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DESIGNING A HUB TO OFFER E-ENGINEERING BROKERAGE SERVICES FOR VIRTUAL ENTERPRISES

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The integration between customer and suppliers in Virtual Organizations requires a better collaboration through the use of Information and Communication Technologies. The phases throughout product development process are executed among engineers in different companies, probably geographically distributed. Engineering service providers can work as Engineering HUBs to offer e-services for industrial networks collaboration in virtual product development teams. This paper describes different e-services offered by engineering HUBs, as well as a classification of the information technologies needed to create collaborative environments. Web services are proposed as an alternative technological solution to build-up engineering e-services. Likewise, applications and tools which have been identified to support collaboration among engineers will be described based on the experiences of two pilot projects.

1. INTRODUCTION

Collaboration, coordination and information/knowledge sharing among companies has been defined key enablers in product development by the philosophy of Concurrent Engineering, were multidisciplinary teams are organized in order to integrate all areas involved in a specific project through customer requirements to product disposal. Therefore product realization in Virtual Organizations involving different companies requires better integration throughout the product life cycle using Information and Communication Technologies. The different phases throughout product development process are executed among engineers from different companies possible at geographically distant locations. Companies must use suitable computer supported tools to facilitate the cooperation, collaboration and coordination of engineering task, with the participation of all the areas (sometimes companies) involved in product development processes. These tools support engineering activities, automate methodologies and techniques used by the engineering teams, enabling better execution times and reducing costs (e.g. travel expenses for face to face meetings). Also collaborative tools allow engineers to communicate and share information regardless geographically distant locations. The necessity of remote collaboration is placing more pressure to engineering teams to develop new computer tools in order to enable simultaneous engineering work. Several years ago the concept of concurrent engineering, begin with the cooperation among engineers inside a company in order to involve all the areas related in a product development process (Molina et al 1995). Afterwards, the collaboration of external partners was getting more importance to perform customer driven product development and co-engineering activities with suppliers. Distant engineering has become an important issue in global product creation. Multidisciplinary teams in remotely location are defined, including people from all functional areas. The concept of Concurrent Engineering is evolving into Collaborative Engineering, because of the industrial globalization, were the extended enterprise concept makes different companies get involved in the product realization process. For example, the OEMs (Original Equipment Manufacturers) are involved in the design of a product which requires the collaboration with the tool manufacturer and manufacturing supplier. All these three actors could be located in different regions. That means, if the companies want to involve all the areas involved in the life cycle of a product, they will require interaction with engineers from its own company, as well as customers, allies and suppliers all around the world. That's why the concept of collaborative engineering has been conceived, trying to offer the solution to this world wide industry needs.

2. E-SERVICES OF AN ENGINEERING HUB

In the creation of industrial networks for Virtual Organizations creation, a Broker entity has been identified, not only to exploit business opportunities in the product transfer to Small and Medium Enterprises (SMEs), but also as a low cost service provider to those SME whose technological capabilities are limited (Mejía and Molina 2002). An engineering HUB is an integrated set of services offered by a Broker entity to provide information systems services to carry out engineering and manufacturing activities. There are six integrated e-Services that an engineering HUB should offer as center for on-demand e-services for value added industrial networks: e-Marketing, e-Brokerage, e-Planning, e-Engineering, e-Supply and e-Productivity.

- *e-Marketing* to support promotion of products and services of industry *networks of SMEs.*
- *e-Brokerage* to underpin the exploitation of business opportunities for the creation of supply chains using Virtual Enterprises based on SMEs.
- *e-Planning to use collaboration platforms offering shared project workspaces for team building, group communication, project management methods, contract management and process representation.*

- *e-Engineering to establish environments that foster collaboration among engineering groups to support integrated product development*
- *e-Supply integrates services related to e-factory, e-logistics for importing and/or exporting materials/products, supplier and customer relation management.*
- *e-Productivity integrates technologies for the diagnosis, evaluation and monitoring of industry networks of SMEs.*

The present paper will be mainly focused on the required technologies to allow the creation of information systems to be offered as e-services to support Collaborative Engineering activities (e-Engineering).

