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LAYMOD; A Layered and Modular Platform for CAx Collaboration Management and Supporting Product data Integration based on STEP Standard

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***Abstract*—**Nowadays companies strive to survive in a competitive global environment. To speed up product development/modifications, it is suggested to adopt a collaborative product development approach. However, despite the advantages of new IT improvements still many CAx systems work separately and locally. Collaborative design and manufacture requires a product information model that supports related CAx product data models. To solve this problem many solutions are proposed, which the most successful one is adopting the STEP standard as a product data model to develop a collaborative CAx platform. However, the improvement of the STEP's Application Protocols (APs) over the time, huge number of STEP AP's and cc's, the high costs of implementation, costly process for conversion of older CAx software files to the STEP neutral file format; and lack of STEP knowledge, that usually slows down the implementation of the STEP standard in collaborative data exchange, management and integration should be considered. In this paper the requirements for a successful collaborative CAx system is discussed. The STEP standard capability for product data integration and its shortcomings as well as the dominant platforms for supporting CAx collaboration management and product data integration are reviewed. Finally a platform named LAYMOD to fulfil the requirements of CAx collaborative environment and integrating the product data is proposed. The platform is a layered platform to enable global collaboration among different CAx software packages/developers. It also adopts the STEP modular architecture and the XML data structures to enable collaboration between CAx software packages as well as overcoming the STEP standard limitations. The architecture and procedures of LAYMOD platform to manage collaboration and avoid contradicts in product data integration are introduced.

***Keywords*—**CAx, Collaboration management, STEP application modules, STEP standard, XML data structures

I. Introduction

CONSIDERING the advantage of new IT improvements that helps designers and engineers to communicate their ideas and design information through the Internet and other IT infrastructures, many CAx software still works separately and locally [1] . Still many traditional commercial CAx systems are working locally and as standalone agents [2], [3], such as I-DEAS, ProEngineer, Solidworks, Unigraphics and so on. The individual CAx designers work with their localized computer systems separately in product design process. This problem gets more serious when considering that today's companies strive to survive in a competitive global environment by offering high-quality products at low prices in a timely manner [4]-[6]. The companies' solicitude cannot be fulfilled based on transcending the traditional paradigm in which all product development activities are locally and internally. So it is a need to support CAx product developers with focusing on a collaborative product development approach in which every CAx product developer concentrates on its core activity and collaborates with other ones for other product development activities [7], [8]. Collaborative design and manufacture between product developers using different CAx software packages, requires a product information model. This information model should support related CAX product data models and other information generated during the product development processes [9]. On the other hand, CAx modules and resources are geographically distributed over the world. Therefore, enterprises require [10] to use a platform to exchange the product data between different CAx software packages. Efficient management of CAx software packages' product data is critical. So techniques and tools that facilitate the modification and control of CAx product data are vital through collaboration technologies.The product data integration is vital in a distributed CAx product development [11]. This feature is required because the CAx software packages are distributed each with their own product data structures. Each of these CAx uses different information structure to represent the product data [12]. To solve this problem many solutions have been proposed, which the most successful was to use the STEP standard -STandard for Exchange of Product data model- as a standard for maintaining the CAx product data [11], [13], [14]. Although it should be considered that the adoption of STEP standard has encountered with problems [15], [13], [16], [3] due to reasons like huge number of STEP AP's and cc's, the high costs of implementation, costly process for conversion of older CAx software files to the STEP neutral file format; and lacks of STEP knowledge, which usually slows down the

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implementation of STEP standard. In this paper the essential requirements of a collaborative CAx system will be declared. The STEP standard capabilities for product data integration as well as its lacks are reviewed and the dominant platforms for supporting CAx collaboration management and product data integration will be studied. Finally a platform to fulfill the requirements of CAx collaborative environment and integrating the product data will be proposed. The different aspects of this platform to overcome the requirements and lacks will be investigated through its structure and procedures.

