Virtual Organisations Enabling Net-based Engineering*

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Abstract New forms of organisations that are net-based have emerged due to new IC technologies. These organisations, often referred as Virtual Organisations (VOs) support all sorts of eWork, eBusiness and eCommerce activities. In particular, they support engineering work by offering to engineers through the Internet a set of new services. These services, as well as, the organisations offering them, are outlined in the paper. The paper presents the main types of VOs enabling net-based engineering, i.e.: engineering-related eCommerce VOs, information brokers for engineers, engineering networks, and virtual libraries. Their services are primarily information and tool delivery. Examples of them are described. As a conclusion, benefits for design engineers together with an industrial significance of new collaborative type of engineering work based upon these services is emphasised.

1. Introduction

The work presented in this paper was motivated by an evident need for a study on how the Internet can enable new forms of engineering work. The objective was to demonstrate to electronic engineers possibilities for improving the way they work through the use of electronic services that are available over the Internet. We look at the engineers' oriented electronic services through a perspective of virtual organisations (VOs). Emerging VOs are the result of recent developments in information and telecommunication technologies (ICT). They offer new technological possibilities for establishing organisations that are entirely built upon the Internet. VOs are sometimes referred as smart organisations [1], eventually also as, extended enterprises [2]. These are dynamic, networked organisations that are characterised by a dynamic and time-limited collaboration between partners. They offer to engineers new on-line services supporting engineering design and often based on sophisticated tools that can be used in collaborative work.

This paper considers the most known Internet-present engineering VOs and their operations. The attention is given to engineering services offered by the VOs. The services were found directly on the VOs' web sites. The performance of some of them was examined. Hence we could conclude about their usefulness for designers. Here the services are shortly overviewed and classified to give engineers hints about possibility to use them in net-based engineering activities. The paper should also bring some justification for the opinion concerning a change in engineering design methodology, especially electronics system design.

The remainder of this paper is organized as follows. The next section gives some foundation of VOs, a few words about a research methodology and consequent categorization of engineering VOs with examples of VOs of which some are shortly described. In section 3 services offered by VOs are described. They are presented in relation to the main types of VOs. Potential benefits for engineers are also mentioned. In

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the last section some conclusions on the influence of the Internet-based VOs on design practices are provided and some predictions for future developments are given.

2. Virtual organisations enabling net-based engineering

Virtual Organisations are the new phenomena that have shown off recently in the Internet and in the domain of distributed computer-aided design and manufacturing systems. Literature brings various definitions of VOs what makes understanding of VOs taxonomy a real challenge. Nonetheless, we would like to refer to work of Butlje and van Wijk who point out key characteristics of VO in their general, working definition: "A Virtual Organisation is primarily characterised as being a network of independent, geographically dispersed organisations 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 Organisation are dependent on innovation and strongly customer-based."[3]. General characteristics of VOs were also pointed out by Jansen in [4]. We have selected key characteristics [3, 4] which, in our opinion, at best describe engineering VOs under investigation. They are collected in Table1.

Table 1 Key characteristics of Virtual Organisations

VIRTUAL ORGANISATIONS:
♦ Boundary crossing
♦ Complementary core competencies
♦ Sharing of knowledge
♦ Network of independent organisations
♦ Geographical dispersion
♦ Changing participants
♦ No hierarchy – participant equality
♦ Based on information technology (electronic communication)

Our investigation of Virtual Organisations was limited to the engineering related VOs. We searched throughout the Internet looking for web sites cooperatively created by different organisations working as associations, consortia or commerce companies. The prime interest was in the sites offering services to engineers. Not all services could be directly used on-line, some of them were only described or advertised, other were available upon certain conditions (e.g., registration). If it was possible we tried to employ accessible services. Their usefulness was tested. According to this usefulness, as well as to the type of services offered and to the way the engineering VOs work we have classified VOs into four main categories: engineering-related eCommerce VOs, information brokers for engineers, engineering networks, and virtual libraries, as it is depicted in Figure 1.

2.1 Engineering-related eCommerce Virtual Organisations

Engineering ECommerce VOs propagate among engineers a new way of acting. They spread ideas of electronic data interchange. Electronic data is suggested to be in XML (extensible markup language) format. It is very useful for engineers cause gives them possibility to conveniently acquire data necessary in a design process. They inform engineers about new useful technologies, like: intranets, extranets, B2B, B2C, etc. Some of these organisations work on invention and implementation standards for business and technical data exchange. The VOs sometimes support engineers in employing new Internet solutions. Examples of such organisations are: Rosseta Net (http://www.rosettanet.org) and

Silicon Integration Initiative Inc. (http://www.si2.org), CommerceNet (http://www.commerce.net), PartNet (http://www.part.net).

