SELF ORGANISING STRUCTURES OF AD-HOC COOPERATIONS FOR CUSTOM MADE PRODUCTS AND SERVICES

NIKOLAOS V. KARADIMAS
VASSILI LOUMOS
National Technical University of Athens
Multimedia Technology Laboratory
9 Heroon Polytechneiou 9
Zografou Campus, 157 80 Athens, Greece
E-mail: NKaradim@central.ntua.gr
E-mail: loumos@cs.ntua.gr

ALEXANDER TSIGKAS
Production Management and Engineering
Democritus University of Thrace, Greece
Senior Consultant
Leonardo Group AG, Switzerland
E-mail: atsigkas@leonardo-group.com

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ABSTRACT

The paper proposes the design of an innovative management model for supply networks. This model promote the requirement of the close cooperation and adaptability as well as flexibility of ad-hoc structures throughout the supply network of custom made products and services. Structures of this type will respect principles that differ from the classical model of the industrial age, and evolve towards self organising and self adapting entities. This type of structures will be organised, so that they provide flexible interfaces for plugging and adapting fairly quickly into other ad-hoc cooperations for the purpose of providing custom made products and services. Once the purpose for which this “Virtual Integration” has taken place, has been served, integration can be abandoned partially or completely and other structures can be formed in order to continue offering custom made and individual products or services in a new form.

INTRODUCTION

Custom made products and services requires the design of Supply Networks that have special characteristics with respect to normal Supply Chains that serve more or less standard products and services. This research work discuss the belief that in the future, markets will be more and more oriented towards individualised products and services and these products and services cannot be offered from only one company or a number of them forming long term partnerships. These structures are too rigid for responding to the new challenges of the globalised markets and therefore new forms of organisation and management structures are necessary to emerge. Furthermore, state-of-the-art web-based intelligent agents technology will be necessary to support operations of such management models.
This paper makes an effort to respond to this requirement in proposing a model for self-organising structures of ad-hoc cooperations for custom made products and services. Therefore, in this case, customisation addresses also the way individual professional teams should be structured, managed and evolved in order to form integrated systems that their purpose is to function as customised supply networks (CSN). These CSN are neither vertically integrated companies nor they are long term partnerships. On the contrary they are ad-hoc collaborations that have defined characteristics to serve the customisation and personalisation market of products or services.
This schema is described in the rest of the paper as follows: Section 2 addresses further research and studies around the issues of how Supply Networks should be designed taking advantage from this new form of organisation and management structures in order to form CSN. In addition, section 3 describes briefly the principles for these ad-hoc structures. Section 4 introduces intelligent agents, a new breed web-based technology with significant potential for a wide range of applications as well as their typology. Section 5 presents the business model proposed for the VAC accompanied by an intelligent agent application description for manufacturing and the opportunities for the agent deployment for illustrative purposes of the business case. Finally, in Section 6, conclusions and future developments are discussed.

VALUE ADDING COMMUNITY

A value adding community (VAC) (Tsigkas, 2005) is a supply chain of organisation structures self-sufficient and autonomous, which offer products or services. The composition of the VAC depends every time on the market needs and may change if market needs change. Participants in the VAC may be not only enterprises but any entity that fulfils the interfacing requirements needed and described below. Since response time is the key issue here, ad-hoc synergies can only be achieved if the participants in the VAC are structured and comply with certain agreed standards that are set and improved by the community. Therefore for more agility to respond to market needs it is necessary that VAC internally exhibits a cellular structure. These cellular structures share certain design characteristics that make the

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structure reusable, re-configurable and scalable. Rick Dove (2001) was the first to use these expressions in his remarkable book “Response Ability” in order to define an organisational structure of an enterprise he names “Agile Enterprise”. These expressions are introduced here in order to define chains with configurable structures to respond to the customisation and personalisation needs. Cells that need to cooperate and form each time a new VAC need to comply with certain organisational principles that make the ad-hoc communication possible with the least time and energy loss (Tsigkas, 2004). These principles form a certain framework that is known as the collaboration framework, which is accepted from the participants in VAC. This framework does not need to be negotiated and re-negotiated every time a new VAC or a chain of VAC needs to be formed. It is well known that cooperation and collaboration negotiations consume today a great deal of effort, time and energy on both sides in a bilateral relationship. Even more in a multilateral relationship effort, time, energy and therefore cost grow exponentially. This reality makes collaboration agreements often practically impossible. The VAC framework targets on the other hand, in alleviating this major constraint towards forming ad-hoc structures. These principles are stated in the next section, but not discussed in detail. It is proposed to the mass customisation community aiming at initiating a discussion that should lead to the determination of a collaboration framework for the creation of VACs for custom made products and services.

