

Collaborative E-business and E-manufacturing in distributed environments

Dr Mikel Sorli, Iñigo Mendikoa

*Fundación LABEIN, C/ Geldo - Parque Tecnológico de Bizkaia, Edificio 700, 48160 - Derio (Bizkaia), Spain,
{sorli,mendikoa}@labein.es*

Abstract

The present paper focuses on the topics of E- business, E- manufacturing and Virtual Enterprises in distributed environments. It is based mainly on the Europe&Asia Link project WECIDM (ASI/B7-301/3152-99/72553) starting in January 2004 and in the Collective project KNOW-CONSTRUCT (COLL-CT-2004-500276) starting in March 2004.

WECIDM project aims to develop an internet-based platform that allows a distributed team to perform a collaborative design in which the knowledge from different parts of the value chain, like design rules imposed by the manufacturing process, since most of the design and manufacturing management systems of an enterprise do not consider all the involved product/process knowledge from the whole value chain.

KNOW-CONSTRUCT project aims to develop a common internet-based platform for SMEs from the construction sector to provide an effective combination of two general functionalities: an innovative decision making support system regarding the products characteristics, applications and other consultancy services for SMEs' customers applying the "web enabled dialogue", and a system for SMEs to support an advanced form of co-operation through the creation of Knowledge Communities of SMEs.

Keywords: Knowledge Communities, Distributed Design-Manufacturing, Ontology, Knowledge Management.

1. Introduction

Collaborative product design and manufacturing among distributed teams through the Internet is becoming more necessary as enterprises are distributing their activities throughout the world. In addition, SMEs need to improve communication with their customers in order to provide better product support and services.

Classical simple Internet solutions often do not satisfy the needs of the SMEs. The support to integrated teams creation through an integrated and well tailored IT approach can lead to crucial advancing in business area.

Application of the state-of-the-art ICT solutions is necessary to assure higher efficiency of the co-operation and integration processes. Necessity of knowledge and competence integration for a successful responding to customers needs imposes a need of establishing the knowledge communities of SMEs.

The systems presented support the integration, management and reuse of knowledge via a common knowledge base, in a form of essential expertise, reachable anywhere, at any time.

2. E-business: KNOW-CONSTRUCT

2.1 Introduction

The construction sector is characterised by a high level of fragmentation, with a large number of participants in each construction project, being the large majority SMEs. To increase flexibility and profitability the bigger construction companies have significantly reduced the scope of their activity and consequently the number of employees, focusing on the core tasks of the construction process and subcontracting most of the work to specialised and smaller companies. The sector is still characterised by a low level of education (in average), low productivity, low quality and expensive maintenance and disposal. A narrow technical specialisation must be replaced by significantly wider technical competence through integrated teams as knowledge communities, followed by on time, within budget works completion.

Taking into account these needs the consortium comprising Construction Industry Associations, SMEs from the same area and RTD organisations from four European countries decided to initiate the research project with a main goal defined as development of an innovative solution of Internet Platform for Knowledge-based Customer Needs Management (CNM) and for Knowledge Communities Support (KCS) for SMEs in Construction Industry. It was identified that the professional associations may represent an ideal environment to provide such a solution. The goal is therefore to contribute to enable the European SMEs in construction sector to increase the application level of the state-of-the-art, knowledge-based ICT solutions in their business relations to customer and mutual co-operation.

In order to successfully meet the challenges described, the KNOW-CONSTRUCT project [1] consortium has defined its main objective as the development of a common platform for knowledge based systems, which provides a combination of two general functionalities:

(a) **Customer Needs Management (CNM) System** as an innovative decision making support system regarding the product characteristics, product applications and related consultancy services, and

(b) **Knowledge Community Support (KCS) System** as a System to support an advanced and efficient formation of communities of SMEs in construction industry, through their specific knowledge integration, management and reuse via a common knowledge base.

The platform will be owned by associations, which will offer to their members possibility to establish individual CNM systems and take benefit of Knowledge Community Support System.

The business objectives can be summarised as improved innovative technical support to product and service users (customers), wider technical competence required to satisfy customer needs, through closer co-operation and knowledge exchange among SMEs within knowledge communities, including improved quality/price ratio and on time completion of increasingly complex tasks.

The innovative system responds to the following aspects: low cost for the involved SMEs and customers, Internet based, efficient customer support, support more open aspects of collaboration between actors in the construction process, record the key information associated with all the involved actors, assuring traceability, assure common terminology and ontology, security, support mobile users (knowledge available in a form of essential expertise, reachable anywhere, at any time), etc.

2.2 Innovation

Starting from the stated business and technical objectives and basing on the analysis of the state-of-the-art and current standards [2][3], the main problems addressed leading to innovations are:

- **Methods for creation of Knowledge Communities of SMEs** in construction industry, where the **Associations** get a crucial role.