RosettaNet is an independent, self-funded, non-profit consortium dedicated to improve and use standard electronic business interfaces. The organisation establishes standard processes for 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. Companies adopting RosettaNet reduce costs, raise productivity and their end-users appreciate speed and uniformity in purchasing practices.

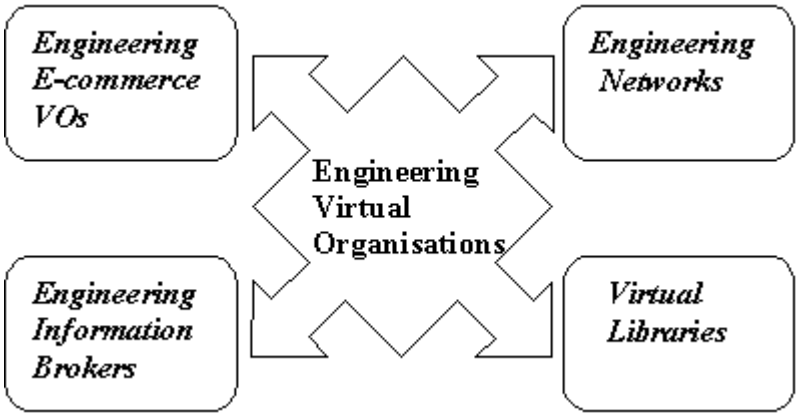

Figure 1 Classification of engineering Virtual Organisations

Silicon Integration Initiative Inc. (Si2) is an organisation of industry-leading electronics companies focused on improving productivity and reducing cost in creation and production of integrated silicon systems. Si2 achieves this by providing dedicated support services, which 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 (Intellectual Property) components are catalogued in databases that are kept and managed by the brokers. Often brokers enrich information they serve by providing links to producers' and other sites, where more information is available. The IP-related information that is gathered and exposed by brokers carries important engineering knowledge that is a key element in a SoC (System-on-Chip) design process. In addition, IP brokers provide news, research, marketing and trading services, as well as IP design tools. Examples of engineering information brokers are: Design and Reuse (http://www.design-reuse.com), ChipCenter & QuestLink (http://www.chipcenter.com or http://www.questlink.com), Virtual Component Exchange - VCX (http://www.vcx.org).

Design and Reuse (D&R) is an Internet-based French company that provides services in the SoC business mainly for hardware reuse and validation. It plays a role of an eCommerce centre that stimulates the IP business through reuse of IP components.

ChipCenter & QuestLink satisfy information needs of electronics design professionals. ChipCenter provides free access to component reference data from major manufacturers. Hence designers do not have to surf all over the Internet to find it. Design engineers can also use on-line available tools, product reviews and data sheets.

2.3 Engineering networks

Engineering networks (ENs) are virtual commercial organisations. They focus their activities on providing information and services to engineers. In this way, they are very similar to information brokers. However, they unify industrial engineering companies and present their offers on the web, while information brokers mainly serve information collected from different sources and not necessarily industry related. ENs provide to the engineering community subject classified information and links to various technology companies. Examples of ENs are: Canadian Engineering Network (http://www.transenco.com/), Electronics Engineering Network (http://www.eenet.com), Design Net (http://www-cdr.stanford.edu/SHARE/DesignNet.html), as well as Electronics Design, Technology and News Network (http://www.edtn.com).

Canadian Engineering Network (CEN) 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, utilise and distribute industry-related information. All members are catalogued according to company name, type of service or product and specialisation domain.

EENet (Electronics Engineering Network) provides to the electronics community information on companies dealing with different types of electronics and various sorts of electronics application. In the EENet directory one can also find many links to different organisations and institutions concerned with various technology aspects. The access to EENet resources is open to everybody without any fees. EENet maintains itself due to paid advertisements.

Electronics Design, Technology and News Network is one of portals led by CMP Media LLC. The EDTN Network 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 in a central location. EDTN also links with numerous network partners.

