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COLLABORATION AND COMMUNICATION IN INTEGRATED SYSTEM OF DIGITAL MANUFACTURING

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Abstract: *The paper presents a short overview of the tools and technologies for product data interoperability and management in digital manufacturing environment. The concept of digital manufacturing requires a reference model implemented within infrastructure of information and communication technologies. Reference model of collaborative process planning is based on merging of virtual organizations focused on product design and development. Such approach provides process planning activities at meta, macro, and micro levels. Usual web platform that supports this kind of work, implemented as a part of a collaborative environment, is the CORE platform. From a technological point of view, the concept of this platform is based on synchronous usage of Internet and services of virtual and augmented reality. Full collaboration assumes extensive application of neutral data formats.*

Key words: *digital manufacturing, IC technologies, CORE platform, Web platform*

1. INTRODUCTION

Product Data Management (PDM) systems are the most important component of the Product Lifecycle Management (PLM) systems, which provide us with monitoring of product lifecycle activities. Therefore, the information storage may be very complex because many organizations and users are involved, causing some activities to overlap, while others to run in parallel [1], [3], [4].

Access to different types of data must be allowed to all users, but at the same time, the data have to be protected from non – authorized access. This implies that different types of users will be interested in having access to different types of data, i.e. the data they understand and require for their tasks. For instance, designer will understand the technical drawing of a component, and the programmer the code that describes the technical drawing. In fact, the core of corresponding data should follow the capability of adaptation to the appropriate application. Modifications made by one user should be saved in the data kernel, so that the same change could be seen and accessed by other users as well [1], [2].

2. MANAGING COLLABORATIVE PROCESS PLANNING ACTIVITIES

The result of transformation of certain business strategies is the concept of extended enterprise. This concept is influenced by the expansion of Internet technologies, consequently affecting the simultaneity and availability of information related to the process planning.

The concept of extended enterprise is more than just the merging of different enterprises connected by a product supply chain. It is based on an organizational paradigm in satisfying not only clients' needs, but also the needs of people involved in all stages of the product lifecycle, such as product design, manufacturing or recycling [1,7,8].

However, in addition to many advantages of concept of extended enterprise, several disadvantages still persist in the industry. They refer to the problems related to different organization of business, differences in the usage of PLM systems, data incompatibility, rules, methods etc. Some disadvantages can be overwhelmed by the usage of distributed, opened and intelligent systems for collaborative work, which implementation depends on technological and economic support of industries that want to introduce them.

Systems for collaborative process planning should enable the users to work at different levels, i.e. these should enable meta-, macro and micro planning. Meta planning refers to process planning on global level. From production point of view, meta-planning determine production process, quality, product cost, etc. Macro planning refers to identification of major turning points and does not include detailed tasks and activities. In other words, corresponding procedures and activities define production equipment, optimum (minimal) number of machines for parts production, and operational sequence. Micro planning assumes detailed definition of tasks and activities, i.e. tooling, tool paths, and the parameters associated to shop floor operations, providing that productivity, quality of the parts and manufacturing costs are optimized [2,3].

2.1 The reference model of collaborative process

Product development and process planning in extended enterprise imply the existence of reference model, which should be implemented in IC technology infrastructure that supports collaborative work within PLM systems. These models are mostly used to provide the reference for different enterprises within the same industrial sector [2,3,7,8].

The basic structure of a reference model implies the definition of needs, resources and criteria (Fig.1). The requirement for development of extended enterprise is to provide development from the basic supply chain to the higher level of cooperation and collaboration in order to achieve greater efficiency and agility. Such needs are seen from the inside of the enterprise network, resulting in closer collaboration between enterprises and suppliers or partners and clients.

The available resources define the level of satisfaction of the expressed needs, presenting the basic indicators for establishment of the criteria and for placing the limits for development of an extended enterprise [3].

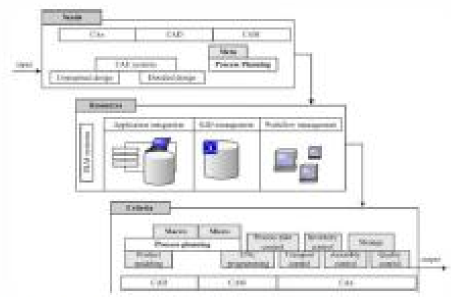

Fig.1. The reference model of collaborative process planning in extended enterprise

Criteria that define the main characteristics of extended enterprise are setting through macro and micro level planning.

2.1 Implementation of IC technologies

From functional point of view, IC technologies, which provide collaborative process planning, should have a client – server architecture (Fig.2) [1,2,3].