3. INFORMATION TECHNOLOGIES FOR COLLABORATIVE ENGINEERING

Computer based information systems have been introduced to support collaborative engineering services, which integrates all the activities, methods, information and technologies to conceive the complete Product Life Cycle. Based on the mentioned considerations, a classification of the system can be as follows:

- FUNCTIONAL: Function oriented systems that support engineers in specific task: CAD, CAM, CAE and Rapid Prototyping.
- COORDINATION: Coordination systems to support sequencing of activities and flow of information. For example: workflow and project management.
- COLLABORATION: Collaboration systems to foster cooperation among engineer i.e. CSCW - Computer Supported Cooperative Working.
- INFORMATION MANAGEMENT: Product information management systems and Knowledge Based Engineering Systems to enable the exchange of product and manufacturing information and knowledge.

Table 1 describes the concepts and most commonly used tools in integrated product design process under a Collaborative Engineering approach. For each type of product or process, these tools may change, but in general these categories include the necessary tools in order to enable the integrated product development supported by information technologies.

4. INFRASTRUCTURE FOR INTEGRATION: WEB SERVICES

In order to integrate the different kind of application and tools used in engineering, an emerging concept in the Information and Communication Technologies field is proposed by authors: Web services. Recently, new architectures based on proven computing standards, called Web services, are being championed by Microsoft, Sun, IBM and other major technology providers, which promise to allow users to bridge these problem domains more easily (Sussman, 2002).

Web services are a form of service oriented architecture (SOA), intended to enable developers to create components that can be assembled and deployed in a distributed and heterogeneous environment (Brown, et. al. 2003). Each software component in an integrated enterprise should interface with other components sharing information and communicating in a common format. Intrinsic capabilities of Web services are loose coupling of application components, separation of concerns, and interoperability across multi-vendor environments. These capabilities can provide advantages and benefits for integrating a Hub Architecture environment.

Table 1 – Computer applications Classification that supports integrated product development

	APPLICATIONS AND TOOLS			
	Functional	**Knowledge / Information Management**	**Collaboration**	**Coordination**
	To carry out and support specific functions	*To share and manage Information and knowledge*	*To Interact and Communicate*	*To manage and control tasks*
Definition	Function oriented systems that support engineers in specific tasks.	Product information and Knowledge management systems to enable the exchange of product and manufacturing information and knowledge	Collaboration systems to foster cooperation among engineer e.g. CSCW - Computer Supported Cooperative Working	Coordination systems to support sequencing of activities and flow of information.
Available tools	• CAD/CAM/CAE • ICAD • Knowledge Based Engineering Systems (KBES) • MAS / SPEED • Rapid prototyping • QFD / AMEF / IDEF0 • DFM / DFA	• PDM – Product Data Management • Product Model • Manufacturing Model • PLM – Product Life Cycle Management	• Net meeting • Forums • Chat • Multicasting • e-mail • Groupware • CSCW • Applications sharing	• Project management systems • Workflow • Groupware • e-management • e-project
INFRASTRUCTURE FOR INTEGRATION: Web-Services				

Under the web services approach, each application and tool to support e-services, become a collection of Web services that work together to control the information flow between different systems and they are exposed as a group of services. When information is required, the application client invokes remote functions on the server to send and receive data using SOAP. The service bus is the level of architecture at which published Web Services within an e-hub can be used across the entire hub. Figure 1 shows the hub architecture (highlighting the Information Technologies classification, proposed on Section 3, for collaborative engineering) and the Web-Services interaction.

The dynamic e-services are facilitated for example through a Partner's Web Site accessing public external web services. A partner could also leverage private Web Services (with proper security controls in place) made available by an enterprise to that trusted partner.

Web services, along with collaborative systems, will enable manufacturers to quickly and easily make changes both internal and external organization. Web services hold the promise of connecting the enterprise through the use of open standards that will help expose services, not just data. The ability to combine services, both internal and external of the operation, will drive collaborative systems to new levels. This will promote a more collaborative environment between small and medium manufacturing enterprises addressed to integrate systems and application when the use of commercial management software is reduced due to high cost and poor Technology Information from developing countries.

