The conceptual model and key technologies of PLM

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ABSTRACT: PLM - a completely new business approach - has been evolved from the early PDM in recent years, and the PLM solutions can offer a concrete integration environment to effectively develop and manage the data of products and processes; also can be the utmost efficient tool for CE. Based on the systematic study of the main solutions and new front technologies of PLM, this paper discusses the definition, status, functions and prospect of the PLM and the conceptual model and extended business process lifecycle management model are built too. Furthermore, the main function structure, key technologies and dominant features of PLM are concluded and evaluated here. Finally this paper endeavored to make the comprehensively analysis and consideration of the PLM.

1 INTRODUCTION
In today's challenging global market, enterprises must innovate to survive. Business innovation must occur in all dimensions—product, process, and organization—to improve competitiveness and business performance. To differentiate themselves, enterprises must capture, manage, and leverage their intellectual assets. This can best be accomplished through proper application of a Product Lifecycle Management (PLM) approach that addresses the needs of the extended enterprise. PLM is a strategic business approach that helps enterprises achieve its business goals of reducing costs, improving quality, and shortening time to market, while innovating its products, services, and business operations.

CIMdata defines PLM as (CIMdata, 2002):
(1) A strategic business approach that applies a consistent set of business solutions that support the collaborative creation, management, dissemination, and use of product definition information
(2) Support the extended enterprise (customers, design and supply partners, etc.)
(3) Spanning from concept to end of life of a product or plant
(4) Integrating people, processes, business issues, and information

It is important to note that PLM is not a definition of a piece, or pieces, of technology. It is a definition of a business approach to solving the problem of managing the complete set of product definition information—creating that information, managing it through its life, and disseminating and using it throughout the lifecycle of the product. PLM is not just a technology, but is an approach in which processes are as important, or more important than data. It is critical to note that PLM is as concerned with “how a business works” as with “what is being created.”

So the PLM is mainly focused on the following business challenges:
(1) The employee, partners and trusted customers need to coalesce together to design and develop the product as early as possible. And by means of real-time collaboration, communication and discussion, the valuable information should be shared along the whole value chain, and it is necessary to shorten the time of new products to market.
(2) The enterprises should respond to market and snatch the valuable information quickly, so to push out the new products that satisfy the customer requirements timely and to ensure the most quotient of the market.
(3) The enterprises need to manage and maximize the value of product throughout its entire lifecycle and make its all business processes reasonable and effective work, which include quality, logistics, environment and health.
(4) All the related information must be greatly effectively captured, disseminated and managed across the extended enterprise. Furthermore it is necessary to dig the knowledge assets from the original data to reuse the information and push the innovation.
(5) Make best of all the resources, which include employee, equipments and legacy systems, in order to cut the cost of product.

We can see from the above issues that PLM is the strategic business approach to empower the enterprises greatly to meet the challenges from the highly intensely competitive market. And technology, process and best practice can be incorporated into PLM solution. Consequently, CIMdata, Aberdeen and Datamation, which are all famous consultative companies, all conclude that PLM is not an option but a competitive necessity.

2 CONCEPTUAL PLM MODEL

Because PLM has a broad definition, and many elements are now included within PLM solutions, the PLM developers would like to give their own features to the PLM solution. And except the core components and functions publicly accepted, there are diversified functional applications under the name of PLM solutions (CIMdata 2001-2003). So it would be confused about the PLM solution structure, and CIMdata offers a world-class model that is constructed by four layers - foundation technologies, core functions, applications and business solutions from bottom to top. It gives a clear view of PLM solution structure, but it is only an abstract model that no clear contents are within it.

By studying most of main PLM solutions in the today's market, which includes UGS PLM Solutions (EDS 2002), IBM ENOVIA&SmarTeam (IBM 2002), PTC Windchill (PTC 2003), mySAP PLM (SAP 2002), eMatrix (MatrixOne 2003), Eigner PLM, IBAAN for PLM (BAAN 2004) and Agile (Agile 2003) PLM etc, and a lot of related papers, we can give a conceptual PLM model of rich contents as Figure 1 shows:

Left part of the model is composed of a series of functional applications:
(1) CAX applications are listed at the bottom, being dedicated to product designing, analyzing, simulating and digital manufacturing etc. they form the platform for product developing and constitute the overall product-designing environment.
(2) Above is CPDM - Collaborative Product Data Management that evolves from PDM, which is the core element of the PLM solutions, so it is blackened in the Figure 1. And it can realize the well-knowing and important functions just like project management, product structure and configuration management and data vault etc.
(3) B2B part aggregates the functional applications that are applied for the enterprises to achieve the intimacy or improve the business processes with customers, suppliers or other business partners of the value chain. There are always a lot of individual and specific components in this part.
(4) On the top is the production elements management, new and developing part of the PLM, and equipments, quality, environment and employee etc are all-important factors that can play the important role in production efficiency and quality. Also it includes many individual functional applications just like MRO, EH&S.