II. Overview of current CAx collaboration management platform and their product data integration structure

To study the current CAx platforms for collaboration management and their ability for product data integration, the following essential requirements are considered in this paper:

1) Ability to manage the CAx collaboration

Competition, globalization, trends toward reuse of information, and the greater product complexity suggest the effective use of resources which are usually distributed. However the vital requirement for the effective use of resources is the ability to manage derived information from these distributed resources [17]. The collaborative platforms for CAx software packages should support collaborative work of CAx team members who are separated in time, distributed in space and rely on each other [18]. During the CAx collaborative processes, the platform requires procedures to support the network and database to enable various engineers to use the product definition model , accomplish collaborative product design, manufacturability evaluation, process planning, NC programming and so on [19]. Also to support the distributed CAx collaboration it is required to formalize, encode and share CAx product data. CAx collaborative platform should provide a mechanism to share information and make decision among the various domains. Further, it should enable CAx software packages to cooperate in collaborative manufacturing environment [20], [10], [21]. Considering these essential requirements, the paper studies the developed platforms and their procedures that enable the CAx software packages to collaborate in manufacturing processes.

2) Integrating the product data based on the STEP standard

To facilitate CAx collaborative design and manufacture, it is important to create a multi-dimensional product information model composed of related CAx models [9]. Integrating different CAx software packages is vital to achieve digital manufacturing and computer integrated manufacturing. It also increases competitiveness of mechanical manufacturing enterprises and their abilities to respond quickly to market demands and changes [22]. The STEP standard –ISO 10303- is one of the most successful efforts for maintaining the CAx product data integration. The STEP development process has been in progress under the auspices of the International Standard Organization since 1983 [23], [1], [24]. The product information models in STEP are specified in EXPRESS, ISO10303-11, a modelling language that combines ideas from the entity–attribute-relationship family of modelling languages with object modelling concepts [25]. ISO 10303-21 defines a character-based file format for the exchange of data corresponding to an EXPRESS information model; it is sufficient for traditional data exchange [24]. EXPRESS is structured in schemas, which represent the model of the product. A schema consists of entities, which are the main objects and data types that support the definitions of these entities. Within the entities are encapsulated attributes and constraints, which restrict the value of the attributes [26], [27].ISO 10303 consists of application protocols (APs) as parts of the standard that define data models for a certain application domain. Each AP defines classes of objects and their relations [28], [29]. Using APs, STEP addresses many industrial data exchange requirements [30]. There are protocols for specific kinds of products such as boats, buildings, and electronic circuit boards that are largely focusing to their respective industries. Some of utilising APs for CAx manufacturing data are AP203 (Configuration controlled 3D designs of mechanical parts and assemblies), AP204 (Mechanical design using boundary representation), AP214 (Core data for automotive mechanical design processes), and AP224 (Mechanical product definition for process plans using machining features) [13].Although STEP standard is the most successful standard to maintain product data integration, it has some lacks. STEP APs capture object information as a snapshot in time and lack the ability to capture how the object changed through time [28], [31]. STEP does not completely capture or represent knowledge related to some aspects of manufacturing processes and outcomes like [32]; there are no concepts/attributes to capture the data such as total cost impacts, modified process types and classifications.Considering the abilities of the STEP standard for product data integration, the paper studies the collaborative platform for CAx product integration based on the STEP standard. It also studies the platforms' procedures to overcome the STEP standard shortcomings.

A. Overview of CAx collaborative and integrated platforms

The "Feature-based collaborative design" [18] proposes a Feature-based collaborative design platform which is an integrated system of CAD, CAPP and CAM based on an Internet/Intranet network. The platform integrates application subsystems that consist of feature-based CAD, CAPP, and CAM system. The platform provides product data for each subsystem through a feature-based product definition model as shown in Fig**.** 1. The platform uses a shared product data structure between different CAx software packages but it is not integrated based on the STEP standard.

The "Collaborative multi-agent systems" is the application of distributed artificial intelligence methods, namely collaborative multi-agent systems in design. This system is named Multi-Agent System for Computer Aided Process Planning (MASCAPP) [33]. The information model for MASCAPP has been designed with STEP-NC and enables

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product data integration based on the STEP standard. The workflow chain for this platform is shown in Fig. 2. The platform does not use any procedures to enable different CAx software packages to collaborate with each other. The platform is reliant to the STEP-NC product data structure and does not apply any procedures to overcome the shortcomings of STEP standard.

