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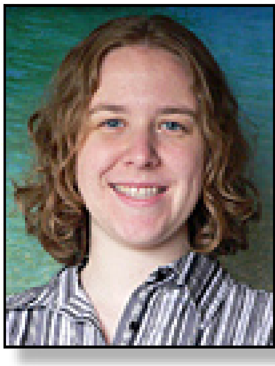
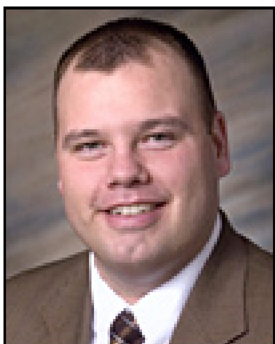


Ms. Karen Waldenmeyer is a graduate student in the Computer Graphics Technology Department at Purdue University currently pursuing her Master of Science in Technology. She received her Bachelor of Science in Computer Graphics Technology with a focus on Virtual Product Integration in 2008. Her research areas of interest include the integration of product data management systems into the product lifecycle and the use of 3D CAD geometry to express design intent. She has been conducting funded research in these and related areas for Roll-Royce Corporation since 2007.



Dr. Nathan Hartman is an Associate Professor in the Department of Computer Graphics Technology at Purdue University. His current applied research interests include the use of constraint-based CAD tools in the design process, model-based enterprise, geometry automation, and data interoperability and re-use. He currently teaches or has taught courses in 3D modeling, virtual collaboration, 3D data interoperability, and engineering design graphics standards and documentation. Nathan has taught graduate courses in the foundations of graphics in technology and instrumentation and measurement in research design. He has worked for a variety of companies in using and integrating CAD tools in the engineering design process through the development of custom training applications and materials. Nathan holds a Bachelor of Science in Technical Graphics and a Master of Science in Technology from Purdue University, and a doctorate in Technology Education from North Carolina State University.

Abstract

The design and manufacturing industries exist in a world with multiple competing CAD packages that possess each of their own strengths and weaknesses. This can become a serious problem for companies trying to integrate their software use, but are faced with high licensing and training costs, compounded by the fact that competing CAD packages do not communicate well, if at all. This is especially apparent in product data management (PDM) systems because typically the out-of-the-box installation for a PDM system does not natively support multiple CAD file types. Therefore, it is important to examine how competing CAD file types are handled within a single PDM system. This paper documents some of the strategies for getting this integration to work, challenges encountered, and the successes achieved. It will also relate these experiences to industry issues and make recommendations on how these integrations could be used more successfully.

Introduction

Product data management systems have typically been produced by the same software companies that develop CAD modeling programs. Each of the major CAD vendors also has a PDM solution that integrates with its native CAD system (Dassault, 2008; Siemens, 2008; PTC, 2008). While this works for companies that only need to store 3D data in one file format, other companies, particularly suppliers, often must manage 3D data in a variety of competing formats (Bean, n.d.). This can have an impact on which PDM tool they choose and how they use it to manage data.

Typically, the software vendor sells additional functionality to integrate competing 3D data types at an increased cost to the buyer. These additional programs are installed with the PDM system and usually add the ability to track product structure that was created in another CAD software, and to store and manage competing file types. In this instance, we are defining product structure as the parts and sub-assemblies that compose a top-level assembly that would be handled by a PDM system. Most PDM systems do not have the same level of complete functionality for multi-CAD data that is offered for the native 3D format provided by the software vendor. Users are able to launch the competing CAD program to edit 3D models, and are able to save the changes back into the PDM system, which is useful, but is often cumbersome compared to the same procedure with the native CAD system. Users also may have the option of translating native CAD data into a neutral 3D format that can be used for lightweight viewing and markup.