<table>
<thead>
<tr>
<th>Production Elements Management</th>
<th>Core Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASE; Assets Management; Quality Management; EH&amp;S Management etc.</td>
<td>System Administration and Security</td>
</tr>
<tr>
<td>B2B Requirements Management; Sourcing Management; Product Catalogue Management; MRO, etc.</td>
<td>Collaboration &amp; Visualization</td>
</tr>
<tr>
<td>ePDM Components of Collaboration &amp; Visualization</td>
<td>Knowledge acquiring and reusing</td>
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<tr>
<td>Program Management</td>
<td>EAI(Enterprise Applications Integration)</td>
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<tr>
<td>Engineering Management: Product Structure, Classification Management, Workflow Management</td>
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<tr>
<td>Data Vault &amp; Document Management</td>
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<tr>
<td>CAX CAD/CAM/CAE/CAPP, etc.</td>
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Figure 1. The conceptual model of PLM
The core technologies include four parts:
(1) System administration and security technologies, which include: database developing and designing technologies, administration of users, API, functions of customization just like (customized interfaces, business processes or templates).
(2) Visualization and collaboration technologies will offer the functions of viewing and marking-up and operating product defining data such as figures and solid model, which perhaps are produced by different types of CAD applications. Collaboration technologies are needed to construct a safe, reliable and highly effective collaborative platform, and now mainly focus on collaboration among the global distributed enterprises or program team members by means of Internet/Intranet. These technologies can help form the virtual web-based program team, call for real time multimedia meetings and share or access the data on Internet.
(3) Knowledge acquiring and managing technologies. Intellectual assets are most valued in PLM, and in order to “be right at first time”, the enterprises need abstract and process all the related information and data, and finally refine the valuable knowledge and best practice from them. These technologies can support product design, manufacturing and decision, and distinguish PLM from PDM obviously.
(4) Enterprise Application Integration technologies. EAI technologies are the foundation of the collaboration and visualization, and they can integrate a lot of individual applications into a seamless network and make convenient communication and exchange among the heterogeneous data. Enterprise Java Bean(EJB), ActiveX Message-oriented middleware(MOM), Remote Procedure Calls(RPCS), CORBA were all used by EAI. EAI structure must be open and object-oriented, so it can easily integrate most of heterogeneous applications.

This model not only gives the PLM structure of core applications, functions and technologies, but also the evolution and prospect of PLM can be read from applications column on the left from the bottom to the top. CAX technologies’ roles as foundation and origin are displayed in the graph, and it stresses that the CPDM is the core component of the PLM. Furthermore all the new contents and multi developing directions can fall into the top two areas. And this model also means that PLM solutions can incorporate all the former individual applications or “solitary product knowledge islands” into single and standard solutions for overall product lifecycle.

3 FEATURES AND KEY TECHNOLOGIES
3.1 Primary Features of PLM solutions
PLM solutions always compose of enormous functional applications, and no solutions are identical. But as the overall product-developing environment, CAD and PDM are in the dominant place (Xiong 2001).

3.1.1 Rich product developing modeling methods
Collaboration is highly stressed by PLM solutions offers. For example, EDS’S UGS PLM Solutions are based on the seven collaboration model, and divide the product lifecycle management into seven aspects: Enterprise, Engineering, Requirements, Visualization, Program and Community. And five phases of product lifecycle are determined too in the model, and they are Requirements planning, Concept development, Manufacturing planning, Production and testing, Maintenance and repair.

But IBM&Dassault has built up a classic PPR model, which is centered on business process and incorporates product, process and resources. The Concurrent Engineering will be realized when the product-process-resources can be modeled concurrently.

3.1.2 Extensive collaboration
All the PLM solutions developers and researchers consider the collaboration is one of the most important functions. The strategy of EDS PLM is to build up extended enterprise based on web and support all the suppliers, partners and trusted customers to capture, manage, evaluate and utilize all the related information. And users can access the PLM environment free of time and place.

3.1.3 Powerful integration
Many enterprises need to have many individual CAX, ERP, SCM or CRM applications work together, and perhaps many of them are already in use before PLM solutions are introduced. So in order not to discard these huge invested legacy systems, the PLM must integrate seamlessly with these applications (Tang 2001). Furthermore if the enterprises want their customers, partners and suppliers to join the work on product developing, they must integrate these value chain members’ key applications. So the information and data can be shared and the collaboration can be achieved. By adopting main PLM solutions on market, the powerful integration of CAX, OA(Office Automation applications), ERP and CRM etc can be easily realized.

