

36 FURTHER DEVELOPMENTS IN VIRTUAL ENTERPRISES

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The area of virtual enterprises is still very young. Although considerable results have been achieved in terms of modeling and technological support, a large number of open issues remain as urgent challenges requiring further research and practical validation. In fact this is a new area of R&D not only for the ICT area, but also for highly interdisciplinary cooperation among different scientific, technologic, social, organizational, and economic areas.

INTRODUCTION

The recent efforts devoted to the development of infrastructures, mechanisms, and tools to support virtual enterprises (VE) are considerable, both at the national level in various countries and at the international cooperation level. As a result, considerable progress has been achieved, but there are still a large number of open issues requiring further developments and cooperation.

In spite of the fact that most of the initial projects are focused on the development of VE infrastructures, various aspects remain without proper solution among which the following cases can be mentioned:

- *Standards for information exchange.* The use of EDIFACT and STEP, including the interoperation between the two standards, is a common practice, but there are other types of information exchange that are not properly addressed by these standards. That is the case of quality-related information, monitoring information for distributed business process management, electronic catalogs information, skills / capabilities models, etc. The mentioned standards have also to be “customized” and validated in many other sectors besides industrial manufacturing, such as the agribusiness and food sector, the tourism, etc.

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- *Full life cycle supporting functionalities.* In past developments most emphasis has been put on the operational phase of the VE. Some projects also developed some functions to support the VE creation and (re-)configuration phase, although more work is necessary here, namely in terms of negotiation and decision making support tools, distributed business process planning and scheduling, configuration of coordination mechanisms based on the contractual clauses established among companies, etc. Regarding the VE dissolution phase the subject is almost not touched by current projects and many support functionalities need to be developed.
- *Interaction with enterprise applications.* As the enterprise applications (PPC, ERP, CAD, PDM, etc.) are both the main sources and consumers of the information that is interchanged among the VE partners, the interface mechanism between these systems and the VE infrastructure has to improve at two levels:
 - a. The information exchange between the applications and the infrastructure. The OAG¹ (Open Applications Group) interoperation guidelines may represent a promising and interesting step in the direction of standardization of information exchange for the enterprise's applications and the VE infrastructure..
 - b. Re-engineering and extension of the applications functionalities. New levels of flexibility in the control mechanisms of these systems are required in order to cope with the new agility required by the VE environment. New functionalities are also needed to support the VE business practices such as the local support for contracts fulfillment, global VE coordination including comprehensive distributed business process management, partners management, etc.
- *Safe communications and independence of the channels.* Although this is one of the most active development areas in electronic business, there is a need for simplification and standardization of mechanisms, making them available as basic services of the underlying network infrastructure.

An important aspect in the area of infrastructures is the “*geographical independence*”. As a VE may involve members in different geographical regions, even in different continents, there are obvious advantages in aiming a wider standardization of the basic levels of the infrastructure. To achieve this goal, there is a need to identify the basic level of functionalities that are needed to become common practice, which also motivates a more global international cooperation. Solutions developed for one particular region are not necessarily easily adaptable to other regions due to the many technological, cultural and business practices differences.

It is also natural that business practices and processes will change as a result of the first experiences on virtual enterprises. As a result new requirements will emerge and new supporting functionalities have to be developed. Not only new tools and applications will be required, but also all the traditional enterprise applications (ERP, PPC, PDM, CAD, CAPP, etc.) have to be “re-visited” in order to take into

account the networked cooperative environments.

NEW DEVELOPMENT CHALLENGES

Besides the aspects mentioned above, several other foreseeable developments can be mentioned such as:

- The focus on less supported phases of the VE life cycle, namely the creation and dissolution. This will have specific consequences in terms of the information models and supporting functions. Some of the aspects mentioned next are related to these two phases.
- The electronic procurement. The electronic search and selection of partners and suppliers is an important necessity in the VE networked environment. Several R&D projects have proposed some initial developments in this area, but a number of challenges are still ahead, including:
 - Standardization of the directories of suppliers, offering common and more advanced representations of skills / competencies and additional information required for partners selection. The search engines associated to these directories should also provide interfaces for access by remote applications or mobile agents. The current interfaces, basically oriented to human users via web browsers, are highly unstable and heterogeneous. With a few exceptions, the information present in such directories is also quite limited.
 - The mobile agents technology might represent a promising approach for partners search in multiple remote directories, implementing a kind of brokerage concept, specially if a standardization is reached at the directories level.
 - Development of multi-step negotiation process as part of the partners' selection. Finding potential partners in a directory is just the first step of the process that might involve several interactions between the VE initiator and those potential partners in order to gather additional information and reach agreements on the forms and terms of cooperation. Understanding this process, modeling it and developing support tools, are open challenges.
- The contract management. The behavior of a VE, i.e. the forms of cooperation among its members, is regulated by contracts. The management of these contracts is an important feature for an advanced VE supporting infrastructure, which requires further work on modeling, management and monitoring. A major obstacle here is the lack of well-established contract forms specifically designed for VEs. Even for the regulation of bilateral cooperation agreements between two enterprises there are a large variety of contractual forms. The new ways of cooperation between enterprises is requiring new forms of contracts. In terms of infrastructure support, some of the topics to be considered include:
 - Formal representation of contracts in a form suitable for computer processing and interpretation. At least it is important to facilitate the

derivation of supervision clauses from the contracts to be taken into account by the VE coordination system. In other words, most rules that define the behavior, rights and duties of both the coordinator and each member, for every particular VE, shall be carefully derived from established contracts.

