Developing an IT Infrastructure for Educational Institutions Teaching Product Lifecycle Management

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Abstract.

Many industry sectors need workers skilled in Product Lifecycle Management (PLM), but educational institutions are lagging in providing education in PLM concepts and tools. The challenges in providing this education in PLM are in part due to the complexity of the IT infrastructure and a lack of appropriately skilled IT resources in educational institutions.

PLM is a business methodology and a strategic approach which makes use of engineering software tools; and it is critical that instructors be able develop PLM courses without being unduly burdened by the complexity of the IT. PLM vendors, to a greater and lesser extent, recognize the implementation challenges posed by their software. But they also need guidance from educational institutions in order to develop sound IT implementation plans. Universities, community colleges and even K-12 schools must emphasize their roles in producing workers skilled in PLM, and in the value they provide to the PLM vendors and more importantly to their customers and the users of the PLM software tools.

Led by its Industrial and Systems Engineering (ISE) Dept., Oakland University is developing a PLM IT infrastructure which can be used as a model for replication by other educational institutions. Siemens PLM Software Inc. is supporting Oakland University in this effort through its GO PLM Program and technical support. In 2013, the ISE Dept. offered its first course entitled Product Lifecycle Management to use this IT infrastructure. Lessons learned from that course has led to improvements in the IT infrastructure, with this improved infrastructure being used in the second offering of the PLM course currently underway. Through these efforts, Oakland University seeks to become a role model for other institutions interested in PLM education.

This paper explains about the problems faced during planning, implementation phase to the students and instructors using it for course and the practices followed to avoid those issues in future. An overview of PLM IT functional architecture at Oakland University is provided so that, it can implemented by other educational institution.

Introduction.

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This paper explains about problems faced during the planning and implementation phases as well as those encountered by the students and instructor during course. Practices developed to avoid those issues in future are presented. An overview of the PLM IT functional architecture developed in response to these problems at Oakland University is provided.

The foundation of PLM is information concerning products, processes and people. With advancements in technology and increasing global competition, companies need to manufacture high quality products in shorter times. Companies need to keep up these changing technologies and tools, but there is often a skill gap between industry needs and available talent. In response to this skills gap, companies are investing heavily in training. This is becoming an expensive option for companies. Dr. Michael Grieves states, "... with training we teach the people what to do, and with education we teach them why to do it. Training is better suited to processes and education is for practices in order to understand the theories of inputs affecting the outputs which will allow creating novel and innovative instances, [1]."

Many PLM software vendors have programs to donate their software to educational institutions. Anecdotal evidence obtained by the authors suggests that at many educational institutions it remains underutilized, or even unused due to installation and configuration issues with IT. The lack of standard procedures and planned IT infrastructure for implementing PLM software in educational institutions leads to operational issues which hampers courses in PLM. Hence, there is a need for a low cost, standard and pre-configured IT infrastructure model [7] which can be implemented by any educational institution (K-12, community college or university) interested in supporting PLM education.

Understanding the critical need for a standard PLM IT infrastructure model for schools and educational institutions teaching / interested in teaching PLM course, this paper will explain the problems in teaching PLM course due to old IT infrastructure:

- Current Issues for PLM implementation for academic institutions.
- Solution i.e. PLM IT infrastructure overview.
- Problems and leanings during PLM implementation at Oakland University.
- Future plan of Cloud based PLM application.

IT Issues and Impediments for Implementing PLM in Educational Institutions.

Some of the issues and impediments for implementing PLM software into educational programs include the following. Some of these issues lie with the PLM vendors and other with the educational institutions. It is clear they must work together is address them.

1) Lack of skilled IT support for PLM implementation in educational institutions.
2) High cost of hiring an professional IT service for installation and maintenance.
3) PLM software installation processes are much more complex than most other educational software and there is a lack of standard documentation for PLM implementation aimed at educational institutions.
4) PLM software license management is confusing.
5) Training material provided by PLM vendors is not developed from the perspective of a student or instructor in an educational institution.
6) There is very little collaboration between educational institutions due to complex IT infrastructure needed to support collaborative projects. Licensing issues also hamper its use on collaboration projects.
7) Customization is required in the PLM software to use it for teaching courses.
8) Issues with local network and group policies.
9) Licenses provided to the universities often are not designed for virtualization/global education. They restrict PLM software use to specific, in-house labs. For example, some CAD software licenses do not support virtualization or the integration with other PLM software.
10) Back-end hardware (servers, switches, etc.) and connectivity needs to be estimated initially, and then adjusted routinely as the number of users grows, the system evolves, and standards and expectations for "up-time" increase (usually to 24 hours a day, 7 days a week).
11) Issues with application compatibility as students use different devices to access PLM tools.
12) Connectivity (i.e., latency) for applications like CAD when working within a managed environment.