3.1.4 Visualization
The advanced PLM solutions always liked to create a “neutral CAD” environment and designers can check, measure, configure and assemble the parts or components produced by heterogeneous CAD systems in a single and uniform environment. And the Dynamic Mock Up-DMU is developed to realize this function. Partners and customers also can read, annotate even edit and assemble the product 2D drawings or solid models as well as related resources.
By ENOVIA DMU, users can penetrate into the components or assemblies to check, navigate and simulate the practical operations and movements. Also the product space analysis, discharging simulation and actions analysis can be executed in different CAD environments and can be unified and viewed in ENOVIA PLM finally to support engineering and program decision.

3.1.5 Knowledge assets
Knowledge can be considered as the valuable assets and treasure of the enterprises in PLM solutions. By uninterrupted abstracting and processing the related information in engineering practice, business knowledge and best practice can be obtained and form the effective business model and routine. So the information and knowledge can be reused and offer the reference to the design and decision.

IBM 3D PLM is the most renowned solution in this aspect and build up the knowledge system framework whose core is PPR model. Most excellent originalities and experience will be deposited and assimilated in the PLM solutions and the developers can reduce the product developing time greatly. So the “Right First Time” has been the main purpose of the repository.

3.1.6 Mature and diversified functions
PLM solutions can offer the satisfying and perfect elementary functions including documents management, product structure management, change and configuration management, program and planning management and workflow management etc. MY-SAP PLM can figure out the related cost and revenue and assign the tasks quickly in its program management. And by configuration management, UGS PLM users can easily set the parameters of the components and assemblies, and the BOM (Bill of Material) automatically changes according to the changes of the parameters, so the product structure can be built immediately.

Furthermore, PLM developers have given full considerations to all the factors of the product lifecycle, and a lot of specific and effective functional applications have been developed, which include mySAP’s quality management, assets management and EH&S (Environment, Healthy and Safe) management and Eigner’s product catalogue and MRO (Maintenance Repair and Overhaul) etc.

3.2 The primary features of technologies

3.2.1 Web based technologies
PLM solutions always use Server/Client/Browser system model, and melt the advantages of web service and C/S applicable databases (William et al. 2003).

It is necessary to develop the absolutely web-based PLM solutions.

3.2.2 Distributed computation technologies
The web-based distributed computation technologies have made great progress recently and there are two main camps in the criterion of the distributed computation technologies, and one is the CORBA criterion made by OMG; the other is ActiveX by Microsoft.

3.2.3 Practical developing technologies
Most of PLM developers adopt J2EE, COM/DCOM/COM+, or CORBA as the main framework of the main technologies system, or offer the interface to support them. And many practical developing technologies such as XML, Microsoft.NET, OLE, JSP and .JT have been applied or supported.

3.2.4 Support many standards
When the STEP standard and related developing applications have been mature, so many CAX and PDM applications support the STEP.

OMG have published the protocols of PDM Enabler, which marks the breakthrough that PDM have made. PDM Enabler has been built on CORBA and regulates the functions, logic models and interoperating modes. And most PDM solutions support this standard (Tong 2001).

3.2.5 Work on many database applications and operation systems
PLM solutions can support most of the common distributed database systems and object oriented database systems (ORDBMS), such as: SQL Server, Oracle, Sybase and DB2 etc.

And the PLM solutions can support all the operation systems like Windows, Linux and Unix and OS on the workstations just like HP-UX, IBM AIX, SGI IRIX, Sun Solaris etc.

4 EXTENDED PLM PROCESS MODEL

The contents and forms of the PLM methods are diversified. But after studying a lot of cases, we have found that the PLM methods had the internal rules. So the PLM process model has been founded as the Figure 2 shows.
The core part of the model gives the main contents of the processes lifecycle management, and the environment and relationships of the process management is also displayed here. This model cannot only be applied to product lifecycle overall management, but also to most of the main functions such as program management, workflow management, assets management and documents management etc.

5 CONCLUSION

Generally speaking, PLM is a strategic business approach to empower the business, to enable product and process innovation. It includes technology, processes, best practices, and other elements that provide a complete solution to business problems. And PLM can effectively integrate most of the advanced manufacturing technologies just like CE, KBE and DMU etc. Many international enterprises have adopted the PLM solutions and won the great return on the investment, which include Boeing, Airbus, and Ford etc. Finally PLM is not an option but a competitive necessity to the Manufacturers.

REFERENCES


