AN AGENT-BASED FRAMEWORK FOR SELECTION OF PARTNERS IN DYNAMIC VIRTUAL ENTERPRISES[58].

Pedro Sanz Angulo
Juan José de Benito
José Alberto Araúzo Araúzo

ABSTRACT

Advances in computer networking technology and open system standards have made practically feasible to create and manage virtual enterprises. A virtual enterprise, VE, is usually defined as a temporary alliance of enterprises that come together to share their skills, core competencies, and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks.

The materialization of this paradigm, although enabled by recent advances in communication technologies, computer networks and logistics, requires an appropriate architectural framework and support tools.

In this paper we propose an agent-based model of a dynamic VE to support the different selection processes that are used in selecting the partners for a dynamic VE, where the partners of a VE are represented by agents. Such a framework will form the basis for tools that provide automated support for creation, and operation, of dynamic virtual enterprises.

KEY WORDS: Dynamic Virtual Enterprise, Agent, Selection of Partners.

INTRODUCTION.

New Information and Communication Technologies (*ICTs),* which have their maximum expression in Internet, together with the advances in telecommunications and means of transport, constitute some of the main factors that configure the new context in which current companies and organizations develop their activity.

In this new situation, success or excellence are achieved thanks to an *effective knowledge management* (creation, storage, transformation and use) which becomes the main source of wealth generation. And, for it, new, more flexible and intelligent organizational structures are required.

Last decades have been witness of the introduction of new concepts, methods, organizational forms and structures which try to satisfy the demands of management and organization processes in these complex environments. Among these new answers, the paradigm of *Virtual Enterprise (VE)* has acquired a great importance and some authors consider it as the organizational strategy of the XXIst century.

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The VE is an organizational structure able to respond to the necessities of current markets better than other traditional structures, due to its adaptability and, of course, due to an intensive use of information technologies.

One of the first steps to make the company "virtual" consists on replacing traditional structures of management by information systems which allow an effective knowledge management. These information systems are, in turn, the basis for one of the key elements of success or failure in any managerial organization: *communication.*

Thanks to the tools provided by modern information systems and extended computer capacity, we can obtain virtual designs with quotas of efficiency in communication and knowledge management better than those achieved by traditional schemas.

In this paper we show some of the main characteristics of VEs, and try to contribute to their improvement by using some of those modern tools. Particularly, we propose an agent-based model to support the different formation processes needed to select the partners of a dynamic VE (*DVE, Dynamic Virtual Enterprise*), which are represented by agents. Such a framework will form the basis for the tools that provide automated support for creation, and operation, of dynamic virtual enterprises. However, in order to understand the VE, we first need to explore the context in which VE arises and evolves, i.e., the environment in which current managerial organizations develop their activity.

THE NEW MANAGERIAL ENVIRONMENTS.

From the 2nd half of the XX century, human society has experienced an extraordinary transformation, and business can not obviate its impact. Fast changes in political, economic, commercial, technological and human environments have drawn a new scenario companies have to face.

From the point of view of *political and historical environment*, events like the disappearance of the Union of Socialist Soviet Republics (USSR), the amplification of the European Union, the agreements of free trade, etc., have developed wider markets with a bigger liberalization grade, opening very important opportunities to "adaptable" companies. Markets are configured in a global way, which foments competition and allows economies of scale thanks to the union of different micro-segments in wider environments.

The *economic environment*, according to (Cuesta 98, Sanz et al 04), is characterized by the employment destruction in the "first world" economies. Although, in a world-wide level there is a descent of unemployment in last years, employment creation has moved from the more developed countries to the less favored ones, where conditions to establish new productive centers are usually more favorable and labor costs are smaller. This fact origins insecurity and a reduction of the consumers' purchasing power and, in consequence, a serious problem of imbalance between global offer and demand.

In a similar way, the *commercial environment* also displays significant characteristics. Traditional markets, associated mainly to the developed countries, are very mature markets with a high level of saturation and, therefore, with a very limited growth potential. As a consequence, current markets present business opportunities that appear in precise moments, in different geographical regions and for briefer periods of time.

Market maturity also has effects on consumers' behavior: companies must face clients with different likes and a high education level, who demand from our products those expectations we have waked up in them. Therefore,

in order to compete in this new environment, it is necessary to know the customers' necessities to make a customized offer in accordance with their authentic particular desires. In order to obtain this we can use principles of marketing such as micro segmentation or pull strategies (Sanz et al 04).