The strategy of licensing "add on packs" to engineering firms also can create much complexity for IT departments in terms of getting the added functionality working and integrated efficiently into the product lifecycle (Sumner, 1999). Engineering process teams also have to make changes to accommodate the anticipated difficulties with adding multi-CAD functionality to their current processes. It also frustrates end users of the PDM system who must learn a new set of instructions and rules for handling the new type of 3D file data (Hartman & Miller, 2006).

All of these challenges can be difficult for a company of any size, because the installation is complex and sometimes riddled with problems, but may help the firm become more efficient in the long run.

Interoperability In Multi-Cad Systems

Without the use of the multi-CAD application additions to existing PDM systems, most companies must use neutral file formats to increase the interoperability between native 3D formats. While there has been much success with this method, such as using the STEP format as an intermediate file format, this is not the ideal scenario for most companies (Szykman, 2001). This is due to limitations in most neutral formats and negatively affects how useful they are beyond just representing 3D geometry (Ball, 2008).

One of the most important parts of handling CAD data inside PDM systems is the recording of design intent in the form of the construction history of a part or assembly, as well as any embedded data. However, until recently neutral file formats could not handle such information. (Gordon, 2007) Upon translation to a STEP format within a PDM system, all intelligence is lost and the model becomes a solid with geometry that loses design intent completely. Therefore it is natural for PDM systems to manage native heavyweight CAD formats and eliminate the need for neutral file formats during the design process.

Another push to eliminate neutral file formats is in the area of integrating native CAD data into design assemblies. This is important because it enables the use of multiple CAD format support to handle multiple formats within one single assembly file, without the need to translate certain parts to dumb solids in a neutral format. Data is retained in an intelligent way for reuse, and it enables management of companies to easily see why the implementation of a multi-CAD PDM environment could be so crucial to a firm's success or failure. New software is coming out that supports a multi-CAD assembly functionality, which in turn pushes for more of its use in the PDM systems as well (EnSuite, 2008).

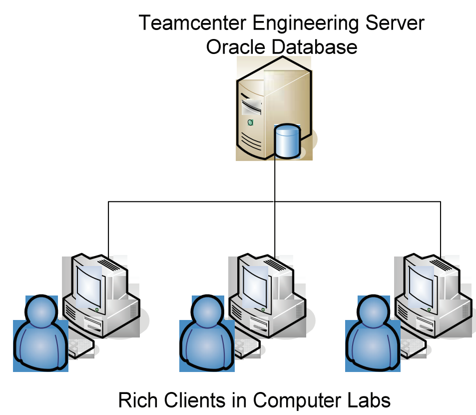
Purdue's PDM Setup Overview

Purdue University's Computer Graphics Technology department teaches its students 3D modeling principles using Dassault Systemes' CATIA V5. CATIA is a hybrid modeler that handles solid geometry as well as surface modeling and works well for class instruction. Purdue's CGT department also has a relationship with a manufacturer in the aerospace industry, and for a specific research project, was asked to set up a Teamcenter Engineering server, which is the PDM system offered by Siemens' PLM Solutions. Siemens' native CAD program is NX, which competes with CATIA as a 3D modeling package. Purdue successfully implemented an instance of Teamcenter Engineering 2005SR1, but wanted to use the software in classes to teach students about PDM principles, and needed a method to integrate CATIA data, which the students were most familiar with, into the existing infrastructure of Teamcenter Engineering.

To solve this problem, the Computer Graphics department sought out a solution provided by Siemens that would enable this integration. The answer came in the form of an additional software program to be installed on the server and client machines called "Teamcenter 2005 Integration for CATIA V5." This program essentially made the necessary changes to the Oracle database to support specific CATIA file types, add functionality to the rich Java client to launch CATIA files using CATIA, and a toolbar within CATIA to communicate with Teamcenter Engineering. This software also added the Teamcenter Save Manager, which directed users in how to save changes made while editing 3D models in CATIA. Siemens also makes similar packages for integrations with other competing CAD software like Pro/Engineer and AutoCAD. This is a step in the right direction for those involved in the computer graphics field of study, because it begins to put more emphasis on the model itself instead of the tool used to create it.