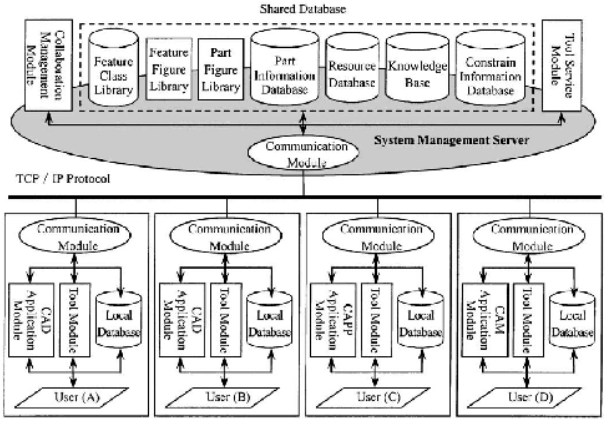


Fig. 1 Platform of feature-based collaborative design [18]

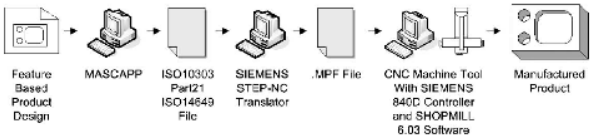


Fig. 2 MASCAPP design to manufacture work flow chain [33]

The "Integrated CAD/CAPP/CAM/CNC" is the architecture developed with the paradigm of omitting data conversion between different CAD/CAM applications [34]. The platform focuses on STEP standards to support data exchange between CAD systems as well as facilitate data flow between CAD, CAPP, CAM, and CNC systems. The architecture of this system is shown in Fig. 3. The platform has used STEP data structure to insure the integration in CAD/CAM/CAPP/CNC machining. Considering the shortcomings of STEP standard, the platform does not suggest any procedures to fulfill them. The platform considers the product data from CAD to CNC machining to be maintained and exchanged based on the STEP standard. The platform does not apply any procedures to enable collaboration among different CAx agents.

The "Fine Grain Feature Associations in Collaborative Design and Manufacturing" is a try to apply a theoretic unified product modeling scheme with fine grain feature-based methods for the integration of computer-aided applications [35]. The platform extends the traditional feature concept to a flexible and enriched data type, unified feature, which can be used to support the validity maintenance of product models.The platform allows multiple applications to share a consistent product model. it maintains the product data integrity and validity. The platform enables the collaboration among different CAx software packages. The authors [35] believed that using geometric data file exchange via a set of neutral formats, such as the STEP standard is no longer satisfactory to support modern product lifecycle management. The platform proposes a comprehensive data sharing to support application integration. As shown in Fig. 4, the platform proposes schemes that enable each application to store the data in a central relational database and also to access the database to retrieve the data that is reviewed and certificated by the platform.

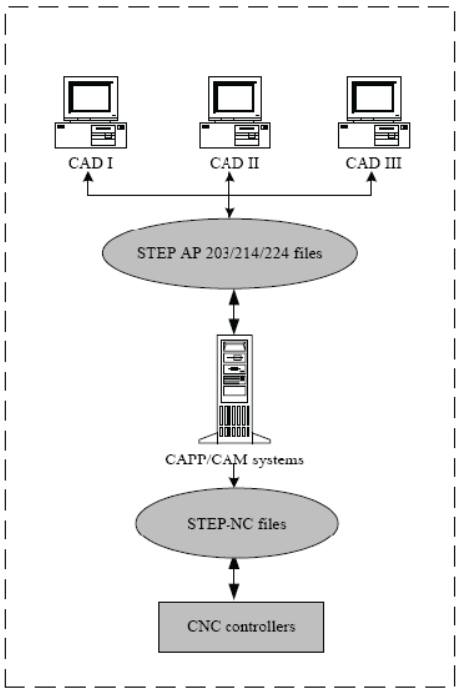


Fig. 3 Integrated CAD/CAPP/CAM/CNC platform [34]

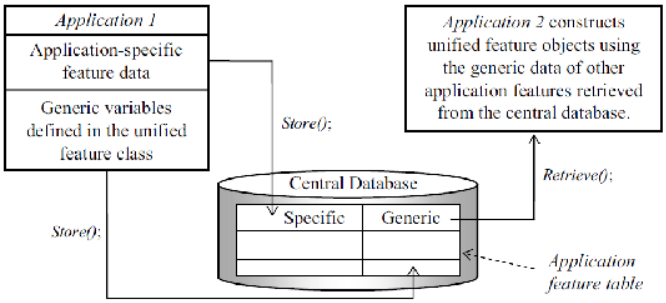


Fig. 4 The proposed Data access method in the platform [35]

The platform uses feature modeling scheme definitions, application feature definitions, the unified cellular model, dependency network, and the change propagation algorithm to integrate the conceptual design, detailed design, and process planning applications.