During the last years, the conception of product has evolved due to this maturity of markets and clients, creating a new *environment of service*. Opposed to a technical vision which considers product like a set of physical attributes (self-centered approach), a consumer necessities based approach is prevailing. From this new point of view, people buy products not only by themselves, but by problems they solve: consumers do not buy products, acquire the hope to obtain benefits (Santesmases 93). In consequence, a product is not only the sum of basic benefits it reports, but also, as Kotler shows in (Kotler 00), a series of formal aspects, like quality, marks, style, design, etc., which form the tangible product, in addition to a set of added aspects as post-sale, maintenance, guarantee, installation, etc., constituting the increased product, or simply, the *service*.

We must get sure that this service satisfies the clients' necessities and demands in the quickest way. But, how can we do that?. The answer is in the permanent knowledge of clients and in the anticipation, which requires an appropriate communication system with them. This communication is the best guarantee to offer customers really want with an optimized cost.

This source of business opportunities has been favored and facilitated by the impressive development of the new information technologies (computer science, telecommunications, etc.), main characteristic of the new *technological environment*. Nowadays it is accepted that the increasing use of the ICTs influences in every aspect of the economic life and in the organization and direction of companies.

The accelerated increase of productivity, and consequently of the competitiveness of companies, is related to the advances of ICTs. Really, ICTs facilitate the adoption of innovations and reforms in the enterprise organization and, on the other hand, modify the conditions of competition and the configuration of markets, causing a great impact on the structure and the vital cycle of companies. Current infrastructures allows to integrate the different components, more and more dispersed from both the structural and geographical point of view, by means of efficient information sharing and communication (Sanz 04).

Finally, we find the *human environment.* People, and concretely their specialized knowledge, have become the real differentiating elements of organizations in detriment of technology and other resources that can be easily bought or replaced in the global market. *Companies are open systems*, made up by people working in different links of the value chain. So we find diverse organizations (suppliers, manufacturers, dealers, etc. and, of course, the final client), collaborating under *partnership* premises instead of the older client-supplier concept.

The changes discussed previously lead us to one of the most important current managerial challenges: the necessity to find a balanced solution between globalization needs and the micro-segmentation of local markets. A company needs to internationalize its offer searching economies of scale and, on the other hand, it cannot forget that consumers demand customized products.

In order to respond efficiently to this challenge, i.e., in order to adapt to the new world reality, a company should carry out four necessary and fundamental adjustments (Cuesta 98):

✓ *Cost structure optimization,* which allow to reach competitive advantage.

- ✓ A *global vision of the enterprise,* responding to global markets.
- ✓ *Specialization of productive units*, relating them directly with the most appropriate geographical location considering both strategic as operative reasons.
- ✓ *Attainment of economies of scale,* through commitments to share productive resources.

For these reasons companies must replace the "vertical integration" concept by the "horizontal process" concept (reduction of the hierarchical levels of the company), and understand the company as an open and global system (Porter's value chain), in which suppliers, clients, and even competitors, are integrated as a whole.

All the above analysis leads us to a multiple and global company model, with a very high specialization level in all of their functions, flexible, adaptive and with a variable and optimized costs structure to reach benefits facing the final prices imposition by the clients. A structural answer to these challenges can be found in the VE concept we discuss below.

DYNAMIC VIRTUAL ENTERPRISE.

The paradigm of virtual enterprise represents a major area of research and technological development for industrial enterprises and an important application area for web-based cooperative environments. We can say that the VE concept is one of the most important ways to raise the agility and competitiveness of manufacturing enterprises.

VE is attracting increasing attention from both the academic and industrial communities. Extensive programs are being conducted worldwide on relevant issues to propagate the VE concept, to build VE prototypes, and to realize VEs (Chu et al 04). Many terms and definitions have been proposed for VE, but so far, there is not an unified definition. For instance, Camarinha-Matos (Camarinha-Matos 01) regards the VE as "a temporary alliance of enterprises that come together to share their skills, core competencies, and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks". For the NIIIP project a VE is "a temporary consortium or alliance of companies formed to share costs and skills and exploit fast-changing market opportunities".

The main objective of a VE is to allow a number of organizations, physically distributed, to rapidly develop a common working environment using electronic means and systems; hence managing a collection of resources provided by the participating organizations toward the attainment of some common goals. Because each partner brings his strength or core competence to the consortium, the success of the project depends on all co-operating as a single unit (Sanz 04).

Based on the different existing definitions, we can identified two well-defined categories of VE, namely the Static VE (SVE) and the Dynamic VE (DVE), (Ouzounis 01):

- ✓ In SVEs a set of business partners is linked together in a static and fixed way, i.e. the shared business processes are tightly integrated. The business relationships among the partners are pre-defined, tightly coupled, fixed, and well integrated and customized among the partners. The network is fixed and pre-determined.

