A NEW PARADIGM OF ENGINEERING WORK ENABLED BY INTERNET-BASED VIRTUAL ORGANISATIONS[1]

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Abstract. *Recent ICT developments have resulted in emergence of new forms of net-based organizations. Those organizations, often called Virtual Organizations (VOs), aim at supporting engineering work by offering to engineers new on-line services that should enhance their creativity and efficiency. The paper highlights a new paradigm of collaborative engineering work that is enabled by VOs' services. These services, as well as, the organizations offering them, i.e.: engineering-related e-commerce VOs, information brokers for engineers, engineering networks, and virtual libraries, are outlined in the paper. Conclusions envision a potential impact of these new technologies onto engineering work.*

1 Introduction

At the very beginning the Internet served mainly researchers in exchanging scientific and technological data. Through years it has developed to a global network with an immense spectrum of applications. Especially invention of WWW (World Wide Web) by Tim Berners-Lee [1] in 1991 influenced its universality and further strengthened its role as enabler for wide area collaboration. Voice over IP and other broadband services like, e.g. distance learning, video on demand, multimedia distributed databases, teleworking are changing collaboration paradigms, and especially those over wide distances. Latest information and telecommunication technologies (ISTs) offer new possibilities for establishing organizations that are entirely built upon new information infrastructures, most predominantly on the Internet. These organizations are referred as ***virtual organizations*** (VOs), sometimes also as smart organizations [5], or extended enterprises [4]. These are dynamic, networked organizations that are characterized by a dynamic and time-limited collaboration between partners. Often they offer technical facilities for conducting collaboration over wide distances.

This paper is concerned with engineering collaboration aspects in VOs. The attention is given to engineering services offered by VOs. They are shortly overviewed and classified in the following section. This overview brings a reflection on the most known engineering VOs and their operations. It should bring also some justification for the thesis concerning a change in engineering paradigm. Finally, we provide some remarks on the influence of the Internet-based VOs on design practices.

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2 Engineering Virtual Organizations and their services

Virtual Organizations are the new phenomena that have arisen lately in the Internet and in the domain of distributed computer-aided design and manufacturing systems. Butlje and van Wijk [2] point out some key characteristics of VOs and consequently constructed this general, working VO definition: "A Virtual Organization is primarily characterized as being a network of independent, geographically dispersed organizations with a partial mission overlap. Within the network, all partners provide their own core competencies and the co-operation is based on semi-stable relations. The products and services provided by a Virtual Organization are dependent on innovation and strongly customer-based."[2]

The objective of this paper is to view the domain of VOs from the engineering services perspective. Authors have investigated VOs state-of-the art especially analyzing the services that are offered to engineers. Services vary from a simple access to information to support to a team engineering work based on the Internet. Services and the organizations offering them are shortly described in this section and summarized in **Table 1.**

2.1 Engineering-related e-commerce Virtual Organizations

E-commerce VOs can be relevant to engineers in different ways, but the most significant thing is that they spread a new way of acting. They propagate ideas of electronic data interchange often proposing XML (extensible markup language) as a method to do this. It is very useful for engineers cause gives them possibility to conveniently acquire data necessary in a design process. They proliferate among engineers new useful technologies, like: intranets, extranets, B2B, B2C. They demonstrate how these technologies can be applied in engineering work. Some of these organizations aim at definition of new standards for technical data exchange. Examples of such organizations are Rosseta Net and Silicon Integration Initiative Inc. (Si2). ***Rosseta Net*** (http://www.rosettanet.org) is an independent, self-funded, non-profit consortium dedicated to improve and use standard electronic business interfaces. The consortium comprises IT (Information Technology), EC (Electronic Components) and SM (Semiconductor Manufacturing) companies. The organization works towards creating and implementing industry-wide e-business process standards. RossetaNet establishes standard processes for the electronic sharing of information concerning business and technology. It creates a new way of communication between partners in a supply chain, which enables perfect real-time information, efficient e-business, dynamic trading-partner relationships, and new business opportunities. ***Silicon Integration Initiative Inc.*** (http://www.si2.org) is an organization of industry-leading silicon systems and tool companies focused on improving productivity and reducing cost in creating and producing integrated silicon systems. Si2 achieves it: by providing dedicated support services that accelerate adoption of solutions, transferring technologies that reduce complexity of silicon design and integration, and facilitating collaborative customer-driven solutions definition, development and implementation.

