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SOFTWARE INFRASTRUCTURE FOR GLOBAL PRODUCT ENGINEERING

Svetomir Simonović
Ph. D., Technical College, Visoka tehnička škola, Bulevar Zorana Đinđića 152a, 11070 Novi Beograd, e-mail:svetomir@sezampro.rs

Abstract:. *In order for Engineering in global circumstances to be possible it is necessary for the process to have strong informational basis. It seems that existing informational infrastructure expressed through internet technology and existing 3D CAD application can be efficiently used under supposition that lightweight data formats and procedures are developed. Desirable properties of the lightweight data technology are enumerated and the MAN example presented .*
Key words*: Lightweight Technology*

1. INTRODUCTION

Due to the combination of a global work force, global production and development resources and a need for speed, the technology of the information systems must be appropriate. The collaborating information systems must be integrated and able to gather, process, distribute, and share data quickly. Commonly, a common design database enables a global "concurrent" engineering process, i.e., various departments at essentially the same time, come together from the very beginning of the design phase even if globally dispersed, as is depicted at Figure 1. These impose considerable expectations concerning data formats and efficiency of software used [1,2,3,4,5].

Using piles of drawing is not anymore the only product data storage and exchange solution for companies that collaborate in the product design stage, internally communicate or make contracts with their suppliers and, as a result of using 3D CAD software, is continually replaced by exploiting of 3D electronics models [6]. However, thereby, the problem of interoperability between various CAD systems is arising, which incite companies to squander considerable amounts of time and oney resources making an effort to cope with the problem **[7**]. Especially, interoperability problems appear in the course of the moving of 3D CAD models created in environments of one 3D CAD application to another application 3D environment, or between various versions of the same 3D CAD application. Although this effort is assisted by classical technologies, such as IGES and STEP, these formats carry an overhead with them due to robust geometry representations that yield a large file size.

In addition to the problems created by data formats that differ from originating CAD data format, frequently it is not permissible for an organization or a department to expose the native CAD files to other organizations or other departments. So, it is necessary to provide customers (both internal and external) with the information they need without compromising the security of the information contained within the CAD model [8].

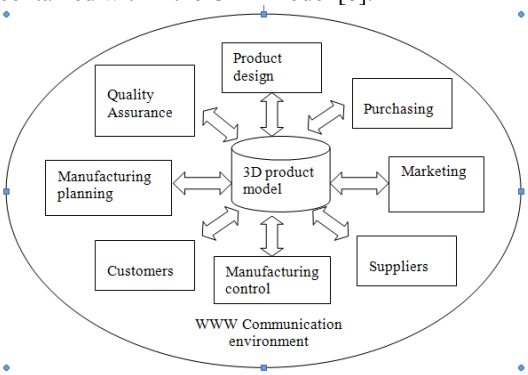

Figure 1. Globally integrated Product Engineering

Also, if native file formats are used, problems of portability and scalability appear with companies that design and manufacture exceptionally large objects, whether regarding geometry scale of objects or their complexity. So, in order to support distributed design collaboration, current software providers strive to establish its 3D CAD applications on more recently appeared file formats. The main reason is that these file technologies are capable to store product information in a lightweight, 3D format, which is not feature of IGES and STEP technology.

2. DRAWBACKS OF CLASSICAL 3D CAD

Classical 3D data comes with a considerable problem, namely, the high costs needed to generate it. Classical 3D CAD is very expensive. Compared to 2D data, classical 3D CAD data is difficult to handle because of the extra dimension of depth. Classical 3D CAD also requires time and money to learn. Especially, classical 3D CAD data cannot easily be shared on the network and classical 3D CAD systems to read the data are very costly and sofisticated, and thus cannot be made widely affordable to potential users.

In classical 3D CAD, parts can be designed by various designers, and the assembled product that is displayed can be composed of a lot of parts, so, data volume can be massive. Typical examples are the automobile and airplane industries, which use high-end 3D CAD systems where data volume is reportedly 20 Gigabytes for cars, and 5 Terabytes for airplanes. Unfortunately, classical 3D CAD is unable to display such enormous data. When data volume to be displayed reaches the level of several hundred megabytes, the display response of the classical CAD declines noticeably. Usually, an industrial machine is consisted of 3,000–5,000 parts, and devices like a printing or copy machines comprise about 5,000–8,000 parts. Reportedly, if the number of parts exceeds 5,000, the display response of classical CAD drops drastically. Obviously, at such an huge data volume, real-time data sharing on the network cannot be done. However, lightweight 3D technology successfully solves this problem. According to reports, some lightweight applications allow 3D CAD data exceeding 10 Gigabytes to be displayed.