PRINCIPLES FOR AD-HOC STRUCTURES

The principles are grouped into the following ten categories.

Self-Contained units: Components of a flexible structure are distinct, separable, self-sufficient units cooperating toward a shared common purpose.

An example of such an organisation is a unit of special forces in a mission, where every one knows which is the objective, which is his own role and the role of the others on the team. They do not sit down and interrogate each other to decide about individual trustworthiness and competency. The team leader may in fact choose the tactical targets, but the task expert will decide how to accomplish the task. And any one of them could have been any one of many others.

Interfacing compatibility: Components of a flexible structure share defined interactions and interface standards and they are easily inserted or removed.

The individual candidate will have to fulfil certain standards with respect to the values that he or she will have to have acquired in order to assure compatibility within a VAC. The problem in many cases in management is not the standard, but the multiplicity of them. With respect to the replacement of a unit or component within a flexible organisation, what should be avoided is a total integration of the components or the units in the final scheme. The total integration of a member within a team may on one hand have advantages in the operation of a team; it may on the other hand have negative effects when this unit or member must be replaced. The objective is here to be able to adjust in a speedy manner the value creating process of the VAC in order to adapt quicker to market changing needs.

As an example it is referred the integration of the suppliers in the production in the end of the 90s that exhibited very good results when operated properly. When on the other hand something goes wrong, these suppliers are so close connected with the system that replacement became extremely difficult.

Flat Interactions / Interactions without hierarchy: Components of a flexible structure communicate directly on a peer-to-peer relationship and parallel rather than sequential relationships are favoured. This is a special and very important feature for every supply chain. Gatekeepers that select, approve, censure or otherwise gate the communications of a system component are stealth members of the system (Dove 2001). For example, many businesses went through a strong process reengineering focus in the 1990s. A lot of that effort was directed at changing sequential processes into cell or parallel processes. In many areas of manufacturing, the concept of cellular processes took favour over sequential processes, partly because the processes that created the problem had the ability to attend to it immediately and directly.

Deferred Commitment: Components of a flexible structure are transient when possible, decisions and fixed bindings are postponed until immediately necessary and relationships are scheduled and bound in real time. Deferred commitment basically keeps existing options open as long as possible. The underlying wisdom here says to not take a decision until it is necessary, knowing that more information arrives with time and decisions should take advantage of that flow.

Distributed control and Information: Components of a flexible structure are directed by objective rather than method. Decisions are made at point of maximum knowledge and information is associated locally, accessible globally and freely disseminated.

Empowerment at the team and the individual level is the classic example when people and organisations are involved. The use of this principle in the design of the VAC facilitates immensely system design since it decreases the need of communication between self sufficient, decentralised units to a minimum possible. Distributed information is often a reinforcement of the self contained unit principle.

Elastic Capacity: The number of components of a flexible structure may be increased and decreased widely within the existing framework.

This principle allows the flexible organisation like a VAC to increase and decrease capacity in order to adjust to the changing demand. For example, when outsourcing became a strategic discussion point in the early 1990s, the focus was generally on core competence issues.

Concentration on strategic differentiations and farming out the rest to others who make a competency from what you consider to be supporting functions. That was maybe the objective, but this concept found its real implementation push from companies that needed rapid capacity fluctuations. VACs should be capable to adjust their response ability to the market by downsizing and upsizing as necessary to accommodate demand changes.

Redundancy and Diversity: Duplicate components are employed in flexible structures to provide capacity right-sizing options and fail-soft tolerance and diversity among similar components employing different methods is exploited.

As it is obvious this principle overthrows the approach of the single optimal solution, since it requires that sometimes is better to get a task done rather than relying on a single optimal approach. LSI Logic maintains a pool of resources capable of fabricating semiconductor wafers; some are wholly owned and some are qualified outsources. When an order arrives, a production chain can be assembled immediately from these pooled resources without waiting for some single resource or some resource with a unique capability that must finish its current commitment. Frequently it is more useful to have multipurpose people than dedicated experts.

Cross training in teams is often justified by the need to always have someone covering every need, regardless of who is absent for whatever reason. This obvious point is violated more often than not, especially in control cultures, where single-point approvals steal momentum, stop activities or put the customer on hold while the gatekeeper is not available for whatever reason (i.e. vacation, out to lunch, ill e.t.c.). Collaborative learning and collaborative work have better results in a group with mixed backgrounds and mixed points of view.

