Toward Autonomous Virtual Organizations

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Abstract

The rapid advances in communication, information technology, and network technologies have had key role in emerging heterogeneous large-scale distributed systems. Besides, emergence of enterprise modeling and high integration of virtual organizations, proffesional virtual communities, and growth of number of practical cases on different forms of collaborative networks represent major trends and challenges in managing these systems. In a virtual organization, managing partners is crucial. An Autonomous System improves virtual organization functionalities and cope with complexity managemnt. Purpose of this paper is to present autonomous virtual organizations describing their characteristics, effects on quality factors, their building blocks architecture, and challenges. It then outlines this autonomous model for a virtual organization environment.

Keywords: Virtual organizations, Autonomic computing, Self-managing systems, Collaborative networks.

1. Introduction

Recently, both the business and scientific world have encountered with many emerging challenges, requiring the emergence of a variety of collaborative networks, enabled by the continuous advances in the information and communication technologies. The emergence of enterprise modeling and high integration of virtual organizations, proffesional virtual communities, and growth of number of practical cases on different forms of collaborative networks represent major trends and challenges in managing these systems. A virtual organization [1] is a set of co-operating legally independent organizations, which to the outside world provide a set of services and act as if they were one organization. It is also supported by a computer network. The changing business situation of companies and customer needs have motivated researchers to investigate Virtual Organization (VO) idea. The evolution of networks and the Internet has increased costs and errors of managing IT infrastructures. The skilled persons who manage these systems are expensive and can not manage them in all aspects specially configuration, optimization, healing, protection, and maintenance [2]. IBM proposed Autonomic Computing Systems as a solution. These manage themselves. Autonomic Computing Systems (ACSs) have been introduced as an approach for developing large scale distributed computing systems

with the aim of decreasing the cost of developing and managing the complex such systems. They manage themselves while hiding their complexity from the view of end users. Autonomics is used for acting or responding involuntary [3].

Due to lack of the number of countries working on the virtual organization term, the number of projects in this context is constraint. Although during the last 10-15 years, a number of research projects have been run in Europe through European Commission and other countries such as Japan, USA, Australia, and Mexico but applying autonomic computing idea in virtual organization is novel. This paper presents an autonomous virtual organization model in order to accelerate the VO functionalities including configuring, healing, optimizing, and protecting the VO members in a Virtual Breeding Environment (VBE) [9]. This idea can be also applied in critical systems.

This paper is organized as follows. In section 2, an overview of self-managing systems is presented including definition, their characteristics, and some important challenges. Different VO definitions, characteristics, and some issues are discussed in section 3. Section 4 proposes autonomous virtual organization model and the main issues in this model. Finally, conclusion is presented.

2. Self-managing Systems

This section presents an overview of self-managing systems. Autonomic computing systems are also called self-managing systems.

2.1. Definitions and Properties

According to Paul Horn definition [4], an autonomic computing system is a self-management system with eight elements. Self-configuration means that An ACS must dynamically configure and reconfigure itself under changing conditions [5]. Self-healing means that an ACS must detect failed components and eliminate or replace it with another component without disrupting the system. On the other hand, it must predict problems and prevent failures. Self-optimization is the capability of maximizing resource allocation and utilization for satisfying user requests. Resource utilization and work load management are two significant issues in self-optimization. An ACS must identify and detect at tacks and cover all aspects of system security at different levels such as the platform, operating system, applications, etc. It must also predict problems based on sensor reports and attempt to avoid them. It is called self-protection. An ACS needs to know itself. It must be aware of its components, current status, and available resources.

It must also know which resources can be borrowed or lent by it and which resources can be shared. It is self-awareness or self-knowledge property. An ACS must be also aware of the execution environment to react to environmental changes such as new policies. It is called context-awareness or environment-awareness. Openness means that an ACS must operate in a heterogeneous environment and must be portable across multiple platforms. Finally, an ACS can anticipate its optimal required resources while hiding its complexity from the end user view and attempts to satisfy user requests. We consider self-configuration, self-healing, self-optimization, and self-protection as major characteristics and the rest as minor characteristics.

2.2. Issues and Challenges

Since autonomic computing is a new concept in large-scale heterogeneous systems, there are different challenges and issues. Autonomic elements [6] are the basic building blocks of autonomic systems and their interactions produce self-managing behavior.

Relationships among autonomic elements have a key role in implementing self-management. These relationships have a life cycle consisting of specification, location, negotiation, provision, operation, and termination stages [7]. Each stage has its own challenges. Designing a robust learning procedure that is automatically performed on a new system can be a research area. Optimization can be also a challenge because in these systems, agents adapting in a dynamic environment are changing their behavior to reach optimization. The optimization is examined at AE level. Robustness is one of grand scientific challenges in the development of autonomic computing systems. With the design of instructions that permit systems to preserve their identity even when they are disrupted, the robustness in systems can be increased. Trust among autonomic elements can be one of important issues in the relationships between them and affects ACS functionality [8]. It means that one AE expects other autonomic elements to reliably perform their tasks to provide their agreed services to achieve the goal.