✓ In DVEs a set of business partners is linked dynamically, on-demand, and according to the requirements of the customers, by deploying a virtual marketplace. The business domains do not have fixed business relationships and thus, the VE might change continuously based on market-driven criteria. The marketplace provides services for the registration of business process offerings based on some generic, well-known, globally specified process templates. Business domains that want to form VE relationships can register offers on the marketplace in relation to the process templates. Whenever a business domain wants to use a particular process, searches the marketplace, and locates all the potential partners that can provide the process. As soon as the list of VE candidate partners has been found, the partner selection process starts. The partner selection process between the domains is usually performed through negotiation.

The main advantage of the dynamic virtual enterprise is its ability to link the most suitable supplier to each individual service to deliver a customer specific solution. Additionally, the DVE provide the ability to recognize, rapidly react and cope with the unpredictable changes in the environment in order to achieve better responses to opportunities, shorter time-to-market, and higher quality with less investment. The DVE allow enterprises to participate in competitive business opportunities and new markets; this way, SMEs will be able to achieve critical mass and appear in the market with a larger "visible" size.

From business point of view it is obvious that dynamic VEs improve significantly the static ones and take full advantage of the open, global, opportunities offered by the Internet and the global economy. However, from technical point of view, the required technical solutions and systems are more complex, sophisticated and distributed (Sanz 04).

The acceptance of agents as an implementation and communication paradigm, the extra capabilities that they offer, like mobility, autonomy, intelligence, adaptability, in conjunction with emerging state of the art agent platforms and standard distributed platforms, flexible content description languages for globally specified ontologies, like XML, emerging, XML-based workflow standards and platform independent programming languages, can provide the basis for the new generation of open, flexible, autonomous, and distributed business process management systems for dynamic VEs (Ouzounis 01).

AGENTS FOR MODELLING VES.

Basically, an agent is software that exhibit some of the following attributes: autonomy, co-operation, intelligence and mobility. It acts typically on behalf of an user or a process in a goal-oriented manner enabling task automation i.e. they operate proactively in pursuit of their goals.

Agents operate rather autonomously to the user (they are often event o time triggered), and may communicate with the user, system resources or other agents as required to perform their task. Through communication, agents may co-operate with other agents to carry out tasks or to achieve goals beyond the capability of a single agent.

Agent's intelligence is based on its ability to solve problems using a wide range of reasoning techniques and learning mechanisms. Finally, agents may be mobile, i.e. they may move from one system to another to access remote resources or even meet other agents and co-operate with them. Agent platforms provide the supporting software infrastructure needed to manage and execute agent-based applications.

From the academic community there is a strong motivation to use agents as the technology for modelling and realizing DVEs (Sobah 02, Camarinha-Matos 99). A DVE is composed of distributed, heterogeneous and autonomous components, the partners of the DVE, and therefore it is natural to use agents to represent them.

SELECTION OF PARTNERS.

Dynamic VEs have a limited lifetime, thus they need to be formed very quickly in order to meet the deadlines of the goals and there is a need to form them often. An important part of the formation is the selection of partners, who are selected according to the ability to fulfill the dynamic VE's requirements (0253).

The short lifespan of the DVE means that the partners that participate in one DVE may also be negotiating on a contract with another VE. By delegating agents to do this job, the partners have the time to do the actual work required in the DVE. The ability to delegate responsibilities to agents and agents being reusable components makes them a suitable means of representing the partners in a VE.

We have developed an agent-based enterprise model of a dynamic virtual enterprise by analyzing the entities in a VE, their relationships and how they can be used in an agent context.

The different agents take part in a dynamic VE can be classified as:

- ✓ *DVE Initiator or DVE Customer Agent, DCA:* who takes the initiative to form the VE throwing a necessity.
- ✓ *DVE Partner Agent, DPA:* the agents which represents the members that form the dynamic VE.
- ✓ *DVE Candidate Partner Agent, DCPA:* represents the entities that would like to participate in dynamic VE.
- ✓ *DVE Representative Agent, DRA:* represents the DVE to the customer, i.e. to the outside world.
- ✓ *Virtual Marketplace Agent, VMpA:* is the agent that provides registration an selection services for dynamic VE candidate partners. It is responsible for administrating services types an service offers.

The selection process can be described as follow:

- ✓ *Phase 1*: every DCPA that would like to participate in dynamic VE relationships registers its processes in the virtual marketplace. The business process *registration is* performed by deploying the existing service types provided by the marketplace. If there is no associated service type for a particular process, a new one is created by possibly inheriting existing service types. This process can be done automatically through the VMpA. During the registration process, certain values for certain attributes related to the service type, like location, quantity, etc., are specified.

- ✓ *Phase 2*: the DCA requests a business process by a DRA.

- ✓ *Phase 3*: if one of the sub-process of the main process must be provided by other domain, the suitable partner for this sub-process should be located. Upon request, the VMpA informs the DRA about all the registered potential DCPA that can provide this sub-process. The DRA can search the

virtual marketplace based on some constraints an get a list of potential candidates that can provide a specific service.