Self-organisation: Components relationships in flexible structure are self-determined and components interaction is self-adjusting or negotiated.

Self-organisation is typically related to natural system such as ecologies, societies and beehives, where seemingly intelligent or at least purposeful behaviour emerges from the total system though no central direction or control is evident. At the level of the VAC organisation, empowerment, teaming, listening to the voice of the customer, organisational learning and other concepts are extremely important. The principle of self-organisation basically means that the components of VAC have some discretion in deciding how to accomplish the goals established for them: what processes to employ, what priorities to set, and when to use which resources. In more advanced levels of VACs, the component can choose what to do, and with whom to do it.

Facilitated reuse: Components of a flexible structure are reusable or replicable and responsibilities for ready reuse/replication and for management, maintenance and upgrade of existing components are specifically designated.

Can a duplicate of an existing component be readily created if another is needed? Can a necessary component be readily deployed when a new system must be constructed? Since within the VAC we are concerned within effective response to dynamic needs, some one or some mechanism is specifically charged with the responsibility for each activity involved. Attempts at formalised knowledge management are actually classical examples of facilitated reusability.

However reusability of knowledge is not sufficient. Knowledge, when created, should be made promptly available to all members of the VAC and to other VAC that may need it. This point is important since knowledge creation should be made with the least possible energy dissipation.

The objective in the metacapitalistic market is to allow knowledge to achieve a high turnover in order to have real growth. It is therefore necessary to remove barriers that put obstacle in the free dissemination of knowledge. Competitiveness will not be gained through knowledge retention but on the contrary how quickly new knowledge can be produced, disseminated and not accumulated and preserved as if it is a scarce resource (Tsigkas et al., 2004).

Evolving standards: Frameworks of flexible structures standardize inter-component communication and interaction, define component compatibility and are monitored or updated to accommodate old, current and new components.

The purpose of the VAC framework is to facilitate reconfiguration, reuse and scalability. A framework should both constrain and enable these characteristics, bounding the set of potential configurations of an acceptable VAC system while encouraging full exploitation of the possibilities. It is the framework where all other principles described above find their right for existence and coexist in a dialectical interaction.

INTELLIGENT AGENTS

Traditional cooperations activities require a large effort from the participants collecting and interpreting information on products and/or services, making optimal decisions and finally entering appropriate transaction information. This difficulty can be alleviated through the use of intelligent agents.

Intelligent agents help to automate a variety of these cooperation activities, mostly time consuming ones, and thus lower the transaction costs. Intelligent agents differ from “traditional” software in that they are personalized, social, continuously running and semi-autonomous. In this way, the cooperation between the members of a VAC becomes more user-friendly, semi-intelligent and human-like.

These qualities are conducive for optimizing the whole exchanging experience and revolutionizing supply networks, as we know them today.

An agent is a software entity which functions continuously and autonomously in a particular environment often inhabited by other agents and processes. The requirement for continuity and autonomy derives from human desire that an agent should be able to perform activities in a flexible and intelligent manner responsive to changes in the environment without constant human supervision. An agent that functions over a long period of time should be also able to learn from its experience. Furthermore, an agent that inhabits in an environment with other agents and processes, it should be able to communicate and cooperate with them, and perhaps move from one place to another in doing so, as well.

THE VAC BUSINESS MODEL

In this model (see Figure 1) it is assumed that the VAC participants are already qualified according to the standards established based on the previously stated principles and that their profiles are managed via a VAC Server.

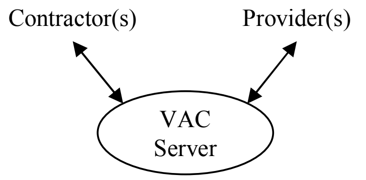

Figure 1. Contractor-to-Provider communication.

The typical business case (Figure 2) starts with the request of a member of the VAC (thereafter the Contractor) for the provision of a service and/or product sent to the VAC server. The server deconstructs the request in its constituents single elements and forwards these elements to the VAC network for searching and finding possible partners that can fulfil the requirements originally requested by the Contractor.
The server waits for the response from the network in order to qualify the answer based upon compatible combinations with repect to the request and feeds it back to the Contractor. The Contractor can then decide on the available options and in this case move on to update the formal agreement already existing among the members of the ad-hoc partnership to substantiate the cooperation. The agreed service can then be performed and the work will be evaluated upon its completion. Evaluation data will become immediately available at the VAC server updating the profile of the ad-hoc participants. Evaluation concerns all members of the ad-hoc partnerships, contractor(s) as well as provider(s). Setting up the request, deconstructing it into individual activities, forwarding and feedback of qualified responses are processes undertaken by intelligent agents. The generation of compatible combinations is performed through specially developed algorithms that run at the level of the VAC server.