- To establish or re-use an adequate domain related **ontology** [4], as well as **classification system** for this sector applicable in SMEs environment.

- An inter-organisational practicable knowledge management system (method & tool) for Construction Industry Knowledge Communities.

- New forms for a **representation of the experience-based knowledge**, very much present in construction industry, bringing a step-forward in the industrial application of fuzzy approaches.

- An **open-architecture Internet based platform** for a combination of two basic functionalities.

- To provide a "web based dialogue" between SMEs and their customers aiming at an **interactive decision support tool** to be used for customer problem solving.

- Approaches for **'training'**, i.e., incorporation of the training capabilities within the methods & tools developed, taking into account SME needs, represents a further step forward beyond the state-of-the-art.

2.3 Research approach

KNOW-CONSTRUCT does not develop new methods but re-uses the most appropriate ones and enhance/adopt

them for specific e-support needs for SMEs.

- **Methodology for Establishment of Knowledge Communities:** The methodology for creation of the SME Knowledge Communities in the construction sector is elaborated with emphasis on knowledge representation and ontology issues.

- **Approach for Knowledge Representation and Ontologies:** To apply adequate domain related ontology, as well as classification system for this sector applicable in SMEs environment. Solutions applied within e-COGNOS are partially re-used.

- **KB Meta Model:** KNOW-CONSTRUCT creates a meta model for structuring the domain knowledge and for setting repositories to store Construction Industry Knowledge (CIK) on products, processes, problems, best practices, legislative issues, experience etc. as needed for both e-CNM and e-KCS functionalities.

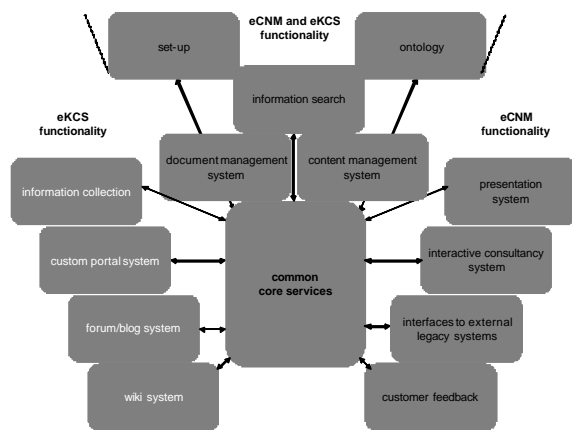


Figure 1: Overall Functional Architecture of KNOW-CONSTRUCT System

The overall functional architecture of the system is represented in figure 1 above, being the main functionalities of both CNM and KCS modules the following:

2.3.1 CNM - Customer Needs Management

- Browsing community resources: facilities to browse freely information about the companies belonging to the community: Products, services, procedures, etc.
- General Browsing: facilities to browse in a structured way through the information made available for the customers.

- Searching materials/products/components/procedures: facilities to search information and knowledge related to materials.

- Searching services/domain/context: facilities to search information and knowledge related to services.

- Interactive, web-based consultancy: tools to help customers to solve problems and get advices.

CNM also features a portal service, providing the customers with access to individual community members e-commerce/e-business systems, integrated with information search and consultancy functionalities. From the community members point of view, CNM provides customer relationship management functionalities in terms of collecting and organizing feedback and knowledge from customers, and managing consultancy services.

Here, the eCNM core services are consisting of the semantic resource management which represent the central knowledge processing and management service of the system.

2.3.2 KCS - Knowledge Community Support

- Knowledge sharing: tools to collect, disseminate and search experiences, problems, best-practices, opinions with the community.

- Knowledge community building: tools to create and share knowledge through collaboration, like discussion forums, twiki tools, news services, etc.

- Content management: tools to classify, organize, search documents, etc.

- Knowledge structure management: tools to manage ontologies and classifications schemes.

- Information collector: collection and organization of information from external sites and portals.

- External search manager: complement searches in the community knowledge with searches to external sites, portals, databases, etc.

Semantic web technologies are fundamental for eKCS in order to provide complex information retrieval, both internally and externally to the knowledge community.

This generic architecture can be decomposed in two layers: *eKCS core services* and *Systems/Applications layer*. eKCS core services layer provide a set of services centred in

the semantic resources management of Know-Construct (KC).

The eKCS core services are divided in *Semantic Resource Management* and a set of functionalities that provide the systems/applications with access to the semantic resources, namely: Ontology manager, Indexing and knowledge extraction, Semantic searching and navigation, Aggregator/integrator, Business data model wrapper.