Setting up a PLM IT infrastructure at Oakland University.

The following process was used in setting up the IT infrastructure for PLM at Oakland University.

1) Normal PLM software setup (traditional IT infrastructure) was completed and tested.
2) Deployed software solutions on physical machines in PLM Laboratory.
3) Provided user accounts to students and feedback was taken from students participating in PLM course.

4) Identified, resolved and documented operational issues during PLM lab sessions.
5) A need for a virtual lab was identified where students can work remotely irrespective of their locations since many students are working professionals.
6) University network limitations allow a limited number of users to login on physical hardware. Hence, a virtual machine which allows 50 concurrent users to login and access an application were created. A pre-configured Siemens Teamcenter PLM application was deployed on virtual machine.
7) User performance was compared for running PLM applications using:
   - virtual machine
   - physical machine
   - shared remote application platform
8) PLM software selection is based on requirements from instructor teaching a PLM course.
9) Attempted to check CAD software performance using virtual machine, but that attempt failed due to licensing issues with the virtual machine. So, the students were asked to install CAD software on their personal computers or use it in the PLM Laboratory. Attempted to host license server for CAD software (Solid Edge 6) on-campus for complete virtualization, but due to compatibility issues the attempt failed, [8].
10) Conducted a cost comparison for virtual IT implementation versus on-campus physical servers.
11) Performance tests were conducted comparing on-campus and off-campus models of accessing PLM tools, [5] and [6].
12) Oakland University social forum portal was used to report and document issues identified by students during the PLM course's laboratory sessions and exercises.

Analysis of the PLM IT Infrastructure at Oakland University.

The following issues have been identified:

1) Operational issues were observed when updates changes were deployed to PLM applications. Also, PLM application deployment activity was found to be time consuming and required high level of resources when placed on physical machines.
2) Due to needed software and traditional in IT infrastructure, students needed to work in on-campus labs in order to complete and submit their assignments.
3) Documentation of problems, helping to solve problems and taking counter measures for application failures during courses.
4) Need for application administrator to centralize the deployment process and solve compatibility issues.
5) Desire to move the software client to students' personal laptops. The use of Siemens Teamcenter as remote application should eliminate the challenges to installing over the web applications on students' laptops and centralize all data created by students, [4] and [5].
6) Selection of a low cost and suitable database software.
7) Identified an important use case as the gap between the vendor provided software licensing restrictions and the licensing needs for educational institutions, [8].
8) Need to study cost and resource upgrade flexibility of virtual IT infrastructure versus physical/on premises infrastructure.

PLM IT Infrastructure Solution.

In respond to the issues observed, it was decided to plan an IT infrastructure which not only supports a single university's PLM curiculium, but also collaboration between universities. Thus, an architecture for IT infrastructure which supports100% online PLM courses was planned, designed, developed and implemented. In considering the critical need of collaborative education, Oakland University's Industrial and Systems Engineering Dept. is currently working on extending this concept to a cloud-based PLM IT infrastructure.

Figure 1 shows a high-level functional overview of current PLM IT Infrastructure for both on-campus laboratories as well as virtual laboratories for students to access from off-campus via a secured Virtual Private Network (VPN).