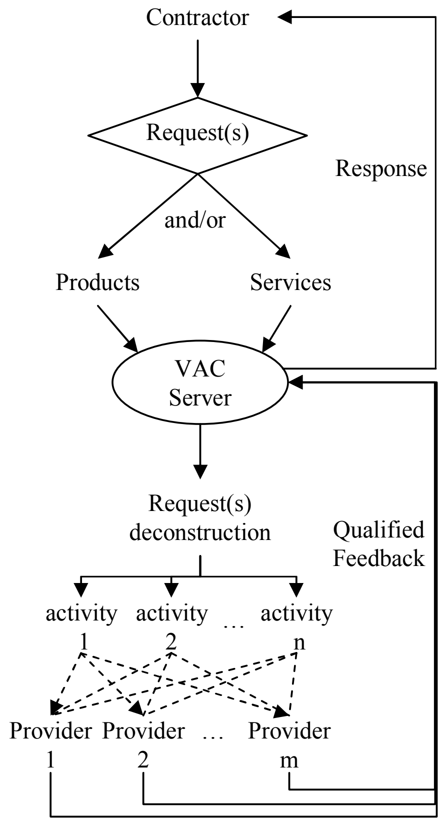

Figure 2. The communication procedure.

AGENT APPLICATION IN VAC FOR MANUFACTURING

In order to provide a business case of how and where agent-based computing can improve the cooperation within a VAC, a manufacturing scenario where agents can be effectively deployed, such as procurement and supply-chain management, operations are identified.
A prototype multi-agent system to facilitate a bidding process for printed circuit board/assembly is discussed in some depth, identifying some of the functions that should appear in that kind of process. In particular, this prototype includes a specialized agent capable of retrieving technical design specification information stored in a standard file format. This could be a Computer-Aided Design file specification language standardized from the community itself and following an approved number of quality standards.
Defining quality is not an easy task. All participants have their own definitions of "quality" based on their subjective experiences. In order to have an objective set of guidelines that both customers and suppliers can refer to, the community should develop a set of quality standards to provide benchmarks for a participant's workmanship and the materials to be used.

A Manufacturing Project

A manufacturing framework develops a process-flow model, which identifies those internet-facilitated transactions for printed circuit board design, fabrication and assembly. The model identifies the major functions in the printed circuit assembly production process. There are certain functions that should appear in the aforementioned scenario.

Firstly, the original equipment manufacturer (OEM) needs to procure the boards and to generate a request for quotes. Therefore, the manufacturer ships the request to a list of electronics manufacturing vendors, which should be approved members of a particular VAC. The manufacturer and the vendors often conduct negotiations of terms. Then, if the manufacturer receives several quotes, he evaluates them and finally selects the winning bid. When the printed circuit assembler receives the order and the product definition package, it will often perform a manufacturability test and ship the report back to the manufacturer. On the other hand, engineering change order often occurs and needs to be evaluated and authorized if warranted, to be processed as an order for a new printed circuit assembly.

Opportunities for Intelligent Agent Deployment

Agent technology can assist in performing a variety of tasks. Agent research communities are building intelligent agents for performing negotiation, mediation, and brokering services. Agent technology also encompasses expert systems approaches that can perform complex scheduling, monitoring and alerting type of services. There are many potential areas for agent application in manufacturing services, such as:

Flexible Customer-to-Supplier Interfaces: Points at the opportunity for agent approaches to 'wrap around' or completely circumvent the existing form-based interfaces on the Web that have pre-defined syntax, implicit semantics, unpublished interaction protocols and, instead, enable automated, on-demand Customer-to-Supplier interface construction.

Optimized Negotiation of Service Cost and Terms: Currently, a human expert is solely responsible for negotiating an 'optimal' set of terms and the cost of service.Often, this person has a limited view of the business situation and cannot react immediately to a new business state of affairs. Agent approaches carry the promise of embedding significant decision making capabilities.

Efficient Intra-Enterprise Technology Adoption and Adaptation: Few means currently exist to accelerate adoption and adaptation of new e-commerce technologies within an enterprise. On the contrary, an agent should provide easier integration with legacy systems through usage of shared languages, ontologies and efficient updates of interaction protocols.