2.2 Information Brokers for Engineers

Information brokers are companies that supply engineers with components of intellectual property. IP components are catalogued in databases that are kept and managed by the brokers. Brokers often provide links to producers' and other sites where one can enrich information obtained from them. The IP gathered and exposed by brokers carries important engineering knowledge that is a key element in a design process of today's SoCs (System-on-Chip). Except for the IP that can be directly reused for design, the companies provide

news, research, marketing and trading services as well as IP design tools. New information brokers for engineers like a French company ***Design & Reuse (D&R)*** (http://www.design-reuse.com) play the role of an IP - trading center with IPs organized in catalogues. Also tools and services for SoC validation and IP Exchange are offered on this particular portal. D&R plays a role of an eCommerce center that stimulates the IP business through reuse of IP components. D&R collects market IP requests and makes dialog forums between potential suppliers and customers, thus creates an innovative e-commerce negotiation process. Nowadays D&R has reached over 17000 registered users. The D&R IP Catalogue allows to access a documentation of over 1750 cores from 190 vendors of ASIC and PLD technologies. Other engineering information brokers are ChipCenter & QuestLink (CC&QL) and VCX - Virtual Component Exchange. ***CC&QL*** (http://www.chipcenter.com or http://www.questlink.com) serves the information for electronics design professionals. ChipCenter provides free access to in-depth, reliable editorial contents that is difficult to find anywhere else. QuestLink gathers component reference data from major manufacturers so a design engineer does not have to surf all over the web to find it. A design engineer can use on-line available tools, product reviews and data sheets. ***VCX*** (http://www.vcx.org) is an eCommerce organization that facilitates B2B transactions in IP by providing international, open market infrastructure. It has already delivered the "VCX TradeFloor" - the Internet-based system for trading Semiconductor IP and VCs (Virtual Components).

2.3 Engineering networks

Engineering networks (ENs) are the virtual commercial organizations. Most of them concentrate on providing information and services to engineers. In this way they are very similar to information brokers. Unlike information brokers they unite engineering companies and present their offers in the network. Additionally, there is ***Global Engineering Networking Initiative (GENI)*** (http://wwwgen.uni-paderborn.de) that conducts various projects to develop and implement new internet-based design methodologies. By these projects GENI influences a new paradigm of engineering and helps establishing public collaborative ENs that can be a medium for running concurrent engineering work. Nonetheless, there are still many ENs which provide to the engineering community only subject classified information and links to various technology companies. Examples of ENs are: Canadian Engineering Network (CEN), Electronics Engineering Network (EENet), Electronics Design, Technology and News Network (EDTN), as well as Design NET. ***CEN*** (http://www.transenco.com/) supplies an interactive database for the Canadian engineering, construction and architectural community. Network members may present their services and products to a local and global market. Both its members and users can access, utilize and distribute industry-related information. All members are catalogued according to company name, type of service or product and specialization domain. There are several tools and resources which individuals and organizations can utilize. ***EENet*** (http://www.eenet.com) provides to the electronics community information on companies dealing with different types of electronics and various sorts of electronics application. Through existing links to different organizations and institutions concerned with various technology aspects, one can get to interesting databases and engineering tools – all rather provided by third parties. ***EDTN Network*** (http://www.edtn.com) provides electronics engineers with access to the most relevant, industry specific information available. The access is to professional information, design and decision support tools, reference materials and e-search of everything necessary to help electronics design professionals enhance their expertise, make smarter design decisions and complete projects. ***Design Net*** (http://www-cdr.stanford.edu/SHARE/DesignNet.html) is a network directory of computer services that

directly support designers and engineers in obtaining information, services, and contacts with other designer and engineers, as well as students. It comprises links to electronic multimedia documents, prototype fabrication pages, product catalogues, collaborative design tools, and virtual libraries.

