An Assessment of the Organization Virtuality with Three Different Reference Models

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The main objective of the research was to test a holistic view on virtual organizations with different perceptions of virtuality. Traditional and virtual organizations could be seen as two extremes of more general model of organization. To asses a transition from the traditional to the virtual organizations we have to grade organizational virtuality. In the paper we discuss three basically different reference models used to asses this transition. Two models are well known – the Mowshowitz's switching principle, and the Model of Business Networking (MBN) as a representative of models preferred by the ICT experts. They see the virtual organizations through implementation of the ICT, particularly the Internet. To express other characteristics of virtual organizations we also presented the model based on the Colored Petri nets and fuzzy logic that we originally used to study an organized anarchy. All three models were implemented to assess the case of the Custom Administration in Slovenia. An assessment confirms that organization of the Custom services clearly demonstrates an efficient utilization of the Internet and other features of virtual organizations.

1 Introduction

Many authors argue that the theory of virtual organizations leads to a generalization of the traditional organization theory. It is not yet a prevailing organizational concept (Klüber et al, 1999) but, Internet, networked and virtual organizations have already proved to be an efficient organizational paradigm that brought to the business world a higher level of flexibility, efficiency, resource utilization and better customer services.

An intuitive perception of virtual organizations is often inadequate and misleading so we are still searching for new managerial principles and practical tools for every day management that could replace still prevailing traditional organizational principles born in the industrial age. The theory of virtual organizations is presently very chaotic. We still haven't developed practically useful indicators to make an objective assessment of virtual organization and to distinguish them from the other forms of organization.

We have learned from practical experience that it is not realistic to classify organization in only two classes - virtual and traditional (Jansen at al, 1999). These should be seen as two extremes of a more general model of organizations. If we need to describe and to assess a transition from the traditional to the virtual organizations we have to grade their virtuality.

In this paper we discuss the indicators that could assess virtuality of specific business organization. In the case presented we studied a real business environment to underline practical issues of virtual organizations and to raise a general issue of their virtuality and efficiency. We used three very different reference models of virtual organizations. Two models are well known – the switching principle and metamanagement (Mowshowitz, 1999) and the Model of Business Networking (Klüber at al, 1999) that represents a class of models used mainly by the IT and Internet specialists.

To learn more about the structure and the internal nature of virtual organizations we also presented a formal definition of the organization, based on the Colored Petri nets and fuzzy sets logic. The definition was implemented in a computer model of non-hierarchical organizations and the organized anarchy (Bavec, 2001). The model was not initially designed to describe virtual organizations. Nevertheless, it predicted some features of non-traditional organizations as fuzziness of organizational rules and boundaries.

2 Reference Models Used

The main objective of the research was to test a holistic view on virtual organizations with different perceptions of virtuality:

- the Switching Principle – is mainly a managerial view with emphasis on organizational flexibility and manageability,
- the Model of Business Networking – it defines inter-organizational relations and predominantly an ICT view on organization with emphasis on modularity and business transparency,

- Model based on the Colored Petri nets formalism shows an internal view on "fuzzy" organizational structures and information flows.

We were well aware that models are not compatible and not even comparable but, we had intentionally selected such different perceptions of virtual organizations. The goal was to get some deeper understanding of potential indicators that could be used in their assessment. To overcome this methodological obstacle we used the models to separately assess seven features of virtual organizations proposed by Mertens et al. (1998):

- boundary crossing
- complementary core competencies
- sharing of knowledge
- geographical dispersion
- changing participants
- participant equality
- electronic communication

2.1 Switching Principle and Metamanagement

The first reference model we used was based on the switching principle and metamanagement introduced by Mowshowitz (1999). In the simplest way we could describe it as an ability of organization to dynamically select the best performer or executor (need-fulfillment) for a particular task (need). That means that an organization treats tasks separately from their potential performers. Switching would take place when replacing one performer would bring benefits that are greater than direct and indirect costs of replacement. Another concept introduced by Mowshowitz is metamanagement. It is basically management of virtually organized tasks and managerial implementation of the switching principle.

