WORKFLOW MANAGEMENT ISSUES IN VIRTUAL ENTERPRISE NETWORKS

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Abstract: Increasing competitive pressure and availability of Internet and related technologies have stimulated the collaboration of independent businesses. Such collaborations, aimed at achieving common business goals, are referred to as virtual enterprise networks (VENs). Though web is an excellent platform to collaborate, the requirements of VENs regarding workflow management systems are in excess those of autonomous organizations. This paper provides a comprehensive overview of numerous issues related to workflow managements in VENs. These issues are discussed in the three phases of virtual enterprise lifecycle: configuration, operation and dissolution; and corroborated by two real case studies of VENs in Australia.

1 INTRODUCTION

The notion of the division of labour to benefit from productivity improvements is well-known since Adam Smith published his five books about "The Wealth of Nations" in 1776. About forty years later, in 1817, David Ricardo sustained Smith's rationale by presenting his idea of comparative cost advantages in his publication "Principles of Political Economy and Taxation". Although the division of labour is restricted by the extent of the market and increasing costs of coordination, it is still common practice for companies to focus on their core competencies and outsource other activities to become lean enterprises that are able to reach world class in their areas.

The invention of the Internet and its related technologies lowered the barriers for inter-organizational collaboration. The result was the emergence of formerly unknown virtual enterprise networks (VENs), understood as consortiums of enterprises that strategically join their skills and resources – supported by computer networks – to improve their agility and broaden their possibilities to better react to market developments (Camarinha-Matos, Afsarmanesh & Rabelo, 2003). Therefore VENs are highly dynamic organizations that existence follows the virtual enterprise lifecycle (Figure 1), consisting of the configuration, operation and dissolution phases. Some authors suggest a further subdivision of the configuration phase into the two phases "partner selection" and "agreements" (Borchardt, 2006). The "operation" phase is particularly subdivided into the interactive phases of "operation" and "evolution" (Camarinha-Matos, Afsarmanesh & Rabelo, 2003).

Organisations within a VEN need to face multiple challenges in addition to those that autonomous organizations do need to deal with.

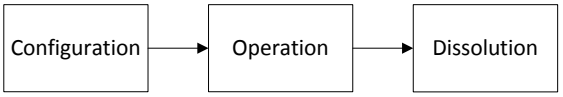

Figure 1: Typical phases in the virtual enterprise lifecycle.

Each VEN member has its own aims, core competencies and resources which might be very different to those of other members. In addition, huge spatial distances between the members' sites and the VEN's being a temporary arrangement, might further increase the complexity. According to Ricci, Omicini and Denti (2002), a VEN's complexity can be reduced by improving coordination. Borchardt (2006) suggests four different types of coordination instruments to reduce complexity: individual-orientated coordination instruments (selecting an overall coordination agent), structural coordination instruments (clearly defining the VEN's organizational structure), technocratic coordination instruments (setting up

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clear production plans, agreeing on internal transfer prices, rules, contracts, etc.) and IT coordination instruments. Although latter include such technologies as telephones, fax, e-mail and video-/online-conferences, the most important IT coordination instruments are groupware and workflow management systems.

In the context of VENs, workflow management systems are a technology that enables virtual enterprises to manage, coordinate and control their business activities (Meng, 2002). Workflow management of VEN is much more complicated than in autonomous organizations because it is confronted with all the complexities that VENs need to face; bringing together all the heterogeneous software services to achieve the conglomerate's original business goal is only one of them.

So far, there are a number of scientific contributions about how workflow management systems for a VEN should be. Examples for research projects in this area are the CrossFlow-project (Grefen, 1999), the CA-PLAN-project (Yan, 2004) and the DynaFlow-project (Meng, 2006). All teams behind these projects identified and tackled the special challenges a VEN has to face when defining and implementing a workflow management solution, but neither have they nor anyone else at any time really concentrated solely on the issues that occur in VENs and concern the implementation and usage of workflow management technology. Although they mention a selection of issues, they immediately focus on possible solutions to these issues which they present in the form of the various projects they are working on.

It is therefore worthwhile to entirely focus on workflow management issues that arise in VENs. This paper will discuss the different issues related to workflow management in VENs based on the virtual enterprise lifecycle (Figure 1). These issues will be subdivided into business, people and technological issues for discussion purposes. Furthermore a brief exploration is carried out on how current workflow management systems and prototypes of research projects try to overcome these issues.

