Enterprise. Handbook of Life Cycle Engineering: Concepts, Methods and Tools., A. Molina, J. M. Sanchez and A. Kusiak. Dordrecht, Kluwer Academic Publishers.
- [9] Katzy, R. B. and Obozinski. V. (1999). Designing the Virtual Enterprise. ICE 99 conference, Den Haag, Netherlands.
- [10] Kosanke, K. and F. Vernadat (1999). CIMOSA: enterprise engineering and integration.
- [11] Mowshowitz, A. (2002). Virtual Organization: Toward a Theory of Societal Transformation Stimulated by Information Technology, **Quorum Books**.
- [12] Rüegg-Stürm, J. (2001). What is a Firm? The St Gallen Model of the Firm (SMF) - Introduction to the Basic Categories of Modern Management, Institute of Management - University St. Gallen.
- [13] Ulrich, H. and W. Krieg (1974). St. Gallen Management Modell, Bern, Haupt.