This principle may seem trivial at the first glance but it opens an entirely new view on the organization. We should notice that in the traditional organization theory and practice it was always a sign of serious miss-planning or "bad organization" when we had to change (switch) a performer in the production phase of the task when organization was already implemented.

Possibility of switching undoubtedly adds to organization and managerial flexibility, but the question that still remains is just how realistic it could be in every day business. Basic idea of virtuality is that switching could be done relatively fast. It would be difficult for the management to implement all traditional risk analysis, so the trust becomes an important decision and even an economic factor. We have to trust the new partner (Ishaya, Macaulay, 1999) and be reasonably confident that he will integrate into our operations and perform his role according to our expectations. If the mistrust is too high it could overwhelm other benefits.

From the Mowshowitz's model we could assume that the level of virtuality is correlated with the ability to implement the switching principle or metamangement. We could use it to assess changing participants and participant equality from the Mertens' list of virtual organization features.

2.2 ICT Oriented Models of Virtual Organization

Another, very different perception of virtual organization is seen in the Model of Business Networking (Klüber et al, 1999). It is a typical representative of models preferred by the ICT experts as they see virtual organizations through implementation of ICT, particularly the Internet. But, the model is more general and incorporates important features of virtual organizations that are highly relevant for the management.

The Model of Business Networking (MBN) has the following elements that were parts of our assessment of a real business environment:

- Customer processes (determine the design of a value chain),
- Integrators and Aggregators (third parties included into business relationships),
- Business Bus (logical space where complex services among business partners are flexibly and efficiently exchanged with the support of service providers),
- Business Ports (standardized interface to access the Business Bus).

Similar approaches are widely used, often under different names in design and implementation of information systems based on open networking like the Internet.

According to the MBN, integrators and aggregators are an essential element of networked and virtual organizations. They provide different business services: knowledge, coordination, process, information, and transaction services. They behave in the way to "soften" or even eliminate organizational boundaries between business partners. The Business Busses and the Business Ports describe inter-organizational relations and interfaces that define mainly an information structure of virtual organizations. But, more generally they describe complementary core competencies, sharing of knowledge, geographical dispersion and electronic communication.

3 Modeling Organizations with Colored Petri Nets

3.1 Rationale Behind the Model

In the year 1994 we developed a model of organization based on the extended Colored Petri nets and fuzzy logic to study organized anarchy and influence of information systems on the organization. Their superior semantic power makes possible a very rich representation of the organization and overcomes some limitations of classical representations. A general definition of the organization was based on abstract fuzzy sets with axiomatically assigned properties. The organization was defined as a

set of rules that determined the chain of authority, description of working (organizational) places, and other organizational relations. It also determined conditions under which organizational processes could change their states. The quality of organization can be measured only through its impact on processes so it must be modeled together with them. The Petri nets proved to be an efficient way to combine organizational structure and the processes in the organization.

This methodology was used for modeling properties that reflect ambiguity or deviation from the traditional hierarchical organization. The study also exposes a paradigm that could be called an *informed anarchy paradigm* in analogy with the organized anarchy. The informed anarchy paradigm is based on empirically founded facts that unclear technology of allocation, dissemination, and also faulty understanding of information are prevailing properties of organizations.

An object-oriented model was developed that interlinks a formal organization with decision and information processes into an integral model. It was based on three classes of objects: organization, decision processes and information processes. An important feature of the model was its ability to model conditions on micro level, that means both on the level of working (organizational) place and individual process.

Further development confirmed that the same model represent also some relevant features of virtual organizations.

3.2 Model of Organization Based on Colored Petri Nets

Petri nets are well proven tools for systems modeling that can describe dynamic and static properties of the system. Similar situations, only much more complex, can be met in business organizations, so we experimented with the possibility to model them with Colored Petri nets (CPN). We published some results of the computer simulation (Bavec, 2001) - relation between the level of organization anarchy, load of problems, formal and informal information systems, and efficiency of decision-making.