Existing CAD/CAM systems are made to work together through format conversion. Internally, each application works independently and uses its own data representation. A typical model of global engineering design implementation is a star-shaped structure with a network database as the central node (Figure 1). One problem of this implementation is that each of the existing CAD systems usually uses a different data format. So, data format conversion between each CAD system and the central database is necessary. Sometimes, manual augmentation of the product design is applied to obtain extra information required for a particular application. Standard data formats, such as Initial Graphics Exchange Specifications (IGES) and Data Interchange Format (DXF), are used to store models in the database. [3,4] For example, the CAD design may contain only points, lines, and arcs in the model data a while the CAM system needs to know the width/length/depth of a slot that is not available from the part design explicitly. Such information has to be available in a format that can be used by a CAM system. This heterogeneous approach can easily integrate various existing components. It does, however, build barriers against a full implementation of the global product engineering concept [5]

When part interference is to be checked by classical CAD, it is necessary to remove irrelevant parts from the CAD layout in order to be able to generate the 2D images and cross-sections and to visually check the cross-sections. This leads to human error problems such as overlooked interferences and extra man-hours needed. Lightweight technology resolves these problems by automatically detecting all interferences taking into consideration complete CAD model [2].

3. LIGHTWEIGHT STATE OF THE ART

Lightweight 3D which can express large volumes of 3D data lightly and accurately is growing in importance. Since most of the popular PCs are 32-bit systems, technology to display large volumes of 3D data on these 32-bit PCs is important. Consequently, lightweight formats have emerged that can display large volumes of 3D data on standard PCs. So, the value of the existence of lightweight 3D data has increased more and more in companies. The cost-performance of individual projects is said to depend heavily on the accumulation of IT assets and degree of use. In other words, companies with a solid IT infrastructure will earn greater profits from these projects than companies without such infrastructure.

Leading CAD vendors in Europe and the USA who have realized the usefulness of lightweight 3D data are also starting to move into this area.

Dassault Systemes of France licensed XVL technology from Lattice for a lightweight 3D format 3D XML. Dassault Systemes' 3D CAD software, CATIA, is extensively used in the automotive and aero-space industries.

At the same time, UGS of the USA is promoting a lightweight 3D format called JT. JT includes both polygon data for display and precision data for CAD data exchange.

The largest PC CAD company, Autodesk, promotes a format called DWF for displaying lightweight 3D polygon data. Such CAD companies promote their respective formats using engineering-type applications.

In 2006, Adobe entered the market with 3D PDF (Portable Document Format). PDF is a very popular document format for distribution. 3D PDF adds Universal 3D (U3D) to PDF. U3D is a lightweight 3D format developed by Intel, Adobe, and the 3D Industry Forum, which includes Lattice. Support for U3D enables 3D PDF to display 3D models in PDF documents. The first version of U3D format employed polygons (triangles) to represent geometry. Its advantage is the capability of quickly displaying geometry on computers. Its drawback is that a lot of polygons are needed to accurately represent smooth 3D CAD surfaces, and that makes the file sizes of polygon-based formats very large. The goal for a lightweight 3D format is to have high

accuracy with small file sizes, and companies are engaged in technological competition over this.

As to international standards, they are not always successful in the world of 3D. There have been many graphics standards like CORE, GKS, PHIGS, VRML, and X3D that have not taken off as anticipated. This may be due to the intense development of the technology; by the time standards are established, they quickly become obsolete. In software arena, as long as the data can be converted from one format to the other, applications will be able to read it. Consequently, the core of the problem of using lightweight 3D lies not just in the data format, but also in the applications that use the 3D data.

