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The challenge of networked enterprises for cloud computing interoperability

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ABSTRACT

Manufacturing enterprises have to organize themselves into effective system architectures forming different types of Networked Enterprises (NE) to match fast changing market demands. Cloud Computing (CC) is an important up to date computing concept for NE, as it offers significant financial and technical advantages beside high-level collaboration possibilities. As cloud computing is a new concept the solutions for handling interoperability, portability, security, privacy and standardization challenges have not been solved fully yet. The paper introduces the main characteristics of future Internet-based enterprises and the different CC models. An overview is given on interoperability and actual standardization issues in CC environments. A taxonomy on possible connecting forms of networked enterprises and cloud-based IT systems with reference on interoperability is introduced, parallel presenting four use cases as well. Finally, an example of connecting cloud and NE is presented as an effective application of cloud computing in manufacturing industry.

1. Introduction

Based on the results of the information and communications technologies (ICTs), a new "digital" economy is arising. This new economy needs a new set of rules and values, which determine the behaviour of its actors. Participants in the digital market realize that traditional attitudes and perspectives in doing business need to be redefined. In this dynamic and turbulent environment that requires flexible and fast responses to changing business needs organizations have to respond by adopting decentralized, team-based, and distributed structures variously described in the literature as, e.g. virtual-, networked-, cluster- and resilient virtual organizations/enterprises. One main aspect of this approach is that organizations in this environment are networked, i.e. inter-linked on various levels through the use of different networking technologies. The new organizational architectures need new information and communication architectures as well.

The architecture of the organizations is in a recursive connection with the IC systems; the IC technology offers new possibilities for restructuring the organization (and its business processes) itself, in other cases the new demands of a business process force the development of a special IC solution. The final goal of all information systems is to provide secure data-, information-, knowledge-, or different services for the users (human beings), and for firms, enterprises.

Today Cloud Computing (CC) is a hot topic, and according to Gartner Inc. there are three cloud-related topics (Hybrid Cloud and IT as Service Broker, Cloud/Client Architecture, The Era of Personal Cloud) among the top 10 strategic information technology list for 2014 [1]. Because of the very positive market forecasts every main player of the IT sector has already developed its own (different) CC architectures, platforms.

Cloud Computing is an important technology for Networked Enterprises, as it offers significant financial advantages (pay only for what you use, less in-house IT staff and costs, etc.) while offering high-level collaboration possibilities. In spite of these advantages the spread of CC in the practice seems to be behind the very optimistic forecasts. The main disadvantages lay in privacy, security and interoperability problems. The IT community tries to find the solution for these problems, e.g. with applying different Deployment Models; for the Networked Enterprises the Private Cloud – where the CC architecture is owned or leased by one, or by a closed group of enterprises – can be a solution.

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According to a survey [2] the biggest contradiction between expectations and results can be seen in operational cost savings, as the expected savings were 74% and only 41% was achieved. But organizations have to cut costs, so if early cloud investments prove that they lower costs, investments in cloud computing will increase. SMEs are moving to the cloud much quicker, because it allows them to get a role in the market above their size.

In cloud computing there is very fast evolution in every field because of the huge advantages offered for the enterprises. Interoperability, portability problems have to be solved in a short time (together with security/privacy) because these elements are the negative factors of the applications. The paper can give only a snapshot on the actual status of the standardization activities and results as many different organizations and groups are working hard in this field and their results can modify the situation introduced in this paper within a short time.

The paper introduces the main characteristics of NE and the different CC models, pointing out why CC can be an excellent solution for NE. The advantages and disadvantages of cloud computing are listed as well giving special focus on interoperability challenges. An overview is given on the interoperability and standardization issues of CC and a taxonomy is introduced on possible connection forms of networked enterprise architectures and cloud deployment models. Finally an example is presented briefly to show the application possibilities of cloud computing in production environment, in the manufacturing industry.