The organization of this paper is as follows. In section 2 the research methodology used is explained, followed by an introduction to the two case studies used in this research in section 3. In section 4 the different workflow management issues in VENs are discussed, under each phase of the virtual enterprise lifecycle. How current workflow management systems and prototypes of related research projects try to handle these issues is described in section 5. Section 6 positions the findings of this paper among the similar work carried out by other researchers. Section 7 concludes the paper with a brief view at the possible areas for further research.

2 RESEARCH METHODOLOGY

The findings of this work result from two case studies and a comprehensive literature review. Two case studies selected for this paper are based on one of the author's involvement in them. In one case, the author was involved in the capacity of an employee of the VEN and as a technology provider in the other. Non formal interviews were used as the main technique of collecting case study related information.

In addition, to these case studies a thorough literature review was carried out. This literature review enabled establishing our own findings from the case studies.

During the course of the research, identified issues of VEN (either from the case study or through literature review) were allocated to the different phases of the virtual enterprise lifecycle, based on their occurrences. This representation gives a well-structured overview of all the issues in their respective phases of the virtual enterprise lifecycle.

3 CASE STUDIES

In Australia, the Western Sydney Region is considered to be the homeland for micro businesses and small to medium enterprises (SMEs). Over 72,000 micro businesses and SMEs in the region contribute to 10% of the Australian economy (Ginige, Murugesan & Kazanis, 2001). Due to this high number of relatively smaller companies, there are definite advantages in terms of employment and economic development. However, being smaller organisations they face other limitations too. One such limitation is their inability to compete in the global market for reasonably larger contracts. Therefore, many SMEs in this region attempt to join forces by forming VENs.

To disclose the various issues that can occur in VENs, two such VENs from Western Sydney region are selected. The first case study is about a group of tool making companies, who attempted to benefit by forming a VEN for the purpose of quoting for bigger jobs. The second is in relation to a virtual consulting company that brought together medical practitioners

and information and communication technology experts to join their expertise in providing software solutions for the healthcare sector.

An overview of the case studies is presented below. These case studies will be utilised in the latter discussions of this paper.

3.1 Tool Makers

Tool Makers are companies that develop instruments (or tools), for other mass scale manufacturing organisations such as plastic moulding companies, or individuals like inventors. Such four tool making companies in the Western Sydney region decided to join forces in 2004.

Tool makers were thriving micro businesses in the 90's, prior to Australian jobs started being shipped to offshore places like China. The workshops of these companies are equipped with machineries of varying capacities. In the new millennium, due to lack of work that suited the capacity of these workshops, they idle. On the other hand, they were not able to bid for bigger global jobs such as parts of aircraft manufacturing, individually, due to lack of capacity in individual workshops. Hence four companies decided to form one VEN to be able to quote for bigger contracts, by showcasing their joint workshop capabilities. One particular tender that they aimed bid for was for manufacturing a certain part of Boeing aircrafts.

The joining of forces was expected to be achieved as a VEN, using a web-based collaborative quoting system. The idea was to have a web-based workflow management system that would allow these companies to enter jobs details, jointly design the jobs, share design details, divide the activities among the four companies based on the capacity, and jointly offer quotes to the customer.

A software development team in the AeIMS (Advanced enterprise Information Management System) research group of University of Western Sydney was given the task of developing suitable software for the purpose of collaborative quoting. AeIMS started the initial developments in late 2004 in consultation with the companies.

Even though these four companies were very enthused about the idea of becoming a VEN, even by late 2005 they were not possible to lift-off as one entity. Then eventually by 2006 they decided to let go the efforts of becoming a single VEN.

This case study provides the classic situation of VEN not being able to become a reality, due to the issues that they face in the configuration stage of the lifecycle. Particular, issues that affected these four companies will be further discussed in the latter parts of this paper.

3.2 Collaborative Consultation

In contrast to the first case study, the second was a success, as it managed to cover the full lifecycle of the VEN from configuration, through operation to dissolution. This collaboration was between medical practitioners and experts in information and communication technology. A few micro consulting companies based in Western Sydney region of Australia decided to join as a VEN in 2005 to provide consulting services to the healthcare sector. This virtual consulting enterprise had a different approach and format to the prior.