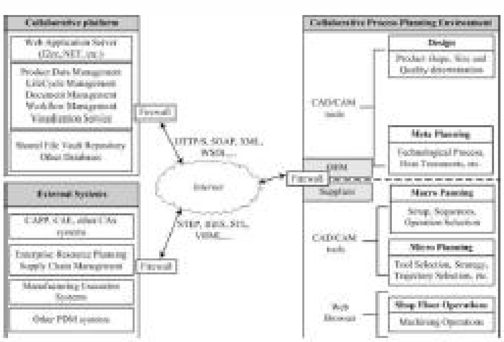

Fig.2. The implementation of IC technologies for collaborative process planning in extended enterprise [2]

Basic server's components support data, lifecycle, documents, and workflow management, as well as the visualization of a common database. On the other side, the client platform should provide connection with server applications using Web browser or CAD/CAM tools. Such concept of a server enables realization of data exchange, design, analysis, and decision making processes [4].

Client-server communication is performed via Internet by using communication standards, such as HTTP/S (*Hypertext Transfer Protocol Secure*), SOAP (*Simple Object Access Protocol*), XML (*Extensible Markup Language*), WSDL (*Web Service Description Language*), RMI (*Remote Method Invocation*), etc. Data exchange is conducting using standards like STEP (*Standard Template for Electronic Publishing*), IGES (*Initial Graphics Exchange Specification*), DXF (*Drawing Exchange Format*), etc. Unauthorized data access is prevented as well.

Most enterprises use PLM systems that are limited for working in heterogeneous environment. In such conditions, it is necessary to analyze PLM systems that are feasible in an environment of extended enterprise.

3. WEB PLATFORM

Data exchange is a very important issue that relates distributed users working on product development. The application of Web oriented PDM systems enables the large number of collaborative activities. A number of issues that concern the product and process complexity are resolved using Virtual Reality (VR) and Augmented Reality (AR) technologies. Web platform that supports this kind of work, implemented within Collaborative Manufacturing Environment (CME) is called Collaborative Product Reviewer – CORE [1]. From technological point of view, the CORE platform concept relies on synchronized usage of Internet, VR and AR services.

3.1 The architecture of CORE platform

Design of CORE platform is based on open architecture and browsing technologies. The architecture involves three layers (Fig.3):

a) data layer,
b) business layer, and
c) presentation layer.

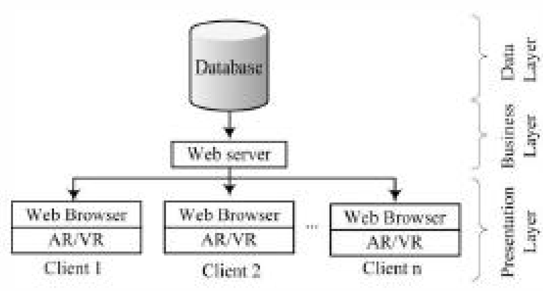

Fig.3. The architecture of the CORE platform

These layers communicate through the Internet or an Intranet, depending on the type of communication [1].

Data layer relates to external databases that store and update the project related data, and provide their stability, consistency, integrity, etc.

Business layer defines business logic, and consists of a number of connection mechanisms that contain algorithms for business distribution and database interaction.

Presentation layer supports the work with clients, where some standard browsers are involved (Internet Explorer, Opera, etc.), as well as the VR and AR applications.

CORE platform architecture suggests that creation, modification, and management of the environment requires establishment of communication between an appropriate Web platform and the VR and AR applications (Fig.4).

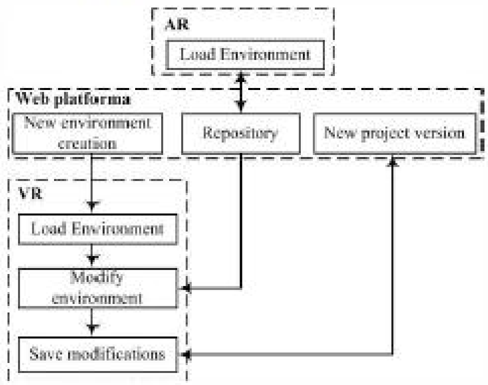

Fig.4. Communication between Web platform and VR and AR applications

This kind of communication is provided by XML technology. It creates data formats that are independent of a platform (Windows, Unix, Linux, etc.) and facilitates data sharing within information system, in particular for web-based systems.

Implementation of the CORE platform architecture is schematically shown in Fig.5. Database stores all essential data that refer to projects and processes. Users (internal or external) access the database via server.

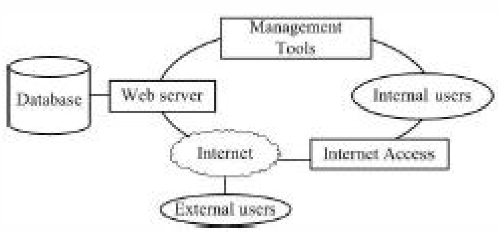

Fig.5. CORE environment [1]

All users can manipulate with a virtual product at any time, without restrictions concerning the number of simulations. When user performs any modification of the product it is instantly seen by all other users.