4. DESIRABLE PROPERTIES OF LIGHTWEIGHT DATA

Following desirable properties of lightweight 3D technology can be enumerated:

- Light 3D application should allow creating 3D data incorporated into HTML files. It would eliminate a need for a separate viewer to open a 3D file and can be effectuated by integrating the evolved 3D lightweight technology with XML.
- The format and associated software should be structured so that extremely large numbers of components can be quickly loaded, shaded and manipulated in real-time.
- The resulting multi-CAD assembly should be managed such that changes to the original CAD product definition files can be automatically synchronized with their associated files resulting in a multi-CAD assembly that is always up-to-date.
- It could be used for Digital mockup (DMU) work, which allows engineers to validate that a product can be assembled together without interferences long before a physical prototype could be produced.
- This "spatial validation" should be enabled by precise measurements and cross-sectioning as well as sophisticated clearance/interference detection.
- Leveraging lightweight formats for digital mockup should allow users to reduce or eliminate costly physical prototypes and decision-making should occur much earlier in the development process.
- It should support the interactive display of very large assemblies (i.e. those containing multiple thousands of components).
- The lightweight file format should be capable of storing an arbitrary number of faceted representations with varying levels of detail (LODs). For example, when the whole product is displayed on the computer screen the hosting application should display only a general, crude view of the model. However, as the user enlarges a particular area of the model, correspondingly finer representations should be loaded and displayed. Over time, unused representations should be unloaded to save memory.
- The data model should be capable of representing a wide range of engineering data. This data should span the broad range from utterly lightweight data representation, containing no more than facet data or it should be full fledged, including geometry representations in strict accordance to NURBS together with product attributes, product structure, meta data and Product Management Information. It should also provide for multiple tessellations and be capable of displaying various levels-of-detail.
- It can be used as a CAD interoperability format for exchanging design data for Collaborative Product Development, where lightweight files are created by translating data from various CAD systems
- It should be suitable for internet collaboration. Collaboration based on lightweight data should allow organizations to send lightweight visualization data to concerned parties much more easily than sending the corresponding classical CAD files. Also, real-time, on-line collaboration should be encouraged because the volume of across the internet communicated 3D data is reduced.
- It should provide an inherent security feature such that intellectual property does not have to be shared with inappropriate parties.
- It can be used in animations
- It can be used in renderings
- Lightweight technology should be capable of performing clearance checks. It should be able to calculate interference in large models without having to subdivide the data each time.
- It can be used on handheld devices. [2,3,4,5,6,7,8,9,10,11,12].

5. THE EXAMPLE OF MAN NUTZFAHRZEUGE

An example of applying lightweight 3D technology is MAN Nutzfahrzeuge's adoption of XVL lightweight technology. MAN had a company-wide product data management system (EZIS), in which it on a regular basis stores XVL data. When a CATIA file is referenced in the system, a corresponding XVL file is automatically generated and stored in EZIS. XVL tool named XVL Studio is used for product design and viewing of designed products is enabled by 3D XVL Player that is installed on nearly every company`s PC and is also used for viewing and discussion with suppliers and customers, etc. In order to avoid network transmission of CATIA files which contain important design information, MAN sends XVL

files or IGES files converted with XVL Studio to other parties. For the sake of security, instead of sending high accuracy CATIA files, MAN transmits XVL files with appropriately diminished accuracy. The users of the system can also choose other type of the output as is a HTML page by using a tool named "XVL Web Master". MAN utilizes XVL as a communication means in all processes. To achieve this, the company established a system that ensures that staff requiring 3D data can access XVL easily. MAN is planning to totally eliminate use of 2D data for the purpose of QA and to use XVL based 3D data for better dimensional and geometrical verification of the product and in order to significantly reduce QA information exchange time, both in internal and external communications. Having intention of exploiting the XVL flexibility, MAN also plans to output 3D PDFs in Adobe format for the sake of technical illustrations. As to the assembly instructions MAN is planning to display XVL based animated instructions to eliminate the time and labor required for preparing static images for visibly clearer and faster on-the-job guidance and training [2].

6. CONCLUSION

Software infrastructure for global product design can be organized as combination of classical and lightweight 3D CAD system in following manner: Units which job is to generate, update or change 3D data, such as the design department, should carry out 3D design activities on classical CAD systems. However, entities that only need to review ore use 3D data will have exceptional benefit if apply lightweight data technology for the following three reasons:

1. There is no need for expensive PCs
2. No sophisticated training required
3. Data can be efficiently exchanged via global network

Departments such as production technology departments, factories, quality assurance departments, service departments, maintenance departments, marketing departments, and suppliers mainly just need to display lightweight 3D data and exceptionally to use some of the desired functions of lightweight data technology previously enumerated. So, creating an world wide web environment that allows these departments to access and view lightweight 3D data is all that is needed to start using 3D data throughout the global enterprise.

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