At the configuration stage, these individual companies had identified their strengths and weaknesses in terms of their skill sets, expertise, associations in professional networks, available technologies and other operational needs such as specific insurance policies they held and location. While they operated as individual companies, they came together as one VEN when they found possible consulting work.

Based on the project they would select a champion among themselves to lead the way and other members who would participate in that particular tender. In making these decisions, they would consider the tender specifications and strengths and weaknesses of individual consulting companies. The selected champion company would coordinate the activities and would see through to the end of the project. After the completion of the project, the VEN would temporarily dissolute until a new project comes along.

This project based formation of VEN, has worked extremely well for these consulting companies. Even to date they continue to form into a VEN quickly for consulting projects and dissolute it at the end of the project.

The success of being able to operate as a VEN does not guarantee that they operate without any problems. The issues that this VEN faces will be discussed later in this paper.

4 WORKFLOW MANAGEMENT ISSUES IN VIRTUAL ENTERPRISE NETWORKS

VENs have to face multiple kinds of challenges du-

ring their existence. While some of them are general, for example the selection of partners, establishing trust, agreeing on sharing of revenues/losses, the duration of the network and how to dissolve the network; other challenges are unambiguously related to the VEN's information technology infrastructure.

Camarinha-Matos, Tschammer and Afsarmanesh (2004) and Camarinha-Matos (2005) point out that the very short lifecycles of modern technologies and the lack of technology-independent reference architectures are the main obstacles to quickly and easily set up a VEN from an information technology point of view. They explain how service orientated architectures can help to reduce the problems that arise from heterogeneous software systems. Thus inter-organizational workflow management systems need to be implemented upon (and to some extent independently from) the underlying information technology infrastructures to automate, manage, coordinate and control the business activities of the network (Meng, 2002).

Figure 2 depicts the occurrence of the various workflow management related issues during the virtual enterprise lifecycle. These issues are further categorised as people, business and technological issues. The subsequent sections of this paper describe these issues in detail.

4.1 Issues in the Configuration Phase

The configuration phase of the virtual enterprise lifecycle is where most issues occur. This is mainly caused by the requirement to agree and set up the network's information technology infrastructure.

As soon as the initial partner selection is done, a VEN coordinator needs to be chosen. This can be either a member of the VEN or an independent instance that is entirely newly established. The coordinator is responsible for ensuring successful coordination of the VEN's business activities.

In our first case study, one of the reasons for their failure was their inability to select a suitable coordinator. There were certain amounts of trust issues involved leading into certain business matters such as in the division of jobs and handling of funds. Some members owned workshop capabilities that were superior to others; hence they expected to be the coordinator of jobs. However, the others argued that whoever brings the project work should be able to be the coordinator of the activities. Due to these differences in opinion the VEN did not manage to select a suitable coordinator.

In the second case study, the selection of the coordinator was project based. Also they had devised successful assessing criteria in selecting a coordinator based on strengths and weaknesses of members and project specifications. Members had the understanding that they may or may not be involved in certain projects, because the rules were laid very clearly at the beginning.

Once the coordinator is identified, the business processes of the VEN need to be defined. For the definition of the processes, it is important to understand the role of each member of the VEN and what they bring into the collaboration.

In our first case study, defining the business processes was chaotic as the tool makers did not have a clear understanding of the contributions of the different members. In contrast, the definition of business processes in the second case study was relatively easy as they accurately had identified the strengths and weaknesses of each member and also their contributions to each project.

The members of the VEN must agree on the information technology they want to use and how interoperability of heterogeneous software systems can be guaranteed. Furthermore, a workflow management system must be chosen, that is able to integrate multiple distributed heterogeneous software systems. The translation of the VEN's strategy – meaning its long-term goals – into business processes and the evaluation of their automation is an indispensable prerequisite for this step of the VEN's configuration.

Since all members of the VEN are usually autonomous companies who existed before the collaboration was founded and who aim to exist after the VEN dissolves, they have their own interests and might compete with each other in other business areas. It is therefore – in contrast to an autonomous enterprise – necessary, that both the workflow management system and the single enterprise's software systems limit the access to software services and data to those partners who really require access to them. Of course, the openness of the VEN's members is a trade-off between offering useful information that helps to increase the network's overall success and disclosing a corporate's secrets, widening the member's window of vulnerability (Frenkel, 2000).