The "INFELT STEP: An integrated and interoperable platform for collaborative CAD/CAPP/CAM/CNC machining systems based on STEP standard" [29] proposes a three-layered integrated and interoperable platform, named INFELT STEP, for collaborative and interoperable product design/development. The layered structure of INFELT STEP as shown in Fig. 5, caters for the requirements of an integrated, interoperable and collaborative computer-based manufacturing and supports the entire range of software packages in the

CAD/CAPP/CAM product development chain. The INFELT STEP tries to overcome the shortcomings of STEP standard by using non-STEP rule maps Where the CAx product data structures are not supported by the STEP standard application protocols. Although it exploits procedures to overcome shortcomings the STEP standard, the platform architecture extension to support all CAx software packages is a time consuming process. The architecture is time dependent and should be refined by the STEP AP's improvement.

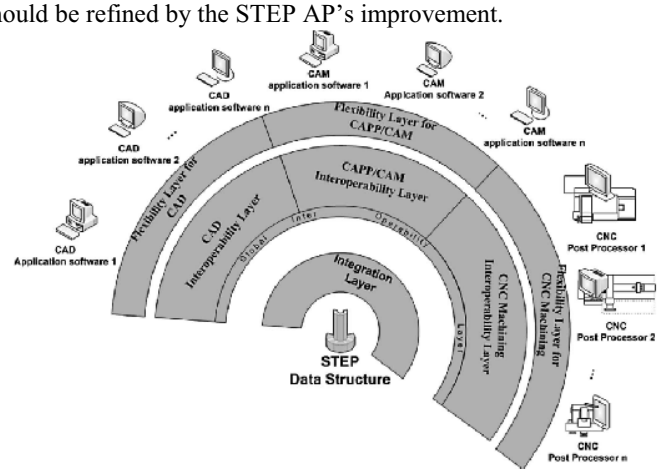


Fig. 5 INFELT STEP three-layered structure [29]

The "Managing Collaborative Process Planning Activities through Extended Enterprise" [36] proposes a reference model for collaborative process planning, while considering certain basic requirements to enable an inter-enterprise environment. The platform is mainly consists of tools as reference model, a workflow modeling strategy and a reference architecture to enable collaborative processes management. The platform uses these tools as shown in Fig. 6 to enable the collaboration among different CAx software packages. The platform uses standardized communication protocols and interchange formats to enable the exchange of pre-arranged standardized formats especially STEP, it does not propose any procedures to overcome shortcomings of the STEP standard. It should be mentioned that the platform enables data exchange based on the STEP standard, so the paper considers it enable of product data integration based on STEP standard.

The "Information Sharing in Digital Manufacturing Based on STEP and XML" [37] proposes platform for STEP and XML to be combined in presenting product information. The platform provides a team environment that enables the CAx software packages to collaboratively develop a product in real time. The platform as shown in Fig. 7, uses STEP standard to define a neutral data format across the entire product development process, and uses the neutral data to share product data for the users over the Internet and Intranet with the help of the XML file format. The platform does not suggest any procedures to overcome the STEP standard shortcomings.

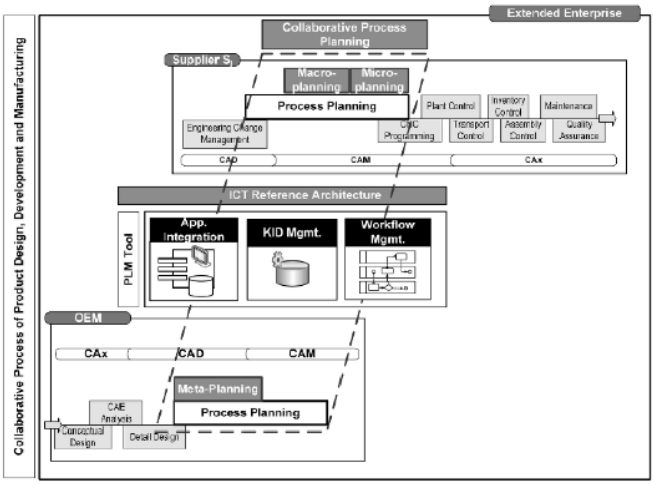


Fig. 6 Reference model for collaborative process planning across extended enterprise [36]