2.4 Virtual Libraries

Virtual libraries (VLs) are catalogues placed in the Internet. These catalogues list interesting Internet resources related to a specific subject. VLs give also access to search engines that look through the sites linked with the VLs. Information found with the help of the VL is very up-to-date since the links collected are systematically updated (in many cases daily). Examples of VLs include: WWW Virtual Library (WWW VL), Edinburgh Engineering Virtual Library (EEVL), and IEEE Xplore. ***WWW VL*** is the oldest catalogue of the web. Unlike commercial catalogues, it is led by a free confederation of volunteers, who compile pages of key links for particular areas in which they are expert. Individual indexes exist on many different servers around the World. Catalogue pages linking all these indexes are maintained at http://vlib.org. All server administrators are responsible for the content of their own pages, as long as they follow certain rules decided by the free association. ***EEVL*** (http://www.eevl.ac.uk) is an UK-based guide for engineering community to useful engineering Internet resources. It is a free service, established and led by a team of information specialists from Heriot-Watt University, with input from a number of other universities in the UK. The site comprises engineering search engines and a catalogue of quality engineering resources - over 5,000 web sites, with new sites added daily. Resources being added to the catalogue are selected, catalogued, classified and subject-indexed by experts. ***IEEE Xplore*** (http://ieeexplore.ieee.org) is an online delivery system that provides access to IEEE's transactions, journals, magazines and conference proceedings published since 1988 and all current IEEE standards.

Table 1. Engineer-oriented VOs as an enabling factor for collaborative engineering

Attribute: **Organization:**	**Data Access**	**Data Category** **Type of IP** **Data search**	**Services and products**	**Business model**
Engineering-related E-commerce VOs	• Only to members	• Information concerning projects and their results. • Data categorized. • Search engines.	• Information, services, tools in a domain of organization activity.	• Not-for-profit organizations.
Information Brokers for Engineers	• Free access. • Sometimes registration required.	• Catalogued information. • Yellow pages. • Search engines.	• Information. • Trading with engineering tools and services. • IP trading centers.	• Commerce companies.
Engineering Networks	• Free access.	• Databases with companies. • Categorized engineering information. • Search engines.	• Information • Advertising. • Consulting services. • Design tools providing.	• Commerce companies.
Virtual Libraries	• Free access. • Registration for those to be listed.	• Catalogues of various engineering information with links to many sites. • Search engines.	• Information - mainly links to engineering resources.	• Free associations or university initiatives supported by other parties.

3 Conclusions about the influence of engineering VOs on design practice

Engineering design methodologies are changing since many organizations aim at exploiting new opportunities given by fast growth of IT - particularly the Internet. As a result many new services are being offered to engineers. These services comprise: Electronic Data Interchange (EDI), IP search, on-line trading (selling and purchasing), advertising, consulting, and possibilities for collaborative work (proper applications like calculation and simulation programs and design tools). These services are offered by the organizations like: e-commerce VOs, information brokers, engineering networks, and virtual libraries. They help engineers to gather information quickly and smoothly. The information is more and more up-to-date and accurate. Designers can easily access IP cores that can be directly utilized for their projects, so they do not need to design from a scratch. On-line access to value added engineering information (IP components, standard components data catalogues, and validation) is very important and helpful technology that comes in a right moment, when engineering community face a complexity barrier of modern ICs, or more precisely System-on-Chip design. New design methodologies based on design and reuse are feasible with an easy access to design components offered by information brokers and VLs. Collaborative Internet-aided design is based on reuse and composition of a system from components available on-line. In order to enable these strategies, digital libraries accessible on-line store and properly organize information about products and their specifications.

In general, design methodologies based on re-use of IP components are well supported by engineering-oriented VOs. Purchasing materials for projects is also faster and more convenient, especially due to the access to distributed databases. New engineer focussed services offered by VOs that have been shortly discussed in the paper predominantly influence design methodologies. They become more and more Internet-based.

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