3. Virtual Organizations: A Concept

The main purpose of surveyed virtual organization concept is to understand the basic elements in the co-operation between enterprises. This section explains main concepts in virtual organization term.

3.1. Definitions and Properties

A virtual organization is defined as a temporary coalition of reconfigurable, independent, networked, geographically dispersed organizations including high level trust and competencies that collaborate and share their resources and competencies in order to better respond to business opportunities. An ideal virtual organization defines itself by common characteristics, absence of physical attributes, special auxiliary specifications such as no internal competition, and utilization effects such as flexibility and adaptability.

A virtual organization is always a form of partnership. Managing partners and handling of partnerships are crucial. Partners should collaborate in order to achieve business opportunities. Trust among them and operation according to a common agreement are essential things for collaborating. Networks or breeding environments are an appropriate context for effective creation of dynamic virtual organization. H. Afsarmanesh and L. M. Camarinha-Matos [1] have called this context as Virtual organization Breeding Environment (VBE) [9]. A VBE is defined an association of organizations and their related supporting institutes, adhering to a base long term cooperation agreement, and adoption of common operating principles and infrastructures, with the main goal of increasing both their chances and their preparedness towards collaboration in potential virtual organizations. A VBE should identify and obtain new business opportunities, know the competencies and capabilities of its members, then select an appropriate set of partners for creation of new VO.

Important attributes for good partnerships are basic principles of human interaction including fairness, trust, integrity, open communication, character, and honesty.

Virtual organization properties are listed into three groups: product and service (dematerialization and individualization), VO conditions and environment (delocalization and asynchronization), and atomization and non-Institutionalization are linked to how the virtual organization effectively operate. Researchers focus on temporary, delocalization, and dematerialization as shared properties in definition of virtual organizations [8].

3.2. Virtual Organization Breeding Environment (VBE) [9]

Efficient creation of dynamic VOs requires a proper environment that the members of new VOs are selected in it according to their capabilities and trust among them. The main goal of VBE is to improve the preparedness of its member organizations for efficiently creating VOs. To achieve this goal, VBE can even find some external organizations to join the VBE and select them as partners to establish a new VO.

Some benefits of VBE include:

- Agility in dynamic VO creation.
- Facilitating VO reconfiguration.
- Providing a bag of assets, resources, tools, policies, and knowledge for better collaborating among members. It also holds the past performance measurements of members for selecting in new VOs.
- Managing competencies and reduction of risk in selecting members for creating a VO.
- Defining criteria for evaluation of members trust with recording their performance history and introducing methods for building trust among the members.

Each VBE serves a specific domain and attempts to select the best members to achieve its specific aims in the domain. VBE such as VO consists of three stages creation, operation, and dissolution. These stages are briefly explained in the following:

1. **Creation:** VBE initiation and start up are two steps at this stage. Initiation is related to define objectives of the VBE, load base information of the domain, and establish plans and rules. Next step is to create common database, find new VBE members to join the VBE, and set up the VBE.

2. **VBE Operation and evolution:** This stage is the main part of VBE life cycle. Evolution occurs for the reason of some small changes in memberships or daily changes in working principles. Operations supported at this stage include management of rules and common knowledge, registration of new members including characterization of competencies, management of competencies and resources, and evolution of ontology for the considered domain.

3. **VBE Dissolution:** After fulfillment of the business opportunity by VO created into a VBE, the VBE should reorganize and keep knowledge collected during the VBE operation. This knowledge can be transferred to the VBE members or other organizations. As the large number of members and open systems are involved and integrated in E-business and VBE creation, the virtual world will need the automation in reconfiguring and healing them. If one of them is modified in VBE or added to VBE, the VBE will need to act correctly and effectively.

3.3. Issues and Trends

Since VO is fixing as a master component of dynamic collaborative networks, there are different issues and challenges in VO creation, management, design, and implementation. VO planning activities [10] can be another issue. It includes receiving and analyzing business opportunities, selecting proper partners, determining high level Work Breakdown Structure (WBS), and setting up VO. R. Camacho and et al [2] present a reference model for VO planning and launching. This model integrates the elements involved in VO creation in VO creation, modeling, and knowledge management dimensions.VO modeling is discussed in four views: Resource, organization, functional, and Knowledge. Unified Modeling Language (UML) can be used for creation of the VO models for each modeling view.

As a VO is composed of different members located at dispersed sites, different issues can affect the VO. Therefore, the VO management must be examined in different aspects. Some problems in the collaboration addressed are categorized in to people, technology, process, and context. Beside, competency management [1], communication between partners, trust [11] among them, trust management [12], and security [13] are important challenges from technical point of view. Inshort, communication between the partners, trust among them, VO planning, and security are important challenges from technical point of view.