✓ *Phase 4*: once the DRA has a list of potential providers the negotiation process is initiated: the DRA will negotiate with every DCPA. The result of this negotiation process is the selection of the best DVE Candidate that satisfies certain classification criteria. This candidate will transform in a DVE Partner and the agreement will be describe in terms of an electronic contract that regulates the agreement.

✓ *Phase 5*: if one of the sub-process assigned to a DVE Partner must provide by other entity, the suitable partner for this sub-process should be located. Upon request, the VMpA informs the DPA about all the registered potential DCPA that can provide this sub-process.

✓ *Phase 6*: once the DPA has a list of potential providers the DPA negotiate with every DCPA. The result of this negotiation process is the selection of the best DVE Candidate that satisfies certain classification criteria for the sub-process.

Obviously, phases 3 to 6 can repeat so many times as sub-process must be provided by outside entities. The selection model is depicted in the following picture:
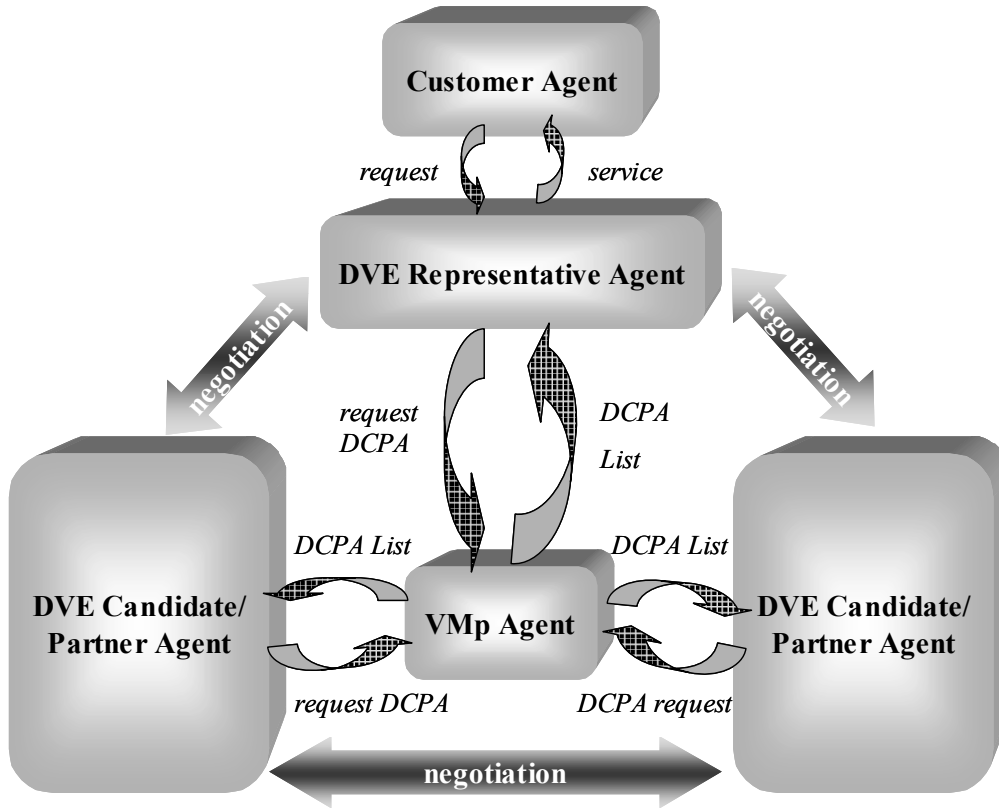
Figure 1: Selection Model and Relations.

CONCLUSIONS.

In this paper, we have shown some of the main characteristics of present environments. In this new situation, success or excellence are achieved thanks to an *effective knowledge management* (creation, storage, transformation and use) which becomes the main source of wealth generation. And, for it, new, more flexible and intelligent organizational structures are required.

In this context, the paradigm of *Virtual Enterprise* has acquired a great importance and some authors consider it as the organizational strategy of the XXIst century. The VE is an organizational structure able to respond to the necessities of current markets better than other traditional structures, due to its adaptability and, of course, due to an intensive use of information technologies.

The materialization of this paradigm, although enabled by recent advances in communication technologies, computer networks and logistics, requires an appropriate architectural framework and support tools. Namely, it requires the definition of a suitable open reference architecture for cooperation, the development of a flexible

and configurable business processes supporting platform, and the development of appropriate interoperation protocols and mechanisms.

In this issue, we have presented an agent-based model of a DVE that can be used to support the different selection processes needed to select the partners of a DVE, where the partners of a VE are represented by agents. Such a framework will form the basis for tools that provide automated support for creation, and operation, of dynamic virtual enterprises.

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