In our first case study, the decision of selecting an appropriate workflow management system was outsourced to an external entity that all parties trusted. Hence the decision to develop a web-based collaborative quoting system was fully supported by all the tool maker companies. However, issues arose when deciding about data access rights and archiving. While everyone understood the importance of sharing information, they had issues

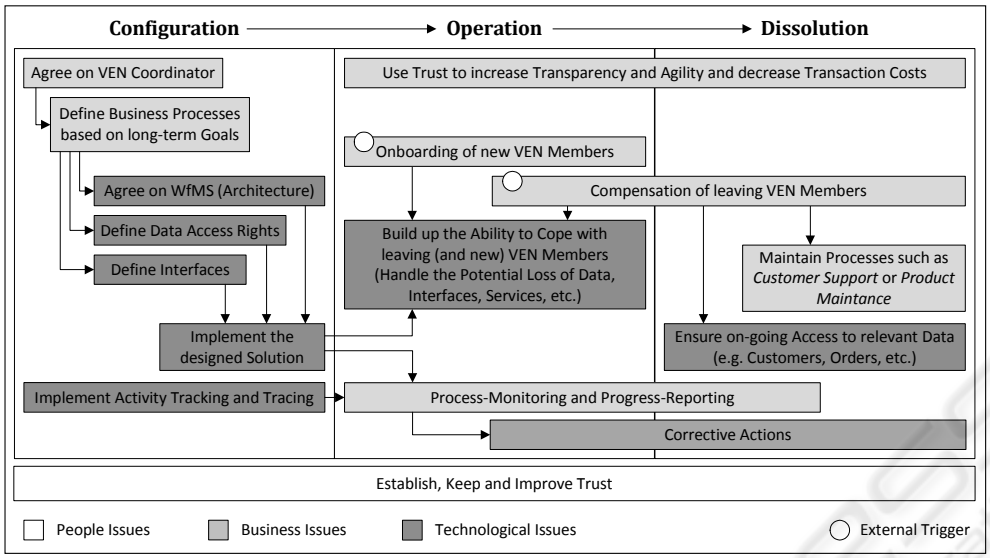

Figure 2: Occurrences of Issues of Virtual Enterprises in Various Phases of the Lifecycle.

in sharing certain design details via engineering drawings. Sometimes, their clients did not want information to be disclosed to other parties. Again it came down to the trust issues that prohibited these tool maker companies from resolving the data access issues.

The consulting company of our second case study had different needs in terms of information technology. The nature of their work did not require special information technologies, except for some project management tools, which were available to everyone. Hence the coordinator of a particular project would keep track of project participation, timelines, and other project related documents. At the end of the project the coordinating company would archive the information and provide a copy of this archived information to the other parties that were involved in the project. Also since these experts came from different domains, their individual client bases were more or less mutually exclusive and they had no issues about the intellectual property. Also over a period of time they have developed a certain amount of trust among themselves that now helps in current operations.

Another issue workflow management systems need to deal with is the proper tracking and tracing of the activities every single member contributes to the final product or service. While this is required by law in some countries it is also useful for identifying errors and continuous quality improvements.

In both of our case studies the members identified the need for keeping accurate records of tracking and monitoring activities. The tool makers' web-based quoting system had the capabilities for each member to report their progress via the system and also to re-distribute work if one member was unable to meet targets due to any reason.

The companies involved in the second case study took rather a lose approach in keeping track of progress. Each member would email the coordinator their progress and the coordinator would keep a record of the progress of the project locally. The other members trusted the project management capabilities of the coordinating member to resolve any timeline or resource problems.

Camarinha-Matos et al. (2003) point out, that the configuration efforts are always the largest for an organization when it participates for the first time in a VEN. This claim is further confirmed by our first case study. Based on the experience of the two case studies, it is conclusive that people issues - mainly trust - are the main factor that needs to be resolved at the configuration stage. It is also evident from our case studies that it is much easier for organisations to resolve trust issues, when they come from different domains where they do not claim to have a common client base.

4.2 Issues in the Operation Phase

The workflow management issues that occur in the operation phase of a VEN concern improvements in flexibility and collaboration. Our second case study will be extensively used to demonstrate the issues involved at this stage.