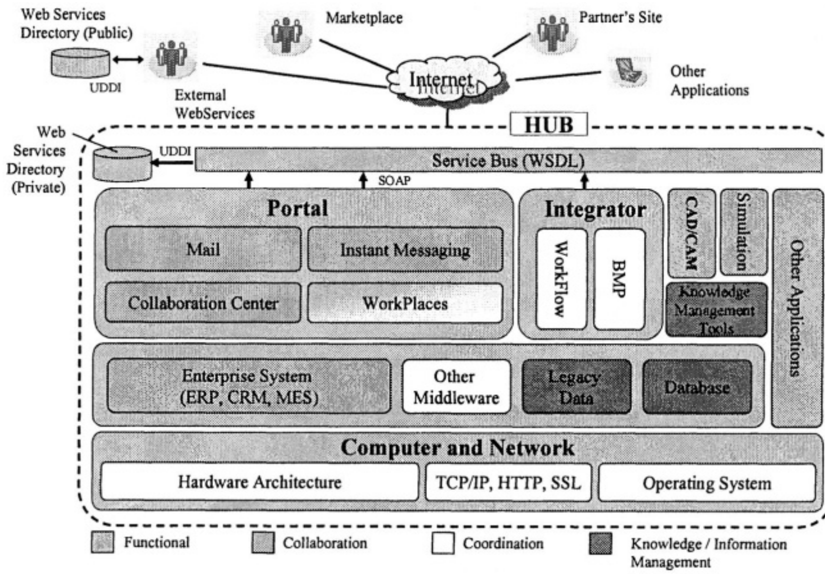

Figure 1 – HUB Architecture

5. PILOT PROJECTS

The research results reported here are focused in the design and development of Web based information technologies to support the first phases of the life cycle (engineering stages). The two case studies presented are:

5.1 Specific applications and web services to support brokerage activities

Different computer systems have been developed to support the Virtual Enterprise Broker (VEB) activities. In order to orient readers, the authors consider the *e-Services* as 'processes', like e-Commerce, e-Business, e-Enterprise and e-Services. The *e-Applications* are specific computer applications that support an e-service (e.g. ERP, CRM and MES). Finally, *e-Technohgies* are generic technologies (e.g. Databases, Web languages and communication services).

Figure 2 – e-Services, e-Applications and e-Technologies

Four e-Services pilot projects were developed in the Virtual Industry Clusters research project in Mexico to support the interaction among manufacturing firms: e-RFQ (electronic Request For Quotation), e-Inspection and e-Fax communication. However these e-services did not use the web services platform (Mejía, et. al. 2002).

An engineering service for manufacturing process definition has been developed using the Web services concept. It provides the capacity to prepare operation sequences of CNC operations using a standardized product design (CAD file). A company requiring to program a CNC machine, can send its product design (using a standard CAD format) to the CAM (Computer Aided Manufacturing) e-service. The company then receives the CNC program specific for its CNC controller. A first experiment was implemented by the ITESM and the University of Holguín. In this case, the University of Holguín has a CAPP/CAM application called Diprotec 2000 which allows transformation from a CAD file to a CNC program. ITESM has develop a web application which sends a CAD file to a Web Service that uses the capacity of Diprotec 2000 to obtain the CNC file. Figure 3 depicts the architecture for this project.

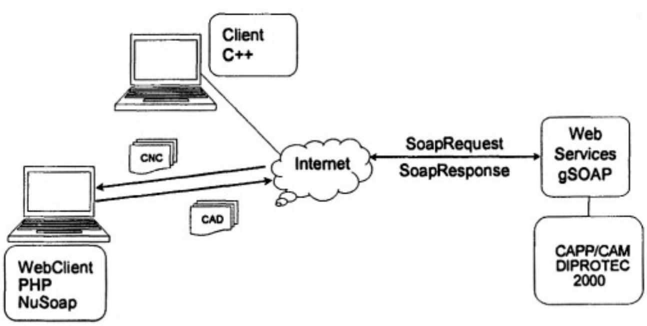

Figure 3 – Webservices Project Architecture to executer remote CAM e-services

5.2 Service for engineering projects planning (e-Hubs)

The service of providing a collaborative platform for engineering projects planning has been identified as a key tool in engineering lifecycle management, extending the capabilities of business partners with joint engineering, knowledge and other resources of individual SMEs by providing brokerage of complementary engineering services. E-engineering tools enable two parties to support and execute engineering project through its lifecycle. Two levels have been identified, operational and tactical. The operational level deals with process sharing and execution; the tactical level deals with partnering, knowledge management and best practices capturing (Schuh, et. al. 2003). An e-Hub (e-Engineering Enabled by Holonomic and Universal Broke Services) is under development for the tactical level (planning and negotiation stages), integrating standard applications for collaboration as "Workflow" modeling for engineering processes. It provides a new approach to facilitate collaboration by offering transparent templates during the engineering collaboration.

