EU-China Collaboration in Design

Research in Web-enabled Collaborative Design Supported by the Asia-Link and Asia IT&C Projects

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Abstract

The research of Web-enabled collaboration in total design supported by the European Union's Asia Link project [1] and Asia IT&C project is reported in this paper. The two projects both aim at enhancing research collaboration between the EU and China. The Virtual Research Institute (VRI) is described first, which is the platform for the collaboration for the Asia Link project and is established by utilizing the advanced Web techniques; and then, the framework for the collaboration and the Web techniques involved in the research are presented which represent the major research of the Asia IT&C project. The effective collaboration between the project partners and the impacts of the project outcome on the partnership are also discussed.

Introduction

The research reported in this paper is related to two projects supported by the European Union's Asia Wide programs: the Asia Link project [1] and the Asia IT&C project [2]. The two projects both aim at enhancing research collaboration between the EU and China. The author leads the two projects on behalf the Nottingham Trent University (NTU) and the Advanced Design and Manufacturing Engineering Centre plays the major role for NTU.

The Asia-Link project is to develop the existing cooperative research links and networking between higher education institutions in European Union member states and China: Nottingham Trent University (UK), Lappeenranta University of Technology (Finland) and Chongqing University(China). They collaborate with each other in a framework for human resource development, i.e. postgraduate research student supervision and training, in mechanical and manufacturing engineering. The target groups are postgraduate research students and University academic staff in the area of Mechanical and Manufacturing Engineering, as well as mechanical and manufacturing industries and allied organisations. The main activities involve collaboration on research student doctoral research projects, in which the students spending some time (minimum 6 weeks per annum) at one of the Universities, other than their 'home' institution, joint postgraduate school and internet-based collaboration. The development of a Virtual Research Institute is one of the major tasks of the project in order for geographically dispersed research teams, universities and industrial partners to collaborate over the Internet. Duration of the project is three years commencing September 2003. For further information, please visit the project Website www.admec.ntu.ac.uk/asia-link.

The Asia IT&C project is to improve co-operation between China and Europe by improving Information Science Interconnectivity in the area of Manufacturing. The target groups are mechanical and manufacturing SMEs in Europe and China, research institutes and trade associations that support research and development in this area, and large global mechanical and manufacturing enterprises. The main activities include:

1. Development of an intelligent Web-enabled environment for geographically dispersed teams to collaborate over the Internet,
2. Research and development into enabling information communication technology (ICT) for collaborative intelligent design and manufacturing and their implementation with the intelligent Web-enabled environment and
3. Case studies to apply the methods, procedures and ICT tools developed. The project consortium consists of Nottingham Trent University (UK), Foundation Labein (Spain), Harbin Institute of Technology (China) and Chonqing University (China). The project duration is three years commencing December 2003. For further information, please visit the project Website www.admec.ntu.ac.uk/asiaitc.

As a major research objective of the two projects, the Web-enable collaboration in total design has been conducted, which is presented in the following sections. The Virtual Research Institute (VRI) is described first, which forms a platform for the collaboration for the Asia Link project established by utilizing the techniques developed by the Asia IT&C project; and then, the framework for the collaboration and the Web-base techniques involved are presented.

Overview of the VRI

The VRI includes four modules:

1. Virtual communication facilities with the functions of exchanging ideas and communicating with each other, which include:
    - Discussion forum for project consortium members to discuss the issues related to the project,
    - A communication board for non-member to communicate with the project consortium,
    - Exhibition hall to display the outcomes of the project including research papers, project results, etc.
    - Virtual conferencing and meeting functions to enable the consortium members and the project Supervisors and students to held meetings virtually.
2. Online teaching facilities: this consists of virtual classrooms and a site for interactive use of the course materials.
3. Software package bank: This is to store software packages contributed and shared by the consortium members.
4. A platform for online collaboration: this will enable the project partners to collaborate online for certain research tasks.

1 Home page of the VRI

In order to develop the VRI in an effective way and to ensure its advanced features, the current achievements in Web/Internet has been be utilized as much as possible and the latest techniques are applied. The team from Finland has developed a virtual learning environment using WebCT [12]. Based on the experience gained, modules (1)-(3) are constructed using WebCT as the major development tool. Figure 1 shows the interface of the home page.

The Advanced Design and Manufacturing Engineering Centre at NTU has been working in Web-based engineering for more than 10 years, which provides a solid basis for the development of module (4). They have been working closely with the project partners of both the Asia-link project and the Asia IT&C project to develop the online collaboration platform.

The WebCT-based part of the VRI has been in use for the Asia-Link project, from which the project consortium member have been benefited. For instance, in the project there is a research student exchange programme, and the exchange students frequently use it for courses and relevant information about the hosting universities and communications with the project supervisors. The development of the online collaboration platform is an on-going research which is to be further presented in Section 3 below.