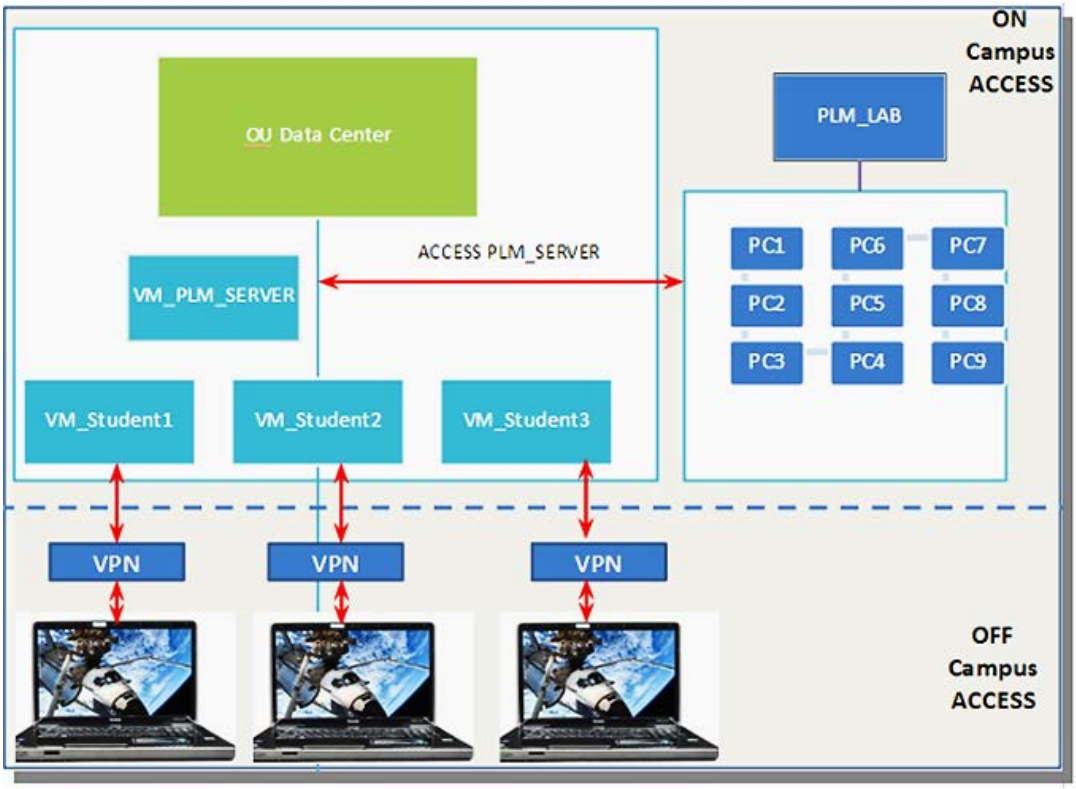

Figure 1. Functional overview of virtual PLM IT infrastructure at Oakland University.

The components of the IT infrastructure shown in Figure 1 are described in the following.

A) OU Data Center.

- Currently, the University's IT Dept. houses hardware's supporting various labs. The IT staff deploys applications, upgrades, etc.

B) VM_PLM_Server (virtual machine hosting PLM application server).

- PLM Application Server - Under the Oakland University network domain, a virtual machine was created with required resources to support 50 concurrent users for PLM applications.
- Database Server - SQL database was chosen after considering factors such as cost, number of users, applications, etc. In order to avoid multiple server management issues, the database and applications were installed on the same PLM server.
- Web application server - Jboss application server S 7.1 was used to support over-the-web application deployment and 4 tier rich clients for supporting off-campus scenarios.
- SPLM License server - The license server was hosted on same virtual machine that is hosting Teamcenter and the SQL database application.

C) PLM_LAB (Product Lifecycle Management Laboratory).

- As shown in Figure 2, the PLM_LAB block displays a traditional IT lab with Windows PC connected in a LAN network. Since the latency of application within on-campus machines was good acceptable, a 2 tier deployment was implemented for laboratories having CAD packages available for integration with PLM application. A standard virtual machine template named PC1 with PLM and CAD applications was created and deployed on it. After testing the deployed application, the same image was cloned on all computers in PLM Lab. Siemens Teamcenter 10.1 and Solid-Edge ST6 integration was established for PLM course.

Figure 2. Virtual Machine with Teamcenter application.

D) Virtual Private Network (VPN).

- As per OU network security policies, all users who want to access PLM applications or other resources need a valid network user id and password. Also, students require a PLM application login id and password to access the application from remote locations.

PLM System Level Architecture.

Using standard practice documents from Siemens PLM and Microsoft, the architecture shown in Figure 3 was developed. While developing this architecture, all consolidated information about previous PLM implementations, IT issues and PLM course requirements were used.