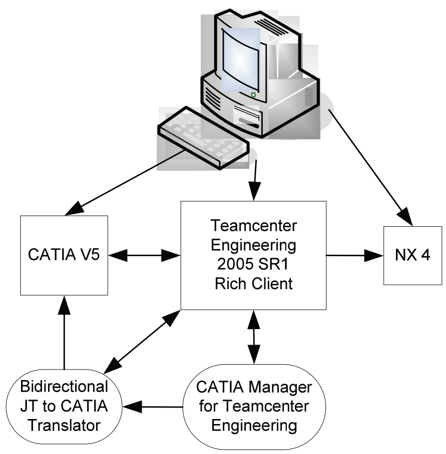
The Teamcenter implementation was set up using a two-tier architecture, with a central server housing the Oracle database, a Teamcenter installation on top of it, and the installation of rich clients in two labs on campus (Figure 1). Both the server and clients had NX and CATIA installed, as well as the integration for Teamcenter and CATIA.

Figure 1. Basic Teamcenter architecture.



The implementation also included another add-on software package, Siemens' JT Bidirectional Translator for CATIA, that facilitated the translation of native CATIA files into the lightweight JT format for viewing and markup inside Teamcenter. This was an important functionality, because it helped students make the connection between the product structure shown in Teamcenter and the physical geometry all within the same interface. It was important to be able to do the translation of these files as quickly as possible, and the Bidirectional Translator accomplished this, and will be discussed later. Siemens also sells similar translators for other competing CAD software. Figure 2 shows the key software elements that users accessed and used to facilitate the use of CATIA V5 inside Teamcenter Engineering.

Figure 2. Client computer software.



One of the aims of the Teamcenter Engineering project was to evaluate how useful it would be as an out-of-the-box solution. Therefore, once it was installed, very little customization was done in order to discover how functional it would be as soon as it was installed. This is different from a typical installation in industry where the customization of PDM software can take months, if it ever ends at all. Companies are leaning more towards *configuring* out-of-the-box software to fit their needs, because it reduces the reliance on specialized staff to maintain customized tools. It also minimizes the long-term incompatibilities as the base software tools are upgraded and revised.

Once the implementation was fully installed and functional on campus, it was introduced in the classroom as lab activities in a course on product data management and product lifecycle management. Students were given training manuals written by Siemens on how to use Teamcenter Engineering, and the CATIA integration, but these guides were not customized for Purdue's specific installation. Students were also required to complete course projects in which they had to apply the basic fundamentals of CAD data management learned through the weekly laboratory exercises in a fashion consistent with an industrial product releasing process.