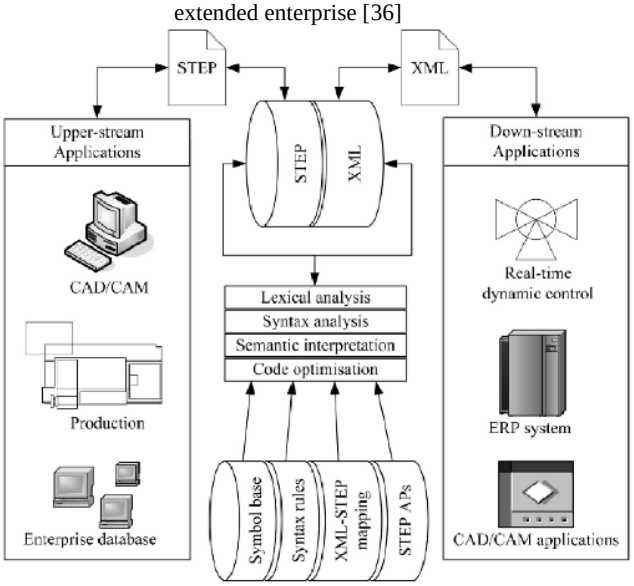


Fig. 7 Information Sharing in Digital Manufacturing Based on STEP and XML platform [37]

B. Proceeding research

Considering the current platform features as shown in Table 1, the first group of the platforms only focuses on integration based on STEP standard that decreases the ability of these platforms to support different CAx software packages each with a different product data format. The second group focuses on collaborative product development environment. Due to the shortcomings of the STEP standard and its limitations, this standard is not applied in these platforms. They used other procedures to maintain the product data through the collaborative platform. This approach deprives these platforms from the benefits of the STEP standard. The third group chooses both integration based on the STEP standard and a collaborative CAx environment. Applying this approach without considering the antonym effects of them on each other causes decrease on both integration through all CAx product development processes and the ability of platforms to enable collaboration among CAx software packages. The last group

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of platforms proposes procedures to overcome the limitations of STEP standard to enable the integration and collaboration management through whole CAx software packages. Considering that the CAx collaboration consists of a wide range of software packages and it is increasing day by day [38] the implementation of proposed procedures is time consuming and may result a high cost for the platform. Proceeding, the paper proposes a new platform that enables CAx software packages collaboration and its ability to integrate product data based on the STEP standard. The platform is designed to support different product data structures and to manage the collaboration among different CAx software packages. The Platform integrates the product data based on STEP data structures and also fulfills the STEP standard limitations. The structure and the procedure of this platform are discussed in detail. The ability of the platform to manage the product data modification is described. Application of XML capabilities for product data distribution will be described based on the STEP standard structures that support XML data structures.

III. LAYMOD; A LAYERED AND MODULAR PLATFORM FOR CAX COLLABORATION MANAGEMENT AND SUPPORTING PRODUCT DATA INTEGRATION BASED ON STEP STANDARD

A. Discussing the platform requirements

As mentioned earlier, the paper focuses on three basic capabilities required in collaborative platforms:

1) Ability to manage CAx collaboration

The platform should enable different CAx software packages to collaborate with each other. This capability considers the procedures that facilitates product data send and retrieve. The platform should propose structures that enable different data structures transitions in and out of the platform. The different modification on product data should be managed to avoid conflicts.

2) The product data integration based on STEP standard

Although different CAx software packages should be able to collaborate with each other, the integrity of product data should be maintained through the platform. The STEP standard is chosen as the data structure in the platform. Therefore the product data is stored via this standard data structure. Meanwhile the platform should support different CAx software packages to use their required product data.

3) Use of procedures to overcome the STEP standard shortcomings

Fulfilling the first and second requirement has some antonym effect on each other. This happens because the product data integration and collaborative environment in a platform usually stands on opposite sides. On one side there is a need to obtain product data based on STEP data structures by means of procedures defined in its protocols called APs [29]. Therefore the limitations of the STEP standard should also be considered in the platform. Limitations such as the improvement of the STEP's Application Protocols (APs) over the time, huge number of STEP AP's and cc's, the high implementation cost, costly process of conversion of the older CAx software files to the STEP neutral file format; and lack of STEP knowledge may affect CAx collaboration and integration of product data. The platform should also propose procedures and structures that overcome these shortcomings too.