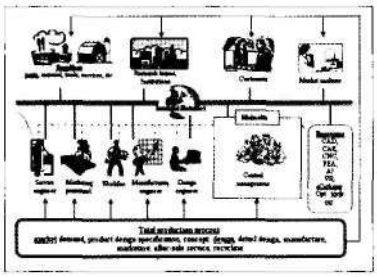
The framework of collaborative design and Web-enabled techniques

The framework of the online collaboration platform is shown in Figure 2 where the total product design processes is used as an example to demonstrate the principles, which include market demand, product design specification, conceptual design, detail design, manufacture, marketing, after-sale service and recycling.

The clients from anywhere in the world can submit their requirements for a particular product to the main site via the Internet. The marketing and commercial representatives at different locations also send market analysis results and customer feed back to the main site in the same way. This enables the central management team to attain the information effectively and to formulate the product design specifications quickly.

At the main site, the central management team controls the total production process. Within the total product design process, several networked organizations/ teams are involved, including:

- The production team, which consists of design engineers, manufacturing engineers, workforce, marketing-personnel, service engineers; some of them may be geographically dispersed but all are connected to the main site via the network;



2 The online collaboration framework

- Suppliers who provide standard components, services, materials, etc.;
- Research teams including universities, research institutions and laboratories, where the Existing and new techniques/tools are tested and evaluated in several scenarios for industrial applications.

Within the online collaboration platform, the ICT tools and resources will be utilized in the following ways:

- It is not necessary for all the ICT tools to be located at one Web site; instead, they can be located at different Web sites.
- It is not necessary for all the ICT tools to be written in the same language to be suitable for operation in a unique platform. Instead, they can be developed in different languages such as C++, Visual Basic, Java, etc, and individual tools may operate with different operation systems such as Unix and PC.
- For instant updating, security and IPR purposes, a large size package/tool is resident at the owner's Web site only while a user from another site is remotely accessing the package/tool online. This does not necessitate down loading of the main package.

A virtual resource database is also linked to the network, which contains software packages/programs, such as CAD, CAE, finite element analysis (FEA), virtual reality (VR) and artificial intelligence (AI), may locate at different sites -- some of the tools may be with the designers, while the others may be at individual web sites; all of them are accessible for the designers via the Internet/Intranet. This enables all the teams involved to share the resources amongst them.

Several methods/approaches have been developed to conduct the Web-enabled collaborative design, which is the major research of the Asia IT&C project. The scope of the research covers the following:

Web-enabled environment (WEE) for collaborative design and manufacture

In the development of the WEE, it has been considered that the partners are not only dispersed geographically but may also work with different platforms, operating systems, protocols and languages. As a large heterogeneous platform for collaboration and integration over the Internet, the WEE has the following features: scalability, openness, heterogeneity, resources accessibility and inter-operation, legacy codes reusability and artificial intelligence [3,9,10,11].

W Online collaborative computer aided design

Current development in this area includes two aspects: (1) Internet-driven collaborative design with 3D feature modeling including form feature, parameterized form feature and parameter list of the form features [4], and (2) Web-service supported online collaborative computer aided design which is further detailed [9].

W Web-enable collaborative computer aided manufacture

This includes prediction and simulation of manufacturing processes and production planning both during the conceptual design when design data are incomplete and during the later stages when the design has matured after several design iterations. The Web-based computer aided process planning and a remote monitoring system are both considered. The approach developed is illustrated with a case study of manufacturing mechanical components using Parallel Kinematics Machine (PKM) [5].

V Effective remote-execution of large size programs

In order to achieve best product design and lowest production costs, some large-sized ICT tools and programs, such as design optimisation and finite element analysis software, are often used in the design phase of product development. They are time-consuming in computation and may not be valid to download due to some reasons such as copyright issues, large size of the software and the limited network bandwidth. Two approaches have been developed to remotely execute such software in an effective way: (1) a CGI (common gateway interface) approach [6], and (2) a client-server approach where the Internet techniques involved include CORBA, Mirosoft's Internet Information Server, Tomcat (a Servlet-enabled server), JDBC (JAVA database connectivity) and ODBC (open database connectivity), which is presented in [9].

V Web-enabled distributed product design

This includes dynamic databases, product data management (PDM) and knowledge based engineering (KBE). Within the system, users interact with the server through the Middleware. This server includes a JAVA application which interacts with the dynamic database and the PDM system. The dynamic databases contain all the necessary knowledge for product design such as design rules and process parameters. The basic PDM features are implemented in a program that resides in the Server. This program is therefore the connection between CAD and CAM users, as well as the KBE and dynamic database for which it gives writing permissions, etc. The KBE modules are for specific part families and production processes. Current progress in this area is reported in [7].