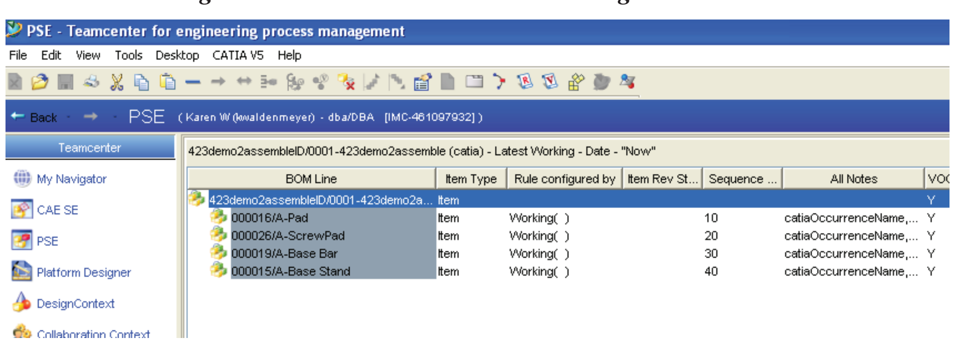
Multi-CAD In The Classroom

It is important to note that no scientific testing or experiment was performed to evaluate how well Teamcenter handled CATIA data in the classroom, but instead an observational case study was conducted on the subject (Bogdan and Biklen, 1998). During the time the program was introduced and used, several impressions and observations were made that may help for future reference. This classroom experience seemed like a great way to determine strengths and weaknesses of a multi-CAD system in an environment where students are faced with challenges in the form of projects and must complete preliminary training and tasks to be able to accomplish their project goals. This is not unlike some corporate scenarios where personnel are sent to training classes (using very similar materials to those used at Purdue), and then being asked to utilize the skills and knowledge acquired in training class to execute their design projects. Given the sheer amount of companies that are going to multi-CAD configurations of their PDM systems, exposing students to them early was an important part of their education in virtual product integration and engineering graphics.

From the benefit of having many different users trying to do similar things on the system, some observations could be made on the positive aspects of a multi-CAD integration of this type. First of all, Teamcenter did a relatively good job of storing product structure even though that product structure was not in its native CAD format. Part of this is due to the method in which Teamcenter defines product structure and then attaches the corresponding files. Teamcenter does this by utilizing an object called an "Item" which can represent an assembly, part, or another designed entity (Figure 3). It manages the structure of Items, and attaches 3D data files and other data documents to those Items to treat each as a data object. The most important functionality of being able to check Items in and out of the vault was present even with Items that were imported from CATIA files. They worked the same as any other product within Teamcenter Engineering, and in a very similar fashion to most other PDM toolsets.

The ability to launch CATIA parts into CATIA straight from the Teamcenter Engineering interface was another positive aspect of the multi-CAD environment. This provided the students with a seamless interface to address, thereby promoting techniques associated with integrated product data management scenarios. Although it was at times slow to launch, this seemed to improve over time, which suggests a memory slowdown associated with CATIA, and not Teamcenter. Parts were properly mapped and renamed within CATIA accordingly from Teamcenter, and students were able to launch a CATIA part without checking it out, which gave users the ability to view the part or assembly in the native CATIA environment. If the user needed to make changes, there were buttons provided by the CATIA integration software to be able to do a variety of different commands without going back to the Teamcenter interface. As long as a user knew the context in which to use certain commands, it became fairly easy to use.

Figure 3. Product Structure Editor using CATIA data.



Another positive, and at the same time, negative, aspect of the CATIA integration for Teamcenter was the Teamcenter Save Manager, which would pop up as a Java application when trying to call certain save commands from CATIA. This manager was very useful because it gave a graphical representation of which parts in a CATIA assembly had been changed, and which needed to be resaved and in what manner (Figure 4). For these tasks it utilized specific icons and a list of all the parts that were in the assembly. The Save Manager also had a toolbar of useful buttons at the top, including one to automatically generate a JT representation of the CATIA file upon save, and allowing the user the choice of which folder, if any, to save the new part into. These buttons were large and relatively easy to use. Although the Save Manager could look confusing at first, with some explanation and practice it became immensely useful in saving CATIA data back into Teamcenter. The creation of JT files in this context would allow a user to share design information with other users (inside or outside the organization), without compromising the security of the native CAD file and without incurring the file size associated with the robust geometry representation in the native CAD file.

While it had its positive aspects, the Save Manager also presented some difficulties. For example, when the user was presented with its interface, they often were presented with a white "x" on a red circle as a warning that a part had not been checked out properly or that the user had to make some other adjustment before being able to save the part properly. However, the communication of this specific error was difficult to determine because the icons and buttons for this portion of the interface were so small, especially compared to the other icons and buttons in different parts of the Save Manager screen.

Another major roadblock that students ran into many times was the physical memory limitations of the Save Manager. No one was able to open and save a CATIA assembly that included more than 10 parts. If a student attempted this, the Save Manager would freeze and the student would be forced to shut down the Java service that was the Save Manager. This problem may have been an issue due to the simple, relatively unconfigured installation on campus, but it presented difficulties that are unacceptable in industry and in education.