Except for the shape of ENs described above there is another idea for the way engineering networks work. It is still under development by a group of European companies and organisations which in 1995 have set up the Global Engineering Networking Initiative (GENI) (http://wwwgen.uni-paderborn.de) - an open co-operation of industry and university partners. This organisation conducts various projects that develop and implement new internet-based technologies and design methodologies. With these projects GENI contributes to establishment of collaborative networks that can be a medium for running concurrent engineering. The association promotes global engineering networking and provides an experimental global electronic market place for engineers. The concept concerns a public collaborative network with intelligent nodes and services for large-scale distribution and control of engineering knowledge.

2.4 Virtual Libraries

Virtual libraries (VLs) are catalogues located 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 links collected are systematically updated. Examples of VLs include: WWW Virtual Library (http://vlib.org), Edinburgh Engineering Virtual Library (http://www.eevl.ac.uk), IEEE Xplore (http://ieeexplore.ieee.org).

The WWW Virtual Library (WWW VL) is the oldest catalogue of the web. It is led by a free confederation of volunteers, who compile pages of key links for particular areas in which they are experts. WWW VL pages have the highest-quality guides to specific parts of the web. Individual indexes exist on many servers around the World. A central catalogue linking these pages is maintained at the server with the www address mentioned above.

EEVL (the Edinburgh Engineering Virtual Library) 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. EEVL is a central access point for various networked engineering information.

3. Services of engineering virtual organisations

Since the Internet is a rich source of engineering information (product and IP catalogues, patents, technical specifications, research papers, e-journals and other resources available directly on-line) it can be time-consuming for an engineer to locate the proper information. In addition, there is no assurance that the information found is reliable. Common and popular search engines very often give thousands of results from which most are useless for professionals. So, trustful and credible services offered by the Internet-based VOs that effectively help in finding in the most convenient way the most useful information are critically important to engineers. Thus, the most meaningful service is “an information delivery”. There are different types of this service depending on how, in which form and by whom the information is delivered. Another important VO service is “a tool providing”. Tools available directly on-line are very useful for processing data and for design. Sometimes they support collaborative engineering work. Engineers located in different places can easily access tools served by VOs. Often one can use them running an application directly in web-browser. Other time one can download certain programs and then install them on a local computer. In latter case free download concerns only demo versions of programs. There are also additional services like consulting, advertising (etc.). Here all these services are described with more details and with references to the organisations by which they are given. General comparison of services provided by different types of VOs is shown in Table 2.

3.1 Information delivery

Information provided by eCommerce VOs, most often in HTML, concerns area of their activity and projects conducted. Usually information in the full extent is revealed only to members giving them a global perspective on electronic commerce. Research provides members of eCommerce VOs with knowledge about trends in technology (e.g. XML-based new standards), applications, and new eCommerce-based business models. It encourages to do business over the Internet and to take advantage of emerging business opportunities.

Information brokers supply on-line access to value added engineering information (IP components, standard components data catalogues, and validation). An IP can be searched with the use of an ordinary www browser. This 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 SoC design. New design methodologies based on design and reuse are feasible with an easy access to design components. Organisations like Virtual Component Exchange or a French company Design & Reuse play the role of an IP trading centres with IPs organised in catalogues. The catalogues contain data proper for making selection of an IP. The D&R IP Catalogue allows to access a documentation of over 1750 cores from 190 vendors of ASIC and PLD technologies. Access to the IP database is

provided upon on-line registration. After the registration one has an access to information on all IP cores and on-line available tools. D&R installs highly protected servers to ensure secure and efficient IP transfer. On D&R pages one can find both a hard core and soft core IP. All they are catalogued according to a taxonomy provided with use of the XML format [5]. Due to this, one can easily find an interesting IP moving along branches of the taxonomy tree.

Engineering Networks deliver technical information about various types of engineering. This information sometimes is collected on a web site managed by the EN (e.g. Canadian EN), or one can get to the information gathered in databases on other sites through existing links (e.g. EENET). Very often the information is industry-related and indicates where certain services or products are accessible. ENs give access to engineering companies databases. ENs also support designers and engineers in obtaining contacts with other designers and engineers, as well as students. They comprise links to electronic multimedia documents, prototype fabrication pages, product catalogues, collaborative design tools, and virtual libraries.

Virtual libraries sites comprise catalogues of quality engineering resources with links to these resources gathered on various web sites all over the World. In many cases new sites (with their addresses) are added daily. Resources being added to the catalogue are selected, catalogued, classified and subject-indexed by experts to ensure that only useful, high-quality and up to date resources are included. Other information accessible in VLs sites are targeted engineering search engines (e.g. the engineering e-journals search engine, the engineering newsgroups search engine), bibliographic and events databases.

Table 2 Comparison of services offered by engineering VOs.