We defined an organization *ORG* as a 12-tuple or an extended Colored Petri net (Bavec, 1995):

$\boldsymbol{ORG} = (B,P,T,D,C,R,I,O,\delta,\eta,\rho,\sigma)$

$B = (b_1, b_2, \ldots b_j)$	a finite set of colors
$P = (p_1,p_2, \ldots p_n)$	a finite set of places
$T = (t_1,t_2, \ldots t_m)$	a finite set of transitions
$D = (d_1, d_2, \ldots d_n)$	a finite set of organizational places (working places, divisions, etc.)
$C = (c_1, c_2, \ldots c_k)$	a finite set of concepts or objects
$R = (r_1, r_2, \ldots r_m)$	a finite set of organizational relations $R = \{R \mid R \subseteq D \times D\}$

$B \cap P \cap T \cap D \cap C \cap R = 0$

$I: T \rightarrow P^{\infty}$	an input function that maps a set of transitions t_i into places p_i
$O: T \rightarrow P^{\infty}$	an output function that maps a set of transitions t_i into places $\vec{p}_i$
$\delta: D \rightarrow P$	a function that maps organizational places $d_i \in D$ into places $p_i \in P$
$\eta: C \rightarrow P$	a function that maps concepts or objects $c_i \in C$ into places $p_i \in P$
$\rho: R \rightarrow T$	a function that maps organizational relations $r_i \in R$ into transitions $t_i \in T$
$\sigma: Z \rightarrow P$	a function that maps multi-set of tokens $z(p_i) \in Z$ into places $p_i \in P$
$\lambda \in [0,1]$	a threshold, an additional condition for firing transitions.

We are aware that business and human organizations, particularly as complex ones as the virtual organizations, can't be highly formalized (structured). Consequently, there is a question how far can we go with formal definitions. But, the model confirms that we could model some features of virtual organizations with the CPN and its derivations (Deng et al. 1990).

In the model we implemented fuzzy logic, mainly through the threshold $\lambda \in [0,1]$ which additionally controls firing of tokens. We also proved that the introduction of concepts or objects (also Bastide, 1996) $c_i \in C$ assigned to organizational places $d_i \in D$ (they could be everything from working places to organizational units) provided us with the tool to model complex relations between organization as the set of rules, and processes that are running in accordance with the organizational rules.

With the controlled firing of tokens in the CPN and fuzzy logic we could describe and study features of virtual organizations like the switching principle, the ambiguity of organizational relations and particularly the boundary crossing.

4 The Case Study - Assessment of the Government Agency

4.1 Beyond the Business Partnership

Emerging experience and the theory of virtual organization is based on the present business practice with very few examples from the government administration. But, there is widely spread belief among researchers that governments and public administrations are one of the most promising grounds for an introduction of virtual organizations. The development of Internet and innovative customer and citizen oriented services in governments in developed countries more than justify this assumption. It is encouraging to notice a similar development also in the middle developed countries, such as Slovenia.

In the case presented we studied the collaboration of the Custom Administration in Slovenia (CA) with different private companies. The case reveals development steps from the traditional government agencies towards highly efficient and technologically advanced organizations that clearly articulate elements of the new organizational paradigm – the virtual organizations. The CA has developed a sophisticated and efficient Custom information system in which 98% of all custom declarations are lodged electronically up to the highest security standards.

The development of the CA information system and computer applications were outsourced to the private company ZZI from Ljubljana. The application was linked to the operation environment of users. Jointly with its partners, ZZI developed an interface to enable its software to be integrated into larger operation information systems based on the BAAN, SAP, NAVISION, etc. It is important to notice that the CA has been equally opened to other potential partners that could develop software and services to enable different users to link their systems to the Custom information system, enabling them to submit the customs declarations and other documents by the Internet.

Beside the software development ZZI and nearly 30 other providers also offer transmission services for the electronic data interchange within different environments and among different partners. The server solutions and programs used by clients facilitate the automatic data interchange within the different environments and applications. Such service for example is the transmission of the messages from the Internet environment of partners to the X.400 environment of the Custom Administration.