An important observation was the speed of the response for launching files into CATIA and saving back to Teamcenter. This depends on many factors, including the physical properties of the server, client machines, and the network as well as the installations of CATIA and Teamcenter. Because the Purdue installation the most basic installation possible, this may have caused some speed problems which some students got frustrated with. On first launch of CATIA, the program would take about 3-5 minutes to load the part. Successive launches became faster, but there was still considerable time spent waiting for the server to save the changes made in CATIA, then confirm that the save was successful. On a more industrial-grade server, launching and saving times would most likely go faster.

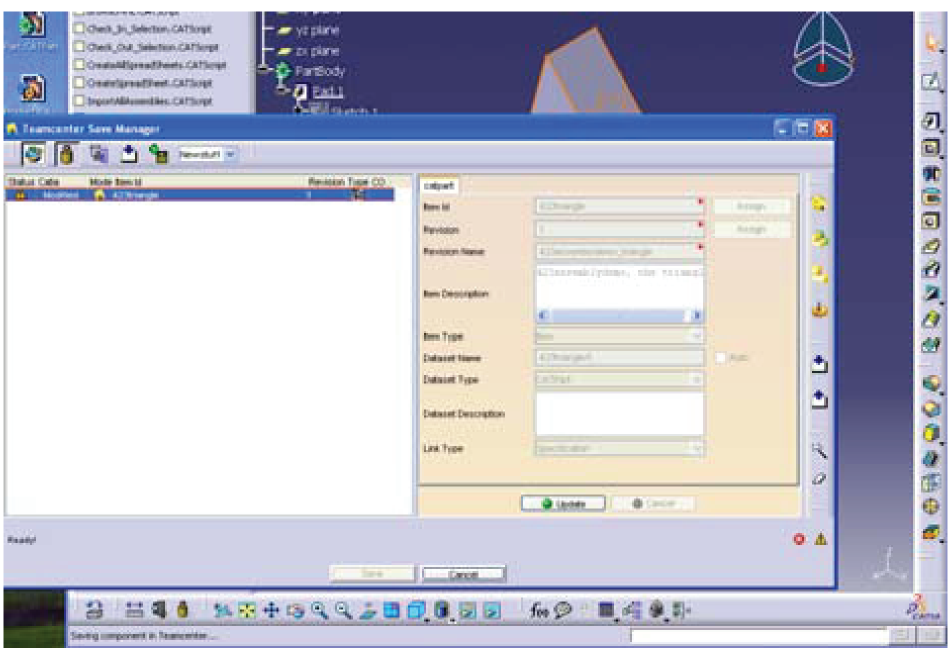
Relations To Industry

After making these observations on implementation difficulties encountered in a relatively simplistic academic setting, it becomes obvious how difficult attempting a multi-CAD integration could be in industry. Moreover, many companies are forced to do this because of customer requirements and may have strict time constraints on when the implementation must be working. There are also training issues involved in getting users up to speed on using the PDM system a different way depending on which CAD format they are working with. Time is needed to discover the quirks of the system and decide on workarounds for the problems that must be addressed.

Luckily, the advantage of buying an integration like the one discussed in this paper is that the integration is developed and sold by the same software developer that created the PDM system. Companies do not have to make an investment in trying to patch multi-CAD functionality in-house anymore, which is major benefit. They also have the resource of being able to go back to the developer if problems arise.

One of the biggest drivers for a multi-CAD PDM environment is requirements in the supply chain. This is especially true of the automotive and

Figure 4. Teamcenter Save Manager for CATIA V5.



aerospace suppliers which often work with customers who have different CAD needs. The complications of a multi-CAD system can take a long time when trying to test how an implementation will affect the existing infrastructure and rules that have been set up and are live on the supplier's PDM system. However, often these suppliers have no choice but to accommodate their customer's needs or risk losing a large part of their business.