2.3.3 KC Knowledge Base

The KC database is composed of the *KC Business Database* and the *KC semantic resources databases*. The former supports the eCNM part of KC in answering to the requirements of decision support system functionalities, and eKCS in provision of the community specific knowledge. The later is divided in (i) a meta data database to store the metadata descriptions of the information/knowledge of the CIK community and (ii) a semantic resources database which stores the CIK high level ontology and the local ontologies.

3. E-Manufacturing: WECIDM

Collaboration is particularly vital for product design since this upstream activity in the product life cycle has a decisive impact on the success of the particular product [5], [6].

In addition, it is becoming obvious that it is not possible to fulfil the new requirements solely based on conventional CAD-CAE systems and the present Internet facilities [7]. New infrastructure, tools, methods and knowledge are needed, a distributed cooperative product design capability is therefore necessary.

Currently most of the design and manufacturing management systems of an enterprise deal with local and static database systems and do not consider all the involved product/process knowledge from the whole value chain. The approach presented mainly focuses on those techniques that can support multi distributed clients and provide a dynamic database service, thus making possible a dynamic distributed design and manufacturing process.

The core application of the system presented manages the distributed design and manufacturing process through the internet between different teams, including the management of all the relevant product knowledge for design and manufacturing processes. The basic structure of the system developed for distributed product design and manufacturing is described, which includes Dynamic Database, Product Data Management (PDM) and Knowledge Based Engineering (KBE) modules.

Figure 2 shows the system basic structure. CAD and

CAM users interact with the server through the Middleware. This server includes a software application which performs the basic PDM features and interacts with the Dynamic Database, residing in the server as well, thus centralizing the design and manufacturing process. This “central server” contains all the project information, i.e., every file related to the product (geometry, process parameters, etc) and external users can interact with it through this specific PDM application.

There are specific KBE modules for specific part families and production processes. Different KBE modules are available for different kinds of parts and production processes (such as forging, machining, etc.) since different processes have different type of rules related. The set of rules includes the necessary “knowledge” for the complete design and manufacture of the part.

On the other hand API applications are developed for specific CAD users packages, so that design rules can be automatically applied by the CAD users in their local CAD system. The users select the remote KBE module and with the correspondent API will be able to work within the local CAD package.

From the users’ point of view, the user’s CAD includes a specific Graphical User Interface through which relevant data can be introduced and visualised. The Middleware includes the necessary tools in order to ensure the correct communication and visualisation of data.

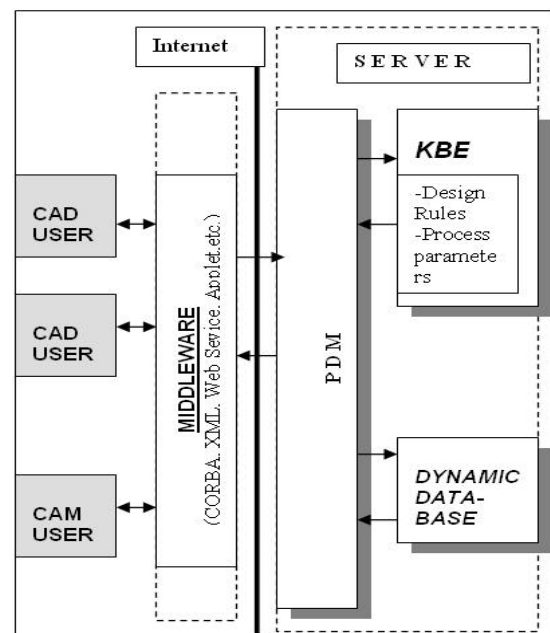


Figure 2. Structure of distributed product design and manufacturing system

2.2 Modules developed

The main modules developed for this prototype are the PDM application and the KBE modules for the manufacturing processes considered, both residing in a central Server.

2.2.1 Product Data Management (PDM)

This application performs the basic product data management features and manages the KBE modules and the Dynamic Database. Modifications in the files and databases in the Server are done hierarchically and controlled by this PDM application.



Figure 3. PDM Graphic user interface

Figure 3 above shows a graphic user interface where information on the selected part of the assembly is displayed and can be modified by authorised users. An assembly may be composed of different sub-assemblies, each of one is in turn composed of different parts. Every part has different files associated, corresponding to geometry, CAM files as well as any other file containing information relevant to the design and manufacturing process for that part. This PDM application is linked to a MS Access database where all the relevant information related to the assemblies, parts and documents is stored. This database cannot be directly seen by the user, whose only interaction with it is through the PDM tool.

2.2.2 Knowledge Based Engineering (KBE)

KBE allows companies to capture and reuse the knowledge and experience of their engineers, together with manufacturing best practice, legislation, costing, and other rules for the product development. In this system prototype, different modules are developed for each process and for each part family, in order to implement the specific design rules and process parameters. These modules are implemented in connection with the dynamic database where the design rules parameters values are stored.