4.2 Implementation of the Switching Principle and Metamanagement

At the beginning of the research we were concerned with the notorious rigidity of the government organization. It seemed quite unrealistic to notice any sign of the switching principle in the government agencies. But, what we really found was a clear presence of elements of metamanagement and implementation of the switching principle.

Services such as the transmission of the messages from the Internet environment of partners to the X.400 environment of the Custom Administration and other forms of electronic data interchange services performed by private companies are without any doubt "switchable". The official policy of the CA is in favor of tighter inclusion of trustworthy participants into the Custom Information System. This just confirms this development. Transferring elements of the CA authority to partners express another important feature of virtual organizations – the trust. From the government point of view it is a major breakthrough to realize that it is more convenient and even cheaper to trust partners and to control them more "softly" in indirect and off-line mode.

Looking into the project and official documents of the CA reveals that the switching principles as well as the role of trust are introduced entirely intuitively, without any reference to virtual organizations. It shows that evolution of virtual organization could be entirely spontaneous and a natural development in the competitive and technologically advanced environments.

4.3 Implementation of the MBN

According to the Model of Business Networking (MBN) integrators and aggregators are essential elements of networked and virtual organizations. They are the third parties included into business relationship. In the case of the Custom information system they are not government agencies, nor the users of the system. Electronic data interchange services performed by the ZZI and other companies are "infomediary" (Österle, 1999). The companies around the CA are playing the role of integrators and aggregators with standardized procedures and with standardized interfaces and can be interchanged and replaced. It gives the CA a very high flexibility, accompanying with noticeable cost reduction and better customer services.

Again, the CA implemented the most visible feature of virtual organization – a very high flexibility.

The overall architecture of the CA information system is modular with surprisingly similar topology as the MBN. Terminology used is different, but its structure could be described with the MBN features. Modular system design and application of the Business Bus (the way to exchange of business services) and the Business Ports (standard business and technological interfaces) offers a tool for optimal organizational design in the CA and their partners.

The Business Bus in this case is a virtual world of custom declaration processing that is separated from the physical world of goods, importers and custom houses. Locations of custom warehouses are the matter of convenience and agreement between the CA and an importer. It indicates the presence of vital elements of virtual organization.

4.4 "Fuzzy" Organizational Bonds

With the description of the virtual organization with the CPN we could identify and formalize some internal features like the strength of managerial and organizational bonds. We could study the mechanisms that make some positions in organization logically members of two or even more different organizations. Many positions or tasks in the ZZI are so strongly linked to the CA, and also opposite, that employees often don't know who their boss really is and to whom to report to in some cases.

It means that some organizational relations are not just fuzzy but they could also extend out of the organization. That is a relatively simple explanation for ambiguous boundary limits and boundary crossing.

The most interesting feature that the CPN modeling offers is its ability to model fuzzy information and decision processes that are the characteristics of the organized anarchy and also of virtual organizations. We were quite intrigued by the fact that we can implement so many ideas of organized anarchy directly on the virtual organizations.

4.5 Results

The reference models used confirm that the organization of the Custom Administration clearly demonstrates features of contemporary organizations with an efficient utilization of the Internet and even more hidden elements of virtual organization. In the absence of proven methodologies and indicators for assessment of virtual organizations we assessed the features of virtual organizations proposed by Mertens et al. (1998).

We transformed the whole problem into seven separated and independed assessments. Each feature was ranked on the scale from 1 to 100 and plotted on the radar chart (Figure 1). The picture reveals an uneven development of virtual organizations futures – some of them are very pronounced, others are still very close to the traditional organizations.