4 Autonomous Virtual Organizations (AVOs)

Merging virtual organization and self-managing systems presents a new idea to cope with complexity management of virtual organizations as one of large-scale distributed systems. This section describes an autonomous virtual organization model.

4.1. Definitions and Properties

Autonomous Virtual Organization (AVO) is proposed as a solution in order to cope with complexity in VO management and develop large scale virtual organization with the aim of decreasing the cost of developing and managing the complex systems. An AVO manages itself while hiding their complexity from the view of end users.

One of agent characteristics in Multi-Agent Systems (MASs) is *autonomous* that can be effective in building AVOs. An autonomic element or agent plays the role of an organization or member in an AVO. Therefore, an autonomous virtual organization can be proposed with serving autonomous idea in a VO environment. This is a new idea although some projects have been defined about applying agent-based framework in VO [1] but for example self-healing implementation for each VO member has not been already discussed yet.

Benefits and some reasons for proposing this model include in the following:

- Reducing costs, complexity, and errors.
- Improving services and save time.
- Spreading costs and risks with partners.
- Improving functionality and capacity utilization.
- Autonomous access to new markets through partnerships.

As this model is autonomous, autonomous virtual organization is a self-management system with four main elements. *Self-configuration* means that an AVO dynamically configures and reconfigures itself under changing its members, components, and the conditions. *Self-healing* means that An AVO detects failed members or partners, eliminates them, or replace them with other members without disrupting the system. There are issues such as competency in this context. *Self-optimization* is the capability of maximizing resource allocation and utilization for satisfying customer requests. Access to knowledge base is one of issues. An AVO must identify threats and damages, prepare security technologies, and cover all aspects of security. Members should guarantee security in three aspects: legal, organizational, and technical. This property is called as *Self-protection*.

As mentioned, the aim of autonomous virtual organization is to improve the system abilities. Therefore, AVO characteristics affect various measurements of quality. Self-configuration improves maintainability, usability, functionality, portability, and stability. Self-healing increases reliability, adaptability, and maintainability. Self-

optimization improves efficiency, maintainability, functionality and flexibility. Self-protection enhances reliability and functionality.

4.2. Issues and Challenges

As an AVO is composed of different autonomous members located at dispersed sites, different issues can affect it. Therefore, the management must be examined in different aspects. People such as cultural and language barriers, technology such as data compatibility, process or project complexity, and context such as resources are basic problems that should be addressed. Other challenges in management include in the following:

- ***Trust*:** Trust means that one organization as a AVO member expects other to behave reliably in performing their tasks for achieving desirable goal of the AVO. Modeling is based on Trust. Modeling is an appropriate tools to enhance an AVO planning and implementation. Trust accelerates collaboration among members, enhances information sharing and knowledge creation, and reduces the management cost and transaction costs between the members. . In a VBE, trust can be built according to result of examining the history of past performance information recorded in the VBE. Designing an efficient algorithm for finding a member with respect to trust parameters can be another issue. Evaluating trust criteria is one of main challenges in an AVO model.
- ***Competency*:** Competency is a set of capabilities and skills that play the key role in partner selection for creating a new AVO. If the partners with high level competencies are selected, new AVO will be able to achieve its goal efficiently. The important issues associated to competencies include applying robustness in competency management, introducing approaches for dynamically competencies collection and updating, and designing an autonomic approach for collecting and upgrading competencies can be introduced as a challenge in this context.
- ***Security:*** Identifying threats and preparing security technologies are important issues. Each member in an AVO should autonomously support its own security and the common resources security. The important issues in security management include controlling access to resources by members at dispersed locations, security in communication between members, and data integrity. The important issues in security management of AVOs including members at dispersed locations are member authorization to control access to resources, security in communication between members, and data integrity.
- ***Negotiation:*** Each AVO member needs protocols and strategies to establish rules of negotiation and to manage the flow of messages among the negotiators. One of challenges is to develop and analyze negotiation algorithms and protocols. Determining an effective negotiation algorithm is one of issues in an AVO model.
- ***Project Management:*** An AVO coordinator should capture processes and the AVO member functions, coordinate them during the AVO life cycle, and improve cooperation.

5. Conclusion

Autonomous Virtual Organization (AVO) is a virtual organization system that manages itself while hiding its complexity from the view of end users. Each autonomic element in an autonomic system plays the role of an organization in an AVO. This paper describes an AVO model including its characteristics and main challenges. As future research, the following topics can be proposed:

- Designing an effective negotiation algorithm for collaborators in an AVO.
- Implementing trust learning and presenting main trust criteria.
- Examining robustness in an AVO system in order to maintain its functions in an active state and persistence.

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