Efficient Engineering Change Order Processing: Each participant in the engineering and manufacturing process should manually sign-off on the change and to make sure that the change is appropriately reflected in the part of the process for which the participant is responsible. Intelligent agents hold potential to make this process much less tedious and error-prone.

Efficient Inter-Enterprise Interaction Technology Support: Very few means currently exist to accelerate the adoption of new Customer-to-Supplier communication technologies across enterprises so that the enterprises can quickly engage in new inter-enterprise interactions.

CONCLUSIONS AND FURTHER RESEARCH

An attempt has been made to define the context in which future supply chain networks, for offering custom made products and services, should operate. In this context intelligent agents have been presented and discussed as being the vehicle for offering ad-hoc variety in the constitution of Value-Adding-Communities (VAC). Such communities need to be organised respecting basic principles. These principles must be defined in detail in the future so that further research and development can take place in developing special intelligent agents for the principles fulfilment. Furthermore, the introduction of intelligent agents in the set up of ad-hoc partnerships within a VAC can induce a breakthrough leading to a drastic reduction in time and effort requirements that traditional ways of setting up partnerships are experiencing today. As a first step it is necessary to develop the necessary agents that can undertake the tasks described above. As a second step it is suggested that VAC members can periodically update the VAC server for any changes on their profile of offered products or services and on their capabilities in general. In this way, a search for compatible partners can be even further accelerated.

REFERENCES

Dove R., 2001. "Response Ability – The language Structure and Culture of the Agile Enterprise". John Wiley and Sons Inc.

Tsigkas A., 2004, "For a new society of citizen: the state, the citizen, the market and the value of knowledge in the MetaCapitalism", (unpublished book written in Greek).

Tsigkas A., 2005, "Mass Customization through Value-Adding Communities". *3rd Interdiciplinary World Congress on Mass Customization and Personalization*, Hong-Kong.

Tsigkas A., Papantoniou A. and Vassili Loumos, 2003. "Towards Knowledge Based Mass Customization: a Framework for an Demand Design (ODD)". *2nd Interdiciplinary World Congress on Mass Customization and Personalization*, TU Munich.

AUTHOR BIOGRAPHIES

NIKOLAOS KARADIMAS was born in Athens, Greece and he graduated from Patra T.E.I. in 1995 with a Bachelor's degree in Electrical Engineering. He then received a Bachelor's degree with Honors in

Electronic Engineering and a Masters degree in Computer Science from Glasgow Caledonian University, Scotland in 1997 and 1998, respectively. He also received a Masters degree in Distributed and Multimedia Information Systems from Heriot-Watt University, Scotland in 1999. Since 2002 he is a Ph.D candidate in National Technical University of Athens. Furthermore, since 2001 he is teaching Informatics in Hellenic Army Academy and New York College, since 2003 he is teaching in T.E.I. of Chalkida and since 2005 he is teaching in Technical NCO Academy, as well. He is a member of the Greek Chamber of Engineers, member of IEEE and member of IEE. His research interests are in the fields of Databases, Optimization Techniques, Geographical Information Systems, Information Retrieval, Decision Support Systems and Multimedia.

VASSILI LOUMOS received the Diploma of Electrical Engineering and the PhD degree in Computer Science from the National Technical University of Athens (NTUA), Greece in 1975 and 1989. From 1975 to 1978 he was a research engineer at the Centre National de Recherhe Scientifique, Paris, France. From 1980 to 1982 he was with CGEE ALSHTOM as a field engineer. In 1990 he joined the faculty of the School of Electrical & Computer Engineering of the NTUA where he is presently a professor. He is teaching Multimedia Technologies and Computer Graphics. His research interests are in the fields of Multimedia, Computer Vision and Internet Navigation.

ALEXANDER TSIGKAS received a BSc in Physics from the University of Athens in 1974, a MSc in 1975 from the department of Electrical Engineering and a PhD degree from the department of Mechanical Engineering in 1978, Salford University in the United Kingdom. He is an active member in the community for Mass Customisation, being a speaker in three World Congresses. He works as a senior consultant for the Leonardo Group and he is a senior lecturer at the Democritean University of Thrace, Greece in the School for Production Engineering and Management. His experience expands to over 20 years in Industry with focus on Business Process Reengineering, especially where, effective and efficient Supply Chains is a key factor for the success of the customer. In the last years 10 years helps Enterprises in Central and East Europe, the middle and far East, who have chosen Flow or lean methodologies in order to implement Supply Chain strategies in their effort to increase competitiveness and leadership in their markets.