2. Challenges of networked enterprises for cloud computing

2.1. Main characteristics of networked enterprises

In order to fulfil the market demands the flexible, effective manufacturing system architectures become more and more popular around the world. Manufacturing enterprises have a geographically distributed nature, so computer networks for production management is an important feature of their operation. There are different approaches, different names that basically cover the same idea; a flexible network of co-operating autonomous manufacturing units. Enterprise architectures of this kind are, e.g. the collaborative enterprise, digital enterprise, smart organization, extended enterprise, virtual enterprise.

Main characteristic of theses architectures is that organizations in this environment are networked, i.e. inter-linked on various levels through the use of different networking technologies. Besides the Internet new (or pilot phase) solutions are offered; wireless networks (Wi-Fi and mobile), powerline communication (using the electric power grid), the Grid technology and lately the cloud computing.

The main characteristics of the digital economy for market participants are as follows:

- networking and horizontal communication, including the smart product,
- networked environment,
- knowledge-based technologies,
- simplification and coordination of structure,
- customer focus and real-time, ubiquitous responsiveness to technical and market trends (what customers want, anytime, anywhere),
- flexibility, adaptability, agility, mobility,
- organizational extendibility, virtuality,
- shared values, trust, confidence, transparency and integrity,
- ability to operate globally co-operating with local cultures.

In this turbulent environment only those organizations can survive which effectively apply the results of the different disciplines.

2.2. Collaboration in networked enterprises

The collaboration and cooperation are main characteristics of networked enterprises, so the contacts among the users, the human beings have outstanding importance. A very important element of this human contact is trust. In a networked organization, trust is the atmosphere, the medium in which actors are moving. Trust is the base of cooperation, the normal behaviour of the human being in the society. As the rate of cooperation is increasing in all fields of life, the importance of trust is evolving even faster.

Himmelman developed a hierarchy of partnerships [3]. The levels of this hierarchy are distinguished from each other by the amount of trust, time, and risk needed to establish and maintain the partnership. In Himmelman's framework, networking, coordinating, cooperating, and collaborating mean different concepts and are built on each other. Collaboration means **e**xchanging information, altering activities, sharing resources, and *enhancing the capacity of another* individual or organization for mutual benefit and to achieve a common purpose.

A new approach, the collaborative network paradigm has been developed and described in [4] that covers the main characteristic of all different networked units providing a framework to describe these organizations. A collaborative network (CN) is a network consisting of different entities (e.g. organization units and humans) that are autonomous, geographically distributed, and heterogeneous considering their operating goals, environment, social capital and culture. The collaboration is supported by computer network and makes possible to achieve common or compatible goals easier, thus generating joint value.

Most forms of collaborative networks can be connected to an organization that covers the activities of its units, giving rules for the participants. These organizations can be called as collaborative networked organizations (CNOs). The key concept related to CNOs is described in [5] parallel providing a high level classification of collaborative networks, and introducing some application cases in the manufacturing industry.

The virtual enterprise (VE) has a dynamic and least of all stable nature in the CNOs. In a VE capabilities and competencies coming from different enterprises are put together but no node in the network plays a central role. This is a temporary association of existing or newly created business entities offered by several companies to form a new agile business entity to satisfy a one-off market need. The communication and collaboration is on highest level in VEs, so the need for interoperability, portability and security is the highest in these organizational architectures.

2.3. Trends in networked enterprises

Forecasts and reports on the future of manufacturing and the connected organizations (factories, enterprises) are regularly published by different institutes, committees to appoint the research directions, themes in this field. The Industrial Advisory Group working for Unit G2 issued a report with the title "Factories of the Future PPP – Strategic Multi-annual Roadmap" [6].

In this study it has been stated that the successful development of high added value technology should consider the following strategic sub-domains:

- sustainable manufacturing;
- ICT-enabled intelligent manufacturing;
- high performance manufacturing;
- exploiting new materials through manufacturing.

The further integration of any newly developed ICT into the production and the industrial environments requires complementary research and innovation efforts. These integration aspects will