Currently, a Web prototype is running on the web, integrating different applications as proposed in the classification of section 3 (one example per category can be: Chat for *collaboration,* e-legal service (Carter, et. al., 2002) as *functional,* Workflow for *coordination* and for *Information management* the file storage option). These technologies, supported by available Web-hosted services, form the basis of the e-Hub. The most representative task for the prototype functionality has been the Workflows development. Figure 4 shows the sequence of workflow design and execution in the e-Hubs Web-prototype. OBE (Organization Breakdown Engine) is the workflow engine, integrated in the prototype, which runs workflow files from "XPDL" format. The program used to design the workflows was JaWE - Java Workflow Editor (http://jawe.obiectweb.org/) and it generates XPDL files which conform to WfMC[1] specifications (Hollingsworth, 1994). A set of Workflows were developed for the definition of a generic process for project planning, and also engineering specific processes for Mechanical engineering areas and Civil & Construction fields.

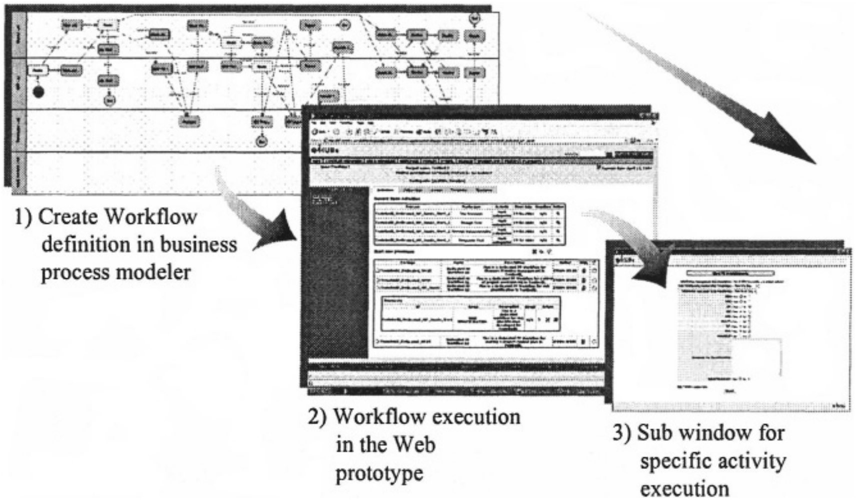

Figure 4 – Workflow design and execution in e-Hubs Web-prototype

[1] The Workflow Management Coalition (WfMC) is an international standard organization on Workflow Management Systems (http://wfmc.org/).

6. CONCLUSIONS

The globalization of the industrial activities and decentralization of the product life cycle activities, have lead companies to work collaboratively and simultaneously with distant engineering partners. The expansion of Internet-based tools has opened new opportunities for collaborative work improvement, through the development of a new generation of tools designed to support this kind of activities. In this paper a classification of information technologies has been presented to help in the identification of necessary tools that engineers needs as a minimal support in their engineering collaborative activities. An engineering HUB architecture based on web services has been proposed as an important player in supporting industrial networks operations of SMEs. SMEs can have access to e-services offered by engineering HUBs for specific needs, without investing time and money in purchasing complex and expensive software tools, or expending time and resources in developing computer applications, which usually are out of their reach. Usually SMEs involved in the Latin American supply markets are not technologically updated and their access to complex and robust information systems is limited. Therefore the engineering HUB is an important alternative to bring near advanced applications to Latin American SME through Internet. Two pilot projects have been introduced as examples of how an HUB can play a major role in supporting engineering activities in Virtual Enterprises.

ACKNOWLEDGEMENTS. The authors acknowledges the Chair in Mechatronics from the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM - Campus Monterrey), and the “IBM SUR Program” for their funding and support in the development of this research. The e-HUB pilot project is part of the e-HUBs project (IST-2001-34031) sponsored by the European Commission.

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