Flexibility is one of the key factors needed at the operational stage of the VEN. In particular external triggers may lead to the introduction of new

members to the network or the departure of existing members. External triggers such as needing new skills that did not exist within the network would result in getting new members. Also due to various business and people reasons, members may decide to totally leave or withdraw their contributions to the VEN. Without being highly flexible in its business processes and the technologies for their execution; the VEN is unable to compensate the exit of one of its members in a reasonable amount of time. The requirements of VENs regarding workflow management systems therefore excess those of autonomous organizations.

The immediate effects of member changes are the business impact that it has on the running projects. In particular when members leave, the remaining workload needs to be shared among the existing members and projects plans need to be redrawn. Sometimes, new members need to be added to the network.

Followed by the business issues, technological implications are faced by the VEN. For example the systems must allow easily changing the setup of the organizational structure of the network; including the workflows and the visibility of and access to data related to it. In addition, the possibility of losing data and single activities within workflows must be considered: It must be prevented that the exit of a member results in the breakdown of operations; meaning that started workflows – for example accepted orders – can no longer be processed due to essential information that left with the exiting member.

In our second case study, agility was one of the key foundations that the VEN was built upon. From the accounts and financial point of view the coordinating company sub-contracted the work of the other members. Hence the operational point of leaving or addition of members was handled in a smooth manner. However, the issues were there when data get lost when members leave, as they do not have had a centralised mechanism to collect information. It was up to the project coordinating organisation to make sure the leaving member provided all the information they possessed to the other members. This totally worked on the trust established and a certain amount of risk was taken by all members in relation to this.

Furthermore workflow management systems do need to support the continuous optimization of the VEN's workflows. In this context, the coordinating instance of the VEN needs to monitor the performance of workflow execution and report relevant findings to single members.

The consulting enterprise of our second case study improved its processes based on the experience that they gained from their past projects. For example, they switched from hiring individuals for which they did not have staff for to registered companies only to solve issues in paying salaries, taxes and superannuation.

Our investigation shows that flexibility and operational work structure, supported by sound information systems, are the key ingredients needed in managing issues in the operational stage. Also the ability for VEN to learn from past experiences and improve their business processes is equally important.

4.3 Issues in the Dissolution Phase

The dissolution of a VEN does not automatically brush aside any workflow management issues. Instead the opposite is the case. Some business processes – such as customer support or product maintenance – must be kept alive although the organization itself dissolved. Even if it does not make sense to provide such services (processes) for the whole lifecycle of the product or service generated by the virtual enterprise, contracts or law might require this for at least a given period of time. Workflow management systems for VEN must therefore be able to deal with this issue – which is again one that emphasizes the requirement of high flexibility – as well. The workflow management system must be flexible enough to overcome the possible loss of data that is only being provided by a single member. Furthermore it must allow regulating access to all the different information according to the regulations the VEN's members had agreed on when they created their network.

The VEN related to our second case study handles dissolution issues by providing the collective knowledge to all the members who were involved in a particular project. Thus no one company had the responsibility of managing such information.

As highlighted by the VEN members of the second case study, the most important aspect of smooth dissolution is firstly identifying the dissolution point at the initial configuration of the VEN. In their case, once every consultation project is completed and final payments are done the VEN dissolves. If there is no such clear identification of the dissolution point it can lead into issues. This dissolution points need to be quantifiable and practical. When reflecting back, it is clear that our

tool makers of the first case study had issues in deciding this dissolution points.

At the early stages of the lifecycle our second case study's VEN prepares a set of guidelines that involve the activities at the dissolution stage. These guidelines provide details of responsibilities of each member of the activities at dissolution, such as providing continues support, finalising financial matters, archiving and distributing information, etc.

Our study revealed that smooth dissolution mainly depends on proper planning at the early stages and support of the information systems that continue to provide necessary information beyond the dissolution for the required parties.

5 ISSUE HANDLING BY CURRENT WORKFLOW MANAGEMENT SOLUTIONS

The increasing number of workflow management systems makes it nearly impossible to keep an overview of their functionalities. Therefore it is not the aim of this paper to provide a comprehensive overview of how different workflow management systems deal with the issues of VENs. Instead it will only be shown how some systems, especially those that result from research projects related to workflow management in VENs, have improved their architectures and functionalities in order to fulfil the special requirements that emerged from the organizational form of VENs.

Some of these scientific workflow management systems or approaches to workflow management in virtual enterprises are PRODNET I and II, SSPS, CrossFlow, DynaFlow and CA-PLAN. A real-life example of a workflow management system that is specialized in inter-organizational collaboration – with a focus on order processing and project execution – is myOpenFactory.