E –commerce engineering VOs	**Information Brokers for Engineers**	**Engineering Networks**	**Virtual Libraries**
• Accessible only to members • Information concerning the projects conducted and their results • Data categorised • Search engines • Information, services, tools in a domain of organisation activity	• Free access • Sometimes registration required • Catalogued IP information • Search engines • IP trading centres • Trading with engineering tools and services	• Free access • Databases with companies • Categorised engineering information • Search engines. • Industry information • Advertising • Consulting services • Design tools	• Free access • Registration for those to be listed • Catalogues of various engineering information with links to many sites • Search engines

3.2 Tool providing

ECommerce VOs try to work out new standard tools useful for technical and business information exchange. However they do not make these tools accessible for parties from outside of their member circle. However, electronics companies are encouraged to participate or at least be aware of projects conducted by organisations, like RossetaNet or Si2, which are certainly useful tools for SoC or EDA design. Examples of such project activities are: ECIX, OLA in case of Si2.

Information brokers deliver tools for SoC validation and IP exchange, as well as tools for the convenient eCommerce trading negotiations. An example is Design & Reuse Company that offers two types of software-services in the SoC validation area:
1) An IP validation service package containing IP FPGA mapping, IP outlining on the Internet, validation service through code coverage estimation and enhancement and possibly property or model checking.
2) A complex design prototyping software and service for multi FPGAs possibly with timing driven I/O multiplexing.
In IP exchange technologies D&R presents two innovative tools [5]:
1) Software called "IP catalogue Builder" that can assist a corporation in creating its intranet IP catalogue according to internal or standard requirements. The catalogue can be created immediately ready for upload and download through intranet as well as Internet. Its content is completely under control of the company and can bring together several heterogeneous catalogues.
2) "XML IP Profiler" is a tool that allows to display the IP socketization in terms of the delivery files also called packaging files of the IPs. It is user-friendly and it is oriented for information upload and information reading or file download. It contains various tests, verification procedures and all qualification data required. What is the most important, it produces an XML description of the IP. This XML labelling of the various files allows an easy upload and download among several data bases.

VCX 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).

ChipCenter &QuestLink deliver on-line design tools for electronic components. Tools can run directly in a web-browser. Examples of the tools are: Active Filter Wizard which synthesizes a circuit diagram from specifications provided and simulates its performance, or Instrumentation and Operational Amplifiers Simulator. All presented tools are supplemented by descriptions and articles. Engineers can find here also links to vendors on-line tools.

Engineering Networks serve tools for specific engineering information search (search engines). Some of the ENs deliver design tools – usually still in demo versions. Other ENs, like for instance ETDN are linked with sites of information brokers serving on-line tools.

3.3 Other VO services

Other services offered by engineering VOs, mainly by ENs, are: advertisement, consulting, help in establishing of WWW sites. The last, when well organised, improve companies communication with their existing or potential clients by offering them an immediate access to updated information on services and products offered.

4. Conclusions

Recent trends in changing engineering paradigm into more collaborative one result also in the fact that development of new products combines efforts of more individuals. Especially in electronics engineering many professionals have to work on new SoCs – System-on-Chips. Use of new information technologies and computer networks becomes indispensable in engineer's everyday work. Anyway, engineers have to learn a lot about new collaborative engineering technologies. This educational role is fulfilled by engineering related eCommerce VOs.

Virtual engineering organisations influence the way engineers work nowadays. These organisations offer some new services which help engineers and make their labour easier.

Currently available services in the Internet are information and tool providing. The latter one includes: EDI (electronic data interchange), on-line trading (selling and purchasing), design applications (giving possibilities for collaborative work). These services are offered by the organisations like: information brokers, engineering networks, and virtual libraries. Thanks to them engineering information can be gathered quickly and smoothly, and is up-to-date and accurate. Designers can easily access IP cores that can be directly utilised for their projects, so they do not need to design from a scratch. 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.

As it was stated before some of the VOs support a team engineering work based on the Internet primarily by offering design tools or their demos. Hence, future of collaborative engineering seems to be in the Internet communication assisted by services offered by VOs. Offered tools still need to be further developed and more openly rendered. Besides the engineering work based on VOs services, there are special design platforms realised in corporation intranets or used by virtual enterprises. Designers working on these platforms can also utilise outside distributed databases. There are many research and industrial projects working in this area and developing engineering knowledge bases and catalogues using multimedia techniques, as well as establishing standards for the intelligent access to the distributed catalogues information.

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