Another factor that affects industry in relation to multi-CAD PDM environments is the sheer complexity of an implementation onto an existing complex PDM system. Most large manufacturers already have rules and procedures set up for dealing with the data in the PDM system, and sometimes these needs necessitate their own group of PDM specialists within a company. When an existing system must be made to accommodate for another CAD format, this creates an extraordinary amount of work for these specialists who must explore all the problems and potential bottlenecks associated with the new technology being integrated into the existing one. It is also necessary to create a new set of rules and processes for dealing with the new data format as well as translating 3D models between the two native formats when needed.

Industry can benefit from a repository of information pertaining to the successes and failures of multi-CAD PDM systems. Unfortunately it appears today that most companies are doing these implementations in a vacuum because they assume that their system is unique and cannot be related to other companies, but this mentality may be contributing to increased workloads and rehashing over problems that have been solved in a similar implementation at another organization. A place to share problems and solutions may help make multi-CAD implementations go more smoothly as well as encourage software developers to fix existing bugs in the software more quickly.

Multi-CAD And Education

Besides the industry implications relative to setting up a multi-CAD environment, there are many that need to be considered for engineering design graphics education as well. Because of the many CAD systems widely used today, it is important to give students an idea of what they have in common as well as some of their individual strengths and weaknesses. It is becoming more and more common for engineering designers to be designing in two or more CAD systems, and while students may not necessarily need to learn all CAD systems, they do need to understand the intricacies of managing data from each of them and between the various systems. Teaching what a multi-CAD system is, what it does, and how this affects industry could be a good start.

At Purdue University, the necessity for a multi-CAD system came out of a need to provide industry-relevant education to the future employees of our corporate partners and to address the changing landscape and breadth of engineering design graphics technology and knowledge. It is an increasingly more common phenomenon in industry that students will encounter, and they must be literate enough in the use of technology to understand what they need to do when they encounter a multi-CAD environment. Besides learning how to handle product structure and BOMs inside a PDM system, giving students firsthand experience with data translation techniques and pitfalls, as well as working in an environment where they must translate and use 3D data from a variety of native CAD systems more closely emulates what they will be working with upon graduation and placement in industry. Although students felt that the whole process was frustrating due to the speed and software limitations, they also felt (albeit anecdotally) it was a good experience for them given the state of industry.

Conclusions

Although there is no single methodology to implementing a multi-CAD system in this instance, it is valuable in the classroom as well as a good demonstration of the difficulties industry faces when doing implementations of this type. There are a variety of different combinations of PDM systems and integrated CAD formats that they manage. This case study covered the integration of Siemens' Teamcenter Engineering 2005 SR1 with CATIA V5 R16 in a small educational environment. This particular combination has many strengths and several weaknesses as well that are being ironed out by Siemens as industry needs change over time. Many companies out there are doing similar implementations of different PDM and CAD systems and having success, although it is obviously not easy success, and most of the work falls to the IT department. It may be helpful to companies who are doing multi-CAD implementations to document their processes for researching and installing their implementations for future use and to avoid rework later on in the process.

Although it is easy to lose track of the graphics element in a topic such as multi-CAD PDM systems, it is important to note that this technology has sprung up due to the variety of different 3D CAD formats and their wide usage in industry. The more companies that go to a 3D based design paradigm, the more demand there will be for interoperability between CAD systems and how PDM systems handle this data. None of it would be relevant if it were not for the ability to manipulate 3D data inside a PDM system or to be able to jump out to the CAD system and perform design changes on the fly.

Purdue plans on keeping this element of its product lifecycle management curriculum in use because of its potential value to students, as well as to aid in researching multi-CAD environments for industry and education. As with all PLM technology, multi-CAD PDM systems are an evolving tool that engineering firms and universities alike should be learning and integrating into their understanding of how PLM works and where it is headed in the future.

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