B. Collaborative and integrated LAYMOD platform

Considering the collaboration and integration requirements, the paper uses a layered and modular approach. The modular approach is based on the new paradigm proposed for the STEP standard. Since the beginning of implementation of application protocols having difficult process of development and use of same type of information (particularly geometry and topology) between different APs [39] development of methods for modularizing APs has started [15]. Applying this, a new AP can be formed by combining existing modules and also by adding one or more new application-specific modules. LAYMOD supports different CAx software packages by applying STEP standard application modules' methodology. Based on product data structure of CAx software packages, related application modules are used to transmit the product data. The second part of LAYMOD platform is to use a layered structure. This layered structure is useful for both to fulfil the antonyms of integration and collaborative environment and also facilitates the application modules functionalities through layers based on the layers' functionalities. Also to provide the different CAx software packages in a collaborative product development environment another feature of the STEP standard is applied. This feature is the new capability of this standard to work with XML data structure. This part is named ISO10303-28 and it specifies the extensible markup language (XML) representation for EXPRESS-driven data and is officially known as STEP-XML [40]. Similar to ISO10303-21, this implementation method specifies the representation of a valid population of STEP entities. This feature helps LAYMOD to transmit the STEP based product data structure through the layers in XML format. This also enables distributed CAx software packages to collaborate with each other.

1) Modules of LAYMOD platform

The LAYMOD is comprised of two sections shown in Fig. 8. The first called "interface modules" section that is consists of procedures to enable collaboration of different CAx software packages. The second called "STEP management modules" section that is the brain of the platform. These sections are discussed with details.Modules of this section are comprised of procedures for CAx software packages collaboration. The CAx software packages operate with definite data format. These formats are included in knowledge base of the "Interface modules" section. The data format definition records are inserted into this bin. Every data format needs to define a data container. For any data format, it is required to define a data container. The data container definition is the structure that transmits and holds the product data format. This may be in the form of a simple txt files or the XML based data structure.

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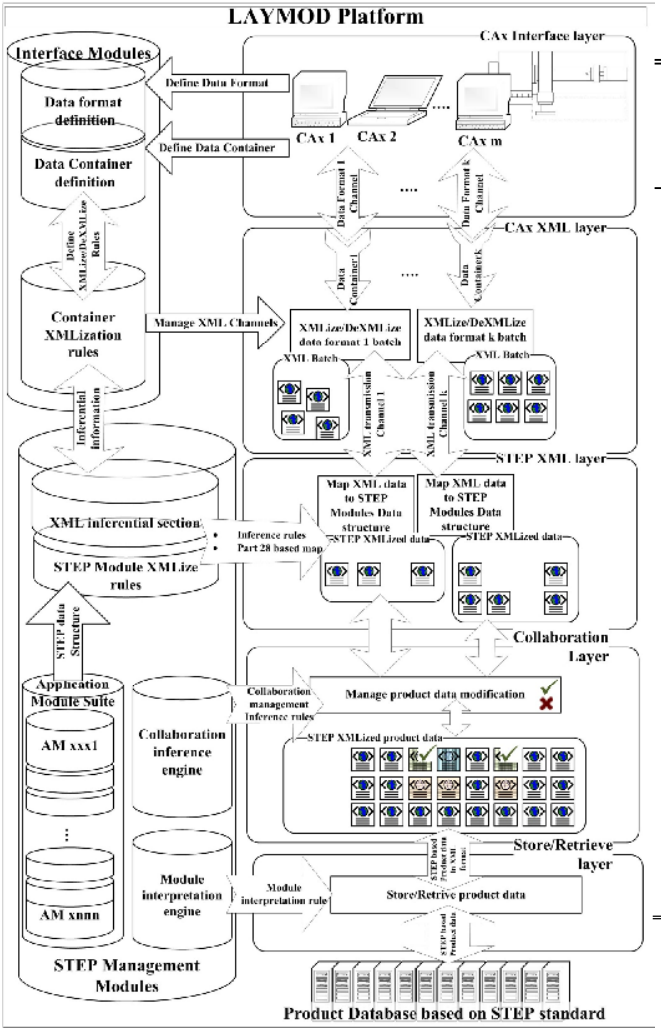