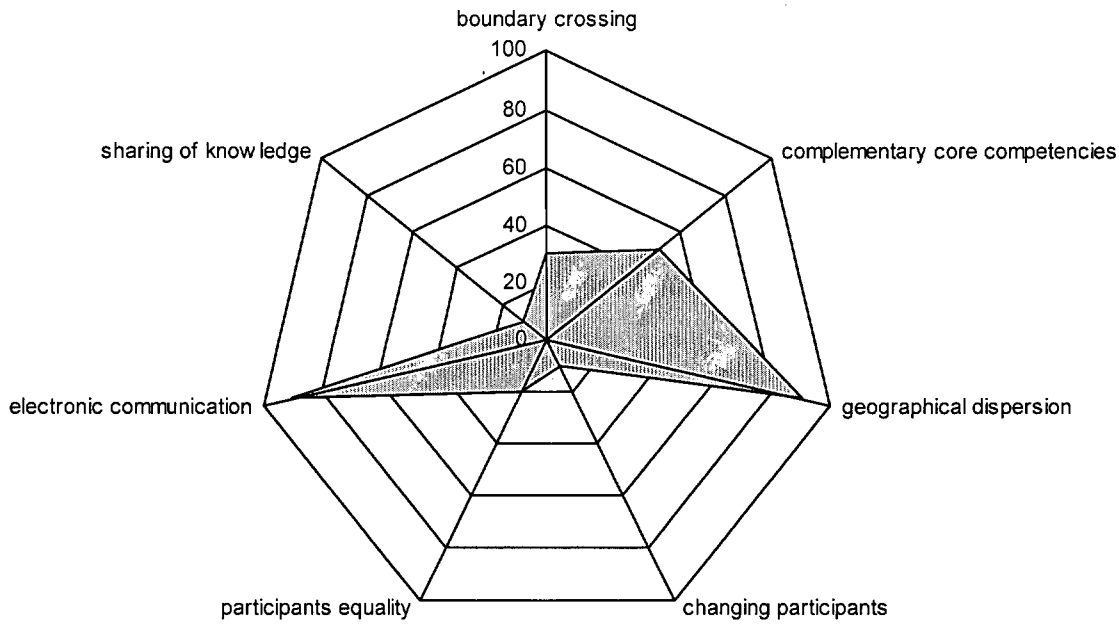

Figure 1: An assessment of the basic features of the virtual organizations – the case of the Custom Administration in Slovenia

An electronic communication and the geographical dispersion are very developed but, in every day business they are the easiest goals to achieve. They represent more technical than managerial challenge. Obviously, it is much more difficult to achieve managerial goals like sharing of knowledge, participation equality and particularly changing participants. They are prerequisites for introduction of the switching principle and metamanagement. Results also confirm what we could intuitively expect - boundary crossing and complementary core competencies are somewhere in the middle on the scale of managerial problems. They could be achieved in the next step, after introducing electronic communication and geographical dispersion on a broad scale.

Conclusion

The research has revealed that the CA had progressively developed towards virtual organization entirely intuitively. At the beginning, their main goal was to outsource development of their information system and to utilize the ICT, as much as possible. It confirms a well known fact noticed in the business community that we presently face an evolution rather than revolution towards virtual organizations. This evolution is spontaneous in technologically advanced environments. But, even if we accept the fact that the emergence of virtual organizations could be spontaneous the management still needs deeper insight into challenges of the new organizational paradigm. It will soon turn out to be one of the most important expertise of contemporary managers.

The case of the Custom Administration also presents a fine example of virtuality - the virtual world of custom declaration processing is separated from the physical world of goods, importers and custom houses. It provides such a high flexibility that Slovenian accession to the European Union won't require any changes in organization of the CA – their virtual world will be

simply extended from Slovenian borders to the whole EU.

An assessment of the degree of virtuality proved to be a real challenge. We are still short of any useful methodology or a set of relevant indicators. Nevertheless, a simple case we investigated showed that we could combine different models in search for more holistic view on virtual organizations.

We were able to detect weaknesses and obstacles in managerial strategies and also to grade their goals from the easiest to the more complex. Technical issues like extensive introduction of the Internet are relatively easy to achieve and to manage. One of the most pronounced features of virtual organizations like boundary crossings is also quite common, even in the early phase of the development of virtual organization.

The ability to change participants has received the lowest grade in our research. It seems that the real managerial challenge is hidden in the switching principle and metamanagement. It could lead us to the conclusion that fully developed virtual organizations are still difficult to achieve. For that reason management needs much deeper understanding of challenges and obstacles in the transition from traditional to virtual organizations. Researchers could contribute with models and tools that would enable managers to set relevant goals and to asses their efforts.

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