The approaches of all those systems to improve inter-organizational collaboration are quite different. Systems like CrossFlow and CA-PLAN create interoperability between the member's individual workflow systems by treating them as services and integrating them through the usage of newly proposed workflow models. Thus inter-organizational service orientated architectures can be set up, with a coordinating instance at its top (Yan, 2004; Grefen, 1999). Ricci et al. (2002) describe that in an optimal case the role of the coordinating instance can be filled out by a software solution. Other systems, such as DynaFlow, expand the scope of the workflow process description language (WPDL) to respond to virtual enterprise's requirements without trying to introduce entirely new standards but instead building up on existing ones (Meng, 2006). This is reasonable because it does not constrain the development of standardized base information architecture for the collaboration of networked organizations. Camarinha-Matos, Tschammer and Afsarmanesh (2004) point out, that the currently on-going standardization efforts in the area of Internet-related technologies would pave the way for the development of such a base infrastructure. In this context, the work of the workflow management coalition (WfMC) is mentionable. Amongst other working groups they have one working group that is especially focusing on improving the interoperability of workflows. Further improvements of the WfMC's standards are desirable not only because of making inter-organizational collaboration theoretically easier but also because of the popularity of their standards in general, thus ensuring a quick spread and avoiding the emergence of other standards and technologies at the same time.

6 SIMILAR WORK

As there are already a lot of publications about VENs and workflow management, this paper can be placed into a broad context of related work. But, as mentioned previously, there are no scientific contributions that entirely focus on the issues related to workflow management in VENs.

To begin with, there are publications that investigate the phenomenon of VENs in general and present their general issues, most often including possible solutions. First of all it is worth mentioning Camarinha-Matos et al. (2003), who describe general challenges which occur during the different phases of the virtual enterprise lifecycle and which constrain the network from achieving its optimal agility. Further examples in this area of research are Ricci et al. (2002), Institut der Wirtschaft Thüringens (2005) and Borchardt (2006). A comprehensive overview of technical and non-technical issues in cross-organizational and cross-border IS/IT collaboration is provided by Madlberger and Roztocki (2007), who have conducted a literature review of 52 research papers, published from 2000 to 2007.

Then there are publications that concentrate on the information technology infrastructure of VENs. Camarinha-Matos, Afsarmanesh et al. published

multiple research findings in this area (2000, 2003, 2004 and 2005). Most of the scientific workflow management systems and approaches to workflow management in VENs mentioned in the previous section can be classified in this category as well. Again, all those publications have in common that they do not solely concentrate on the issues but instead more or less skip this step by only mentioning some of them and trying to develop and present possible solutions instead.

To facilitate future work about workflow management in VENs, it is therefore useful to entirely focus on the workflow management issues that arise in VENs and to create a single place that discusses them and shows how current workflow management systems and prototypes of research projects try to overcome them. For this purpose this paper has been written.

7 CONCLUSIONS AND FUTURE WORK

In this paper the plurality of workflow management issues in VENs has been described and corroborated by two real case studies of VENs in Australia. It has been shown that people, business and technology requirements to workflow management systems exist and that they are not limited to an initial configuration but rather occur during all phases of the virtual enterprise lifecycle, even after the VEN has been dissolved.

Although multiple efforts have been made, there is no standardized base information architecture for the collaboration of networked organizations so far. Organizations as the WfMC need to provide a suitable framework fostering formalization and normalization of information-semantics and business processes. Due to today's very short life-cycles of technology, the framework needs to be as much open and technology independent as possible, to preclude that the usage of technological advances is being hindered. VENs must then make use of this framework to increase their agility which is a prerequisite for broadening their possibilities to better benefit from latest market developments.

Further research, for example in the form of focus group surveys, could help to identify additional issues regarding workflow management in VENs. Rating their individual severities would allow organizations as the WfMC and manufacturers of workflow management systems to focus in their work on what is considered most important. Furthermore, in-depth research could be done, reviewing the various workflow management systems and scientific notions and assess how well they solve the different issues. Beyond that further research could immediately focus on the different phases of the virtual enterprise lifecycle and their particular people, business and technology issues; reducing the severities of or finding ways to avoid single issues as a whole, facilitates configuration, operation and dissolution of VENs and therewith increases their economic attractiveness.

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