- Modeling and representation of corporate knowledge about contracts negotiation, performance monitoring and task enforcement. Such models may be the basis for a negotiation process as mentioned in the partners' selection process above.
- Support for dynamic changes in contracts and their consequences (on supervision clauses, for instance) as a result of the changes in VE goals, or trust building process among partners.
- Modeling and characterization of the various actors involved in a contract.
- An aspect deserving particular attention is the one related to the quality-related clauses, as new regulations are imposing new duties to the members of a supply chain, requiring additional monitoring support.
- A management functionality to help companies in keeping track of the various active contracts regarding their multiple business processes and their participation in multiple VEs.
- Distributed business process management. Some recent projects started to focus the attention on the modeling of business processes for a VE environment. That is for instance the case of the VIVE² project. But as a complement to this modeling activity, it is necessary to develop an effective "executor" for such processes on top of the VE infrastructure – a distributed business process (DBP) management system. Projects like PRODNET³ or MASSYVE⁴ made some preliminary developments and proposals in this area but further work is necessary, with a concentration on:
 - Tools to support DBP modeling, planning and scheduling.
 - General DBP supervision system, coping with process distribution, execution supervision, conflict and error detection and recovery, considering both the roles of VE coordinator and VE member. Conflict / error resolution also calls for advances in dynamic BPs.
 - Extensive integration of DBP management with hierarchical coordination mechanisms and federated information management.
 - More clear and flexible interfaces with the enterprise applications, namely the ERP and PPC systems.
 - Assessment methods adequate for DBP and to evaluate the performance of the various actors (VE members).
 - Standardization of the BP and supervision clauses representation, facilitating the interchange of business processes between applications and VE nodes.
- Telepresence. Advanced forms of subcontracting and the new cooperative forms in design and manufacturing induced by the VE paradigm require mechanisms to support controlled "intrusion" of a company into the "territory" of its partners. An initial example of this "intrusion" is the access to selected

(authorized by contract) subsets of the information (for instance, the orders' status, stock levels, etc.). But this process may assume more extensive forms. A company might want to "open a window" over the shop floor of its partner (subcontractor) to monitor the manufacturing process of the ordered parts and even interfere from distance, in cooperation with local people, in the shop floor processes. Techniques from the area of telepresence / telesupervision and telerobotics can, therefore, be integrated in (or required by) a VE infrastructure.

- Technological consolidation of advanced ideas developed at prototype level. Several concepts developed within research projects and tested in a limited way at prototype level, need to be extended and "productized", in order to fully assess their relevance and contribution. Examples are the federated information management and the hierarchical coordination mechanisms developed in PRODNET II.
- Generic configuration tools. Although projects like PRODNET II have identified flexibility and configurability as key requirements for a VE infrastructure, current solutions, based on many diverse components, still require a considerable installation and configuration effort. The initial attempts of some PRODNET tools to include certain configuration functionality, suitable for a business process expert and not requiring specialized ICT knowledge, have to be more extensively pursued towards a plug-and-play solution.

NEW APPROACHES ON TOP OF A VE

Once a VE infrastructure is established, new business and working practices will emerge requiring further support.

- Some of these areas are already "waiting" for adequate tools. That is the case, for instance, of distributed concurrent engineering and teleworking. Concurrent engineering is already a "classical" area for which many developments had taken place, but which faces new challenges when the engineering teams belong to different enterprises (members of a VE) and work in remote places. Telework is another active area whose models and tools need to be integrated with the general VE environment. Some of the major development areas here include:
 - Coordination management and modeling.
 - Exception handling and adaptive processes.
 - Definition of assessment metrics.
- Another emerging area is the "engineering as a service". Consortia of engineering companies (or of individual engineers) can benefit from, and use similar infrastructures, as the industrial manufacturing VEs. Specific emphasis will be required on the topics of:
 - Engineering and consulting services modeling and management.
 - Highly dynamic organizations. Clusters of engineers and other experts may be organized as a pool for potential virtual organizations that need to be organized every time a new business opportunity is being created. Similar to

the partners search, specific tools are required to be developed in this area to assist with the planning of the structure for virtual team organization, based on the characteristics of the business opportunity and the specific skills (and availability) of each engineer / expert.

- Virtual training organizations. This is a particular case of virtual enterprise where different training organizations join their expertise in order to offer more complete and comprehensive training courses / services. Life-long training is emerging as an important market niche, that requires high dynamism from the training organizations, and a capability to tailor the training offers based on the specific needs of each particular client. Complementarily there is a growing interest for remote training areas, namely supported by Internet, as a solution to provide training services without requiring the trainees to move from their jobs to the training organization offices. An important development area is therefore the combination of the two areas of virtual enterprises and remote training. In some cases, an additional area may be added, the virtual laboratory area, allowing students to have access, via Internet, to remote equipment / laboratories. Tools to support joint experiments on these laboratories by teams of students / trainees located in different geographical places have to be developed.

New forms of organization of cooperation and new business scenarios are likely to emerge, that will require new conceptual and technological developments. Complementarily there is a need for more interaction between the technological developments and the socio-organizational issues and legal aspects. The social and organizational impacts of these new paradigms require a careful analysis not only to guarantee a smooth implantation, but also to guide the developments in the more adequate directions.

CONCLUSIONS

The area of virtual enterprises represents a very dynamic sector for which many challenges and open issues remain. The cases enumerated above are not an exhaustive list but it gives enough examples to justify the claim that this area still demands extensive R&D work.

This is however an area that can only be properly addressed if a highly interdisciplinary cooperation among different scientific, technologic, social, organizational, and economic groups is achieved, what is perhaps the biggest challenge.

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