W Grid infrastructure

Grid infrastructure which enables a large number of manufacturers and retailers at different locations to cooperate with each other within a Virtual Organization. This system can support two modes of inventory management to enhance the Quality of Service, which would greatly facilitate the interaction process between the manufacturers and retailer [8]

W Web-enabled supplier selection system

The system is to aid designers and manufacturers to effectively make decision for supplier selection and strengthen collaboration between people of all functions who involved in the procedure of product development. Two major sections are composed of the system. The first is focused on the supplier selection under the general condition [13,14]; the second is concentrated on the supplier selection within the mass customisation condition [15,16]. The main stream of the system is focused upon the flexibility and quick responsiveness through selection of potential optimal suppliers under the various conditions. This will enhance manufacturers' efficiency and flexibility, and allow them to avoid or minimize risk when external conditions change. The business theories, Analytical Hierarchy Process(AHP), and Analytical Network Process(ANP) have been applied in combination with Web Services and J2EE Technology to implement the task.

Collaborative partnership of the project

The project has been conducted successfully and benefited from the strength of the partnership of this project. The project consortium is composed of six international research teams with different expertise in the project domains, so that they can compensate and collaborate with each other to ensure the success of the research. The consortium members special strength in each area of the tasks allocated makes the most effective operation of the project.

As the leader of this project, Nottingham Trent University team has rich experience in managing and conducting international collaborative projects; while as the main developer of the WEE and RE system, NTU team also has a strong expertise in the relevant research areas. They have been involved in this research area since 1998 and about 10 Ph.D. research projects have been / are being conducted. In addition, NTU team has been actively involved in the research areas of CAD/CAM/CAE, PKM and worm gears with more than 100 research publications in high quality journals and prestigious international conferences. Those provide a solid ground for them to conduct the research in CAD/CAM and the two case studies of this project

Partner LABEIN (Foundation Labein, Spain) is a private, non-profit technological research & innovation centre, and has a good experience in carrying out collaborative projects at the European level from different European RTD and TT & innovation programmes. LABEIN team is involved in the development of Web-based PDM system because LABEIN team has substantial expertise in product knowledge management focused on design and has a wide range of experience in the use of PDM systems. LABEIN has more than 45 years of experience in supporting enterprises and administration bodies in their technological and innovation needs.

Partner HIT (Harbin Institute of Technology, China), one of the top 9 universities in China, has been involved in research area of PKM technology since 1994 and has substantial expertise in CIMS. They also have a close partnership with the Liuwei Company in the development of PKM applications. HIT'S research merits make them best for the development of Web-based manufacture system as well as the case study.

Partner CQU (Chongqing University, China) is a designated prestigious university in China. CQU team's experience in online CAD provides useful experience for the Web based collaborative CAD. Besides, the CQU team has considerable expertise in worm gear research, gear stress analysis and finite element analysis.

All the members of the consortium are from academic and research institutes, to overcome the weakness in engineering practice, the consortium has been best utilising/enhancing their connections with industry, which includes existing industrial partners. For example, in the last year, the following connections with industry have been established to enhance the partnership.

- HIT teams' connection with Harbin Steam Turbine Works, China - As a proper user for the Parallel Kenematics Machine (PKM), Harbin Steam Turbine Works has been working with HIT to utilise the Web-based CAM system into the machining of spade, which is a key component of steam turbine with complicated geometry.
- HIT teams' connection with Liuwei NC Equipment and Technology Company, China - Liuwei is a high-tech company mainly working on the development of numerical control system for PKM. With the cooperation with Liuwei Company, HIT team gained necessary technical data and related Information for the development of Web-based CAM system.

Concluding remarks

The EU-China collaboration in the research in Web-enabled collaborative total design supported by the Asia-link and the Asia IT&C project is reported in the above sections. The total design process concerned includes market demand, product design specification, conceptual design, detail design, manufacture, marketing, after-sale service and recycling.

During the conduction of the two projects, through the international collaboration between partners, three of them are from Europe countries, and the other two from China, the presence of European information and communication technologies in China has been increased and, the connection of EU and China in the design and manufacturing sector has been enhanced. The following are examples of the evidences illustrating the project consortium members' contributions to the achievement of the project objectives

- Remote execution of large size program - By using the remote execution system of large size program developed by this project, users in China can now remotely invoke a gear design optimisation program, which resides in the server located in Nottingham Trent University, UK, through the Internet.
- Web-based CAD data sharing - By using the Web-based CAD data sharing system developed by this project, partners from different counties, UK, Spain or China, can exchange their design idea and share their CAD data simultaneously.
- Manufacturing of component with complex geometry - With the collaboration between HIT team and Labein team, component with complex geometry was manufactured by the PKM machine. The component is designed by Labein team, and manufactured by HIT team.
- Enhancement of collaboration in higher education between the EU member states and China - The activities implemented so far in the Asia-Link project, via the VRI and the student mobility programme, enhanced the students' knowledge to the requisite level for qualified engineers who can contribute with competence in technology for the community and industry. These have met the demand for individuals who have the necessary skills to analyse and understand complex problems and learn the technologies. The projects have provided opportunities for the students to work in an international environment and enhanced the students' skills of working as part of not only a multidisciplinary but also multinational team. In addition to the knowledge gained in technical fields, the students also gained further understanding of the higher education and cultural difference in foreign countries.

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