Fig. 8 LAYMOD platform

a) Interface modules

The data definition enables different CAx software packages to work based on their own data structures. The other bin in the "interface modules" section is named container XMLization rules. Any data container has definite rules to map product data in XML data structure and vice versa. The LAYMOD platform uses XML data structure to transmit product data between different CAx software packages. This structure helps [41] achieving flexibility to support distributed CAx software packages. The previous researches show [42] [43] that the application of the XML data structure facilitates data transformation. This feature is used to transmit product data among different layers.

b) STEP management modules

This section is comprised of procedures that manage and integrate product data modification by different CAx software packages. The STEP standard modular structure is adopted in this section. The procedures in the "STEP management modules" section use developed STEP modules' interpretation rules to map product data in different STEP standard data

TABLE I
CURRENT COLLABORATIVE CAX PLATFORMS STUDIED

Platforms	Ability to manage CAx collaboration	Integrating the product data based on STEP standard	Use of procedures to overcome the STEP standard shortcomings
Feature-based collaborative design [18]	YES	NO	NO
Collaborative multi-agent systems [33]	NO	YES	NO
Integrated CAD/CAPP/CAM/CNC [34]	NO	YES	NO
Fine Grain Feature Associations in Collaborative Design and Manufacturing [35]	YES	NO	YES, proposing unified feature modelling schema
INFELT STEP: An integrated and interoperable platform for collaborative CAD/CAPP/CAM/CNC machining systems based on STEP standard [29]	YES	YES	YES, Proposing non-STEP rule maps
Managing Collaborative Process Planning Activities through Extended Enterprise [36]	YES	YES	NO
Information Sharing in Digital Manufacturing Based on STEP and XML [37]	YES	YES	NO
LAYMOD	YES	YES	YES, use a modular and layered structure

structures. The mapped data are based on STEP-XML data structure. This facilitates data transitions to other layers. Also there is a bin called "Module interpretation engine". This bin is comprised of interpretation producers. These procedures adopt rules of the STEP Modules interpretation. The product data are stored and retrieved from the STEP product database by means of these procedures.The basic knowledge of this section is constructed based on the STEP Modules. As mentioned earlier any product data format which is defined in data definition bin, may needs some application modules. It depends on volume of widespread in product data related to those CAx software package activities. As different application modules are introduced or modified the related procedures are modified in application module bin. This bin modifies the related rules in STEP module XMLize/deXMLize bin and STEP interpretation bin.

2) Layers of LAYMOD platform

LAYMOD platform is consists of 5 layers. These layers are used to decrease the antonym effects of procedures that enable collaboration management and product data integration based on the STEP standard. The LAYMOD platform is flexible enough to enable different CAx software packages to collaborate with each other and on the other hand integrates the product data based on STEP data structures. The layers also help the LAYMOD platform to overcome the STEP standard shortcomings. In these layers, the product data are

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transmitted based on the XML through. Layers and their roles in the platform are discussed in following sections.

a) CAx interface layer

The CAx interface layer provides the procedures to retrieve and send the product data related to a CAx software packages based on the definite data format. This is done by the data format channels. These data format channels are defined base on the data format defined in the "data format definition" bin. The data format definitions are designed to get or send a data container. These channels get the product data based on their data container definition from CAx software packages and deliver them to CAx XML layer. Vice versa these channels may send back the product data for a specified data format through their channels and deliver it to the related CAx software package.

b) CAx XML layer

This layer facilitates transition of product data through the platform layers. The procedures in this layer are defined by the XMLize/DeXMLize rules defined in the "Container XMLization rules" bin. Researchers have shown [44], [40] (29] that XML based data formats can be easily transformed through different web protocols. This is an important feature of LAYMOD platform. The platform can support the distributed CAx software packages and enable them to collaborate with each other even when they are distributed in different locations. The procedures in this layer receive the product data container from data format channels. The product data are structured based on the XMLization rules related to the data format definition. This makes a XML batch to be transformed to the lower layers through the XML transmission channels.Vice versa, the product data in XML format are received as XML batches and then the related procedures extract the product data based on DeXMLization rules. The product data is then filled in the related data container and is sent through the data format channels to the related CAx software package. The XML batches vary in size based on the outspread of product data domain which the CAx software packages have worked with. The XML batches are delivered to or retrieve from the STEP XML layer.