Designers can in this way get the parameters values in order to apply the design rules in the product design. These data will be automatically used inside the CAD system through the appropriate API application developed for that specific CAD package.

Figure 4 shows the graphical user interface that allows an authorised external user to read or write the values of some design rules parameters corresponding to a typical forging process. These parameters are such as: flash land geometry, preform volume, draft angles, convex radius.

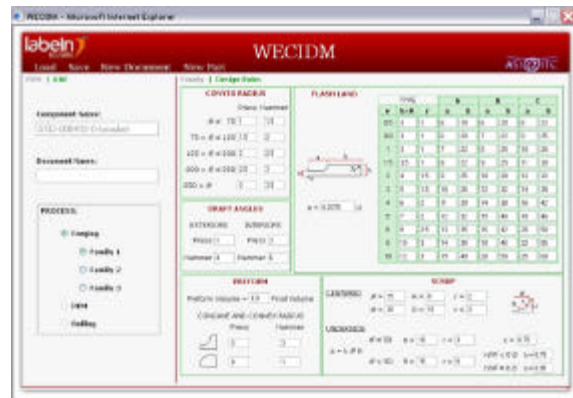


Figure 4. Design rules for a forging process

2.3 Collaborative design and manufacturing methodology

Using the specific case of forging part design and manufacturing as example, the distributed design and manufacturing methodology through the tool developed would be the following.

Manufacturers introduce or modify the design rules parameters. Designers will be able to get automatically a design in their local CAD system incorporating the design rules selecting the specific forging family, part dimensions and process options in the user interface like that shown in figure 4. This information (family type, part dimensions and process options) will be stored in a file residing in the central server that the designer can download. This file will contain as well the current design rules imposed by the manufacturer, and, in this way the designer can automatically incorporate the manufacturing rules in the design.

For the CAD user to be able to apply the process and geometric information automatically in the CAD package, a 2D CAD parametric “template” must have been developed for that CAD package and that particular family. In this prototype the system is available for SolidWorks CAD package, being the parametric template developed that of figure 5, which corresponds to a specific forging family.

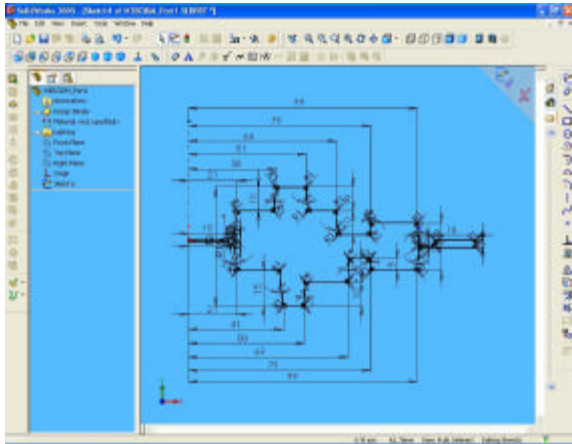


Figure 5. SolidWorks parametric template for forging family

This template resides in the CAD user local system, in this case corresponding to a rotational part. The CAD model is thus generated applying the information introduced by remote users, and therefore fulfils the forging design rules imposed by the manufacturer.

Neutral format is used and uploaded (to the remote central server) by the designer user, so that the CAM user can get the geometry of the part and is then able to generate the CAM files from the geometry.

Acknowledgements

Project "Internet Platform for Knowledge-based Customer Needs Management and Collaboration among SMEs in Construction Industry" is funded by the European Commission under the Collective Research program (Project contract: COLL-CT-2004-500276).

Project "Web-Enabled Collaboration in Intelligent Design and Manufacture" is funded by the European Commission under the Europe-Asia collaboration program (Project contract: ASI/B7-301/3152-99/72553).

The authors wish to acknowledge the contribution of the consortium partners.

References

- [1] KNOW-CONSTRUCT project (COLL-CT-2004-500276), available at <http://www.know-construct.com/>
- [2] CWA3 – CEN Workshop Agreement, *European eConstruction Ontology (EeO)*, 2004. Documents produced by the CEN/ISSS eConstruction Workshop, Brussels, 2004.

- [3] ISO 12006-2 Building construction — Organization of information about construction works - Framework for classification of information, DIS version 2001.
- [4] W3C, 2002. Requirements for a Web Ontology Language, available at <http://w3.org/>
- [5] I. Horváth, J.S.M. Vergeest and Z. Rusák. "Six ingredients of collaborative virtual design environment", *International Design Conference*, Dubrovnik, 2002.
- [6] A. Chaudhari, V. Patil "Future Trends in Collaborative Product Data Management Systems". *Tata Consultancy Services*, 2002.
- [7] M. Sorli, J.A. Gutiérrez "New Paradigms in product Development". *EDC2002 (Engineering Design Conference)*. London, July 2002.