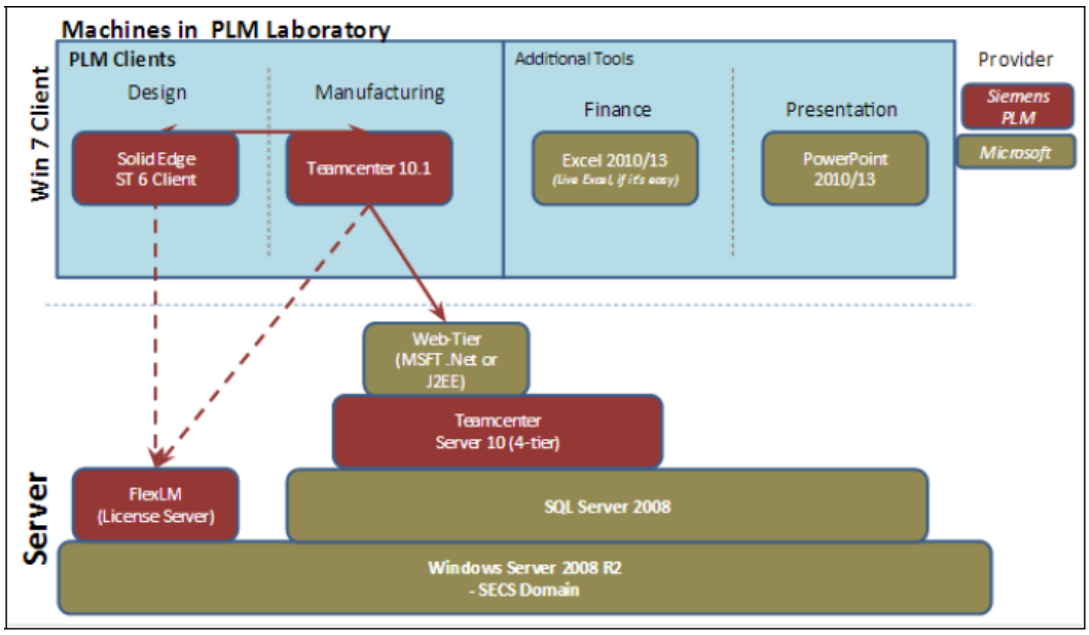

Figure 3. System level architecture for PLM Course.

The system level architecture consists of two sections: the server and the clients. The server is a Microsoft Windows server 2008 R2 virtual machine hosting Teamcenter 10.1 with a four tier architecture, SQL server 2008 database, J2EE application server and Siemens PLM License server. Client machines have Microsoft Office 2010 installed and 64 bit windows operating system. Over-The-Web (OTW) and 2 tier clients are installed as well as a Solid-Edge ST6 CAD package with Teamcenter integration. The PLM administrator deploys changes to the main server which then get pushed automatically to Teamcenter clients. A common volume is shared by all users which is hosted on the main PLM server.

Using VMware virtualization management tools, the PLM administrator makes a back-up once a week using a snapshot utility. This is useful in case of sudden application failure, saving both time and cost as well as the students' work, [9].

Platform Level Architecture.

Current and planned IT infrastructures are shown in Figure 4 and described below.

A) On-campus/traditional IT infrastructure (Current).

- Traditional infrastructure hosts all the applications on an in-house IT platform. All hardware and virtual servers are hosted on local physical hardware in an on-campus data center. All maintenance activities are performed by local IT support. This model offers security and is good for an online class, but is not feasible for collaboration with other universities due to limited support availability from the local IT Dept. with respect to scaling the infrastructure. All regular software and hardware related maintenance activities are handled by the local IT Dept.

B) Service infrastructure (In-Progress).

- This architecture is best suited for Virtual PLM (100% online PLM courses) since hardware maintenance, scaling, storage, networking and virtualization are managed by a third party vendor. This allows the university to focus on managing application deployment, operating system, student data management and middleware software. As shown in Figure 4, Oakland University is working on purchasing infrastructure as service from a third party vendor to build a scalable PLM IT infrastructure which allow collaboration with other universities.

C) Platform as service infrastructure (Future).

- Oakland University aims to be the first university hosting PLM applications on the cloud, thus collaborating universities will only manage applications and data generated by PLM tools. This infrastructure is preferred for global PLM education as it eliminates building an IT infrastructure for participating educational institutions seeking to add PLM applications in their curricula.