c) STEP XML layer

This layer receives the XML batch from the CAx XML layer. The procedures in this layer work based on inferential rules. These rules are obtained from two bins. The first type of procedures are responsible to inference the product data based on XML structure and then the second type of procedures map them to STEP Modules XMLize rules based on part 28. The recent advantages of STEP standard enable [39] this operation. Vice versa, the operations can proceed to map the product data from STEP XML based format to a define container XML batch.This layer works with "STEP management Modules" section. The application modules' interpretation rules are adopted from "Application Modules suites" bin. These rules are then implemented based on part 28 in the form of different procedures. These procedures are capable of mapping product data in different format to STEP based data structure in XML format. The result of mapping operation is a STEP XMLized data batch. The product data are based on the STEP module data structures in XML format. Based on the product domain the CAx software packages have worked different XML based data structure are produced e.g. a CAD software packages worked on geometry data, results in a STEP XMLized batch based on map rules in Part 1039, Part 1059, Part 1068, Part 1131, Part 1507 and Part 1510. This XML batch is consist of STEP data structures produced in XML format. The STEP XMLized batch is delivered to collaboration layer. The operations can be in reverse order to retrieve the product data through XML formats based on application modules data structures. The product data are then mapped reversely to the CAx data format through XML data structure and will be sent to upper layers.

d) Collaboration layer

This layer is comprised of procedures that manage the product data modification. This layer is responsible to avoid conflicts in CAx software packages' collaboration. Different product data batches are delivered to this layer. These batches are from different CAx software packages, where each software packages have worked with a definite data format. Note that the upper layers have converted the product data in XML format and based on STEP Modules' data structures. The procedures in this layer searches the STEP XMLized batches and find the similar modified data units. The procedures verify those XMLized units and if there are no conflicts, the XMLized units from different XML batches are merged. If there are any conflicts, the related STEP XML batch is not accepted and the product data are sent back to upper layers to inform the CAx software packages about the conflicts. The result is the collaborative and integrated product data in XMLized format based on the STEP standard data structures called Integrated Resources (IRs).This layer uses collaborative inference rules. These rules work based on STEP module data structures. Any modification in product data or request for achieving a specified domain in product data are recognized and managed based on these rules. This layer sends the integrated product data to store/retrieve layer for storage operation or retrieves the product data from this layer.

e) Send/retrieve layer

This layer is responsible to send the product data to database and retrieves it vice versa. There are two types of procedures in this layer. The first type receives the product data in XML format. They recognize the product data according to the STEP standard data structures. Then the product data is sent to the database for storage. The second type retrieves the product data from database and interprets it to XML based unit and produces an integrated STEP XML batch of product data. This batch is then delivered to

collaboration layer to be transmitted to upper layers for modification by CAx software packages. As the STEP XML layer and the send/retrieve layer use the same interpretation rules which indeed is based on the STEP application modules' interpretation rules, product data is send and received without any information losses.

IV. Conclusion

Despite the advantage of new IT improvements still many CAx software work separately and locally. To be competitive in global environment, it is required to support the CAx product developers to focus on the collaborative product development approach. The collaborative product development speeds up the product development processes. To enable Collaborative design and manufacture in CAx software packages, it is essential to develop a product information model that supports related CAx product data models. To implement this paradigm, many solutions were proposed in previous works that the most successful one was to use the STEP standard. In this paper the STEP standard capabilities and limitations, the dominant platforms for supporting CAx collaboration management and product data integration are reviewed and finally a platform named LAYMOD to fulfill the requirements of CAx collaborative environment and product data integration is proposed. This platform is a layered platform to enable collaboration among different CAx software packages. It adopts the STEP modular architecture to overcome the STEP standard shortcomings. The XML data structures embedded in the platform facilitate transition of product data through the platform layers and enable collaboration of CAx software packages distributed over outspread locations. The LAYMOD platform procedures to manage collaboration and avoid contradicts in product data integrity are introduced.

Operating based on the STEP standard application modules; further researches may propose new collaboration support procedures.

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