4. INFORMATION EXCHANGE IN DIGITAL PRODUCTION

The information exchange of the products and processes between different systems or/and applications should include total product definition. PLM systems that are built on the same kernel have similar data format, providing complete data exchange with no information loss. However, in the heterogeneous PLM environments data exchange is prone to errors or incomplete data and information transfer [2,5,6].

4.1 Review of standards for data exchange

Product information and data exchange in heterogeneous production environments most commonly uses standard exchange formats, such as STEP and XML.

STEP standard contains the data of the complete product lifecycle. The possibility of describing models in text format provides the access to any type of information that the text includes. Manipulation with STEP model can be performed by using appropriate CAD/CAM system or by user-defined application.

The architecture of STEP standard (Fig. 6) contains three levels:

- application level – contains all the information about model,
- logical level – maintain the consistency of data structure which are exchanged, and
- physical level – generates the file sharing. [5,7,9]

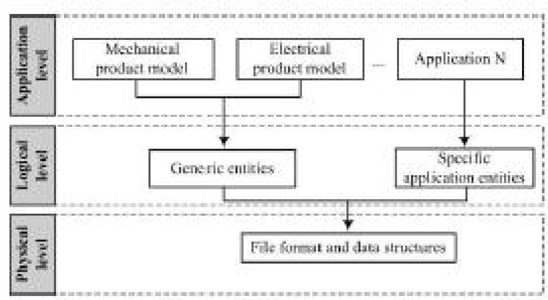

Fig.6. The architecture of STEP standard

Data specification described by STEP standard is performed by descriptive and implementation method. The descriptive method contains the EXPRESS language for formalization of STEP models, and implementation method contains techniques for structuring information defined by STEP standard [9], [5].

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STEP Data Access Interface (SDAI) represents the standard for the low-level data access applications using EXPRESS language. The binding can be early and late. The difference is in accessibility to data libraries in some applications. Early binding generates the specific data structure according to EXPRESS schemas and definitions of programming language. Defined entities within EXPRESS schema are converted into classes of programming language C, C++ or Java. Late binding is using the low level library for the access to some simple functions in order to assume or define parameter values [6].

XML contains different rules for defining semantic description of product model aimed for classification and identification of document's entities. Although XML is very easy to use, there are potential conflicts between flexibility and easiness of usage. Elimination of conflict situations is provided by Document Type Definition (DTD) formalism for document structure description. It defines constraints in XML document structure and declares all types of elements, attributes, entities, processing instructions, etc.

5.1 The architecture of digital production

Modern PLM systems (such as, Catia, Pro/Engineer, SolidWork, etc.) have the ability to save or load STEP AP203 standard files. In order to ensure working with Web oriented applications that integrate distributed users, the transformation of STEP AP203 document into XML documents is being performed. The architecture of a system that supports such procedure is shown in Fig. 7.

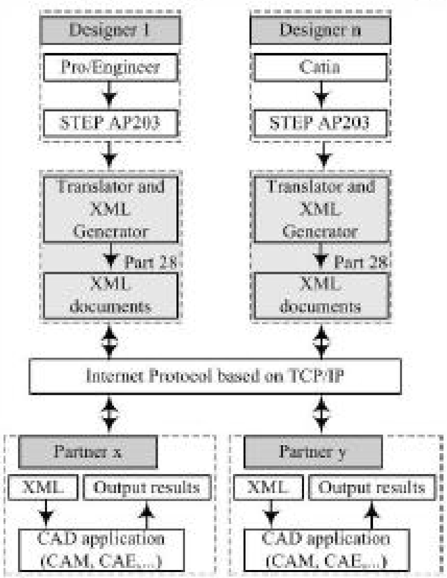

Fig.7. System architecture [1]

As this is a multi-user environment, which implies multi-application environment, it is necessary to save product models in STEP AP203 format. Distributed users may download these models as XML documents by using appropriate Internet protocols. The models stored in this format are appropriate for usage in different applications.

5. CONCLUSION

The reference model of collaborative process planning is based on merging virtual organizations that are focused on product design and development. The companies that make an integral part of the extended enterprise should use these tools to reduce costs and time-to-market. This is particularly evident within planning activities, which are often crucial for product development.

Complete collaboration includes the application of a neutral file format. Nowadays STEP standard file formats are in common. The conventional methods of implementation are inflexible for the complete model manipulation via Internet. This deficiency is eliminated by the description of product models using programming languages, such as Java, C++, XML, etc. In such cases XML and STEP are considered as the complementary technologies.

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