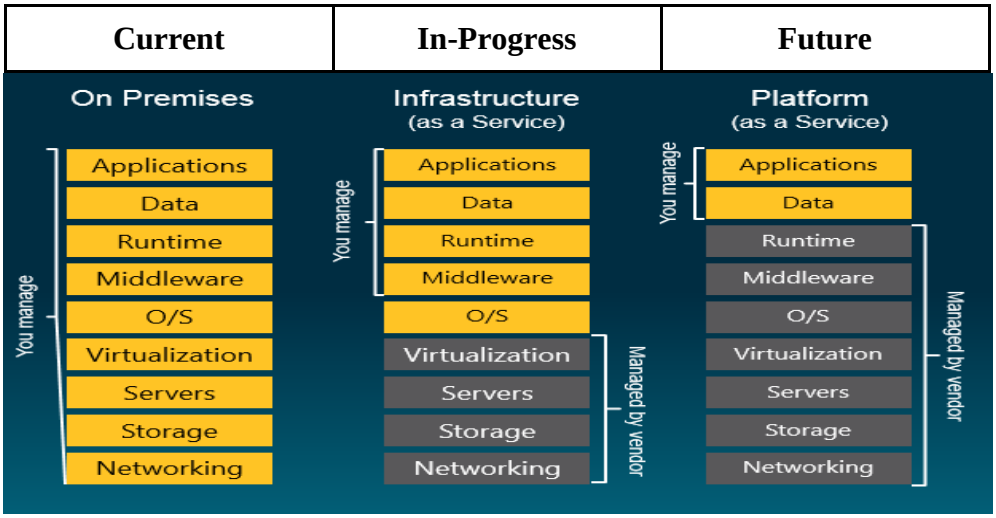

Figure 4. Current and future implementation platforms, [13].

Conclusions and Future Considerations.

- Teamcenter (PLM) and Solid-Edge (CAD) integration has been implemented successfully at Oakland university for a PLM Course.
- An IT infrastructure to support an off-campus PLM course has been developed and implemented.
- Microsoft Windows terminal services RemoteApp, [2], deployment utility is used to package applications for remote users to solve deployment and compatibility issues in pre-configured Teamcenter application.
- A standard practice document describing Teamcenter and Tecnomatix suites implementation at Oakland University is being developed using vendor provided documents and based on experience in the implementation at Oakland University, [3] and [4].
- Future plans concern the development of a cloud computing shared platform for hosting the Teamcenter application.

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Short Biographies

Atul Khiste, B.S. Mr. Khiste has over 3 years' experience in PLM and Manufacturing Execution Systems (MES) integration, deployment and product validation. He has a B.S. in Production Engineering and is currently a student in Oakland University's Industrial and Systems Engineering M.S. Program. Atul is working with Oakland University faculty and staff to set up an IT infrastructure for Siemens PLM products. He also functions as a Teaching Assistant for Oakland's PLM course. His research interests concern PLM-MES integration. Atul is a passionate about the automobile and aerospace industries. He is also an active blogger on PLM.

Patrick Hillberg, Ph.D. Dr. Hillberg has over 25 years industrial experience designing and developing Product Lifecycle Management (PLM), Digital Manufacturing, Process Planning, Robotics and Machine Vision implementations in the Aerospace, Automotive, Shipbuilding, Construction and Packaging industries. He has a B.S. in Computer Science, an M.S.E. in Industrial and Systems Engineering, and Ph.D. in Systems Engineering. He is an Adjunct Faculty member in the Industrial and Systems Engineering (ISE) Dept. at Oakland University, and is assisting in the development of their PLM and Robotics curricula. He has co-authored journal articles for the Frontiers in Education Conference and the International Journal for Industrial Engineering, among others. He functions as a Solutions Architect for Siemens PLM and a member of the ISE Industrial Advisory Board at Oakland University.

Robert Van Til, Ph.D. Dr. Van Til is a Professor and Chair of the Industrial and Systems Engineering Department at Oakland University, Rochester, Michigan, USA. He has a B.S., M.S. and Ph.D., all in Mechanical Engineering. He has held visiting positions at universities in the Netherlands and Australia as well as at Chrysler and Ford. His current research and teaching topics include PLM, modeling and analysis of manufacturing systems as well as the application of lean principles to manufacturing and service systems. His research and educational projects have been funded by the National Science Foundation, Michigan Economic Development Corp., Chrysler and others. He is the lead faculty member in guiding Oakland University's participation in the Siemens Go PLM Program**.**