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Original Article

Optimizing Product Lifecycle Management Infrastructure with Site Consolidation for Centralized Data Management

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Abstract: *This paper discusses the optimization of Product Lifecycle Management (PLM) infrastructure through site consolidation for centralized data management. As companies grow, product data across various locations can be inefficiently managed, creating data silos and inconsistent product development practices. Companies can streamline communication, enhance collaboration, and ensure accurate, up-to-date product information across the lifecycle by consolidating disparate sites into a unified platform. The study focuses on the most crucial strategies for achieving site consolidation: cloud-based solutions, data integration techniques, and best practices for centralized management. Moreover, it touches upon the challenges and solutions of a smooth transition toward cost reduction, improved productivity, and faster time-to-market.*

Keywords: *Product Lifecycle Management, Site Consolidation, Centralized Data Management, Data Integration, Cloud Solutions, Collaboration, Product Development, Infrastructure Optimization, Data Silo, Digital Transformation, Lifecycle Efficiency.*

I. INTRODUCTION

Product lifecycle management is an evolving technological domain that facilitates operations within the engineering, production, and manufacturing sectors. The overarching concept is that PLM systems entail "a singular source strategy for the collection and management of product data within a unified system" [1]. This objective is challenging to achieve due to the decentralized structure of engineering tasks and systems.

The paper [2] establishes a methodology for modeling the product system throughout early development, integrating system design with sustainability considerations from a forward-looking perspective. The research furthermore concentrates on enhancing modeling constructs through pertinent behavioral elements that encapsulate semantic connections and information. In [3], it illustrates that PLM systems constitute a crucial foundation for attaining a more sustainable paradigm for life, encompassing creation, engineering, manufacture, utilization, and disposal of products. The study [4] addresses the pressing issue of developing integrated PLM solutions within the contemporary European automobile sector.

This study aims to tackle a challenge in the industrial sector using the Product Lifecycle Management application, Teamcenter, which will serve as a centralized management solution worldwide.

Teamcenter serves as a virtual portal to a company's product information, facilitating collaboration among all individuals requiring access to product and process expertise. Teamcenter enables the engineers to digitally manage the product and production data in the context of the product lifecycle.

The Teamcenter solution portfolio can be tailored to realize the PLM concept by:

- Integrating concept management and needs planning into the digital life cycle management, product development, and manufacturing process.
- Connecting partners and suppliers with secure global access to your product information according to access regulations.
- Facilitating uniform, reproducible procedures and standardization.
- Teamcenter facilitates all stages of the product life cycle, encompassing planning, development, execution, and support through the provision of tools for:
- Systems engineering and specifications
- Product structure and configuration management
- Manufacturing process management
- Workflow and change administration

II. SITE CONSOLIDATION

The primary challenge confronting the global manufacturing business is the difficulty of managing data synchronization between manufacturing units located in various locations worldwide. PLM Site Consolidation serves as a comprehensive solution by facilitating site consolidation, allowing sites to utilize information equivalent to local data. This is accomplished through a succession of configurations and implementations, which are examined in this paper. Teamcenter is the PLM solution under consideration for strategy and concept discussions.

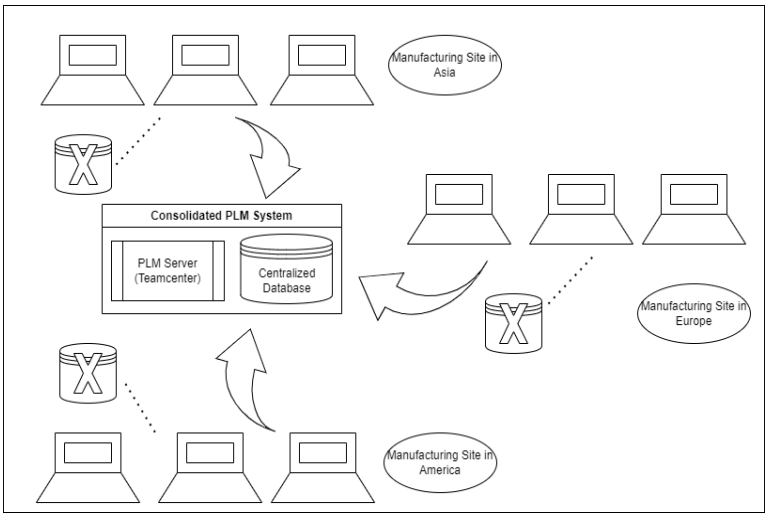

Figure 1: Site Consolidation representation

A. Estimation and planning

Formulating the system requirements and configuration for the target system is an essential aspect of the site consolidation process. This entails a thorough investigation of the data volume at each location and the formulation of a consolidated data estimation, resulting in enhanced accuracy of the estimates.

A quick overview of Teamcenter architecture is presented below that would help in the estimation of the system requirements.

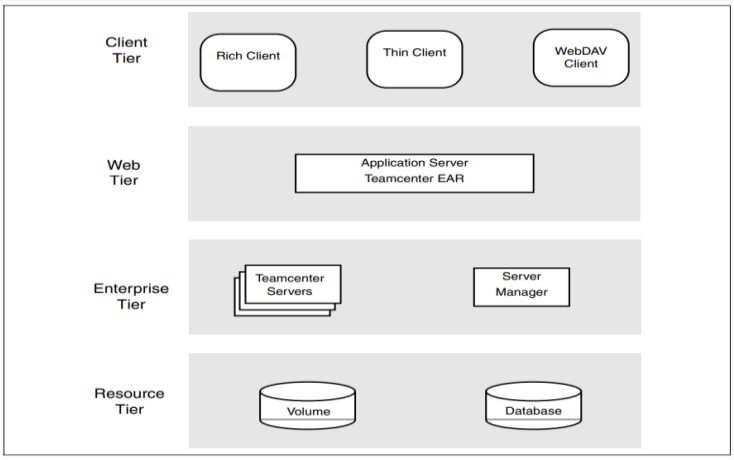

Figure 2: Estimation and planning

B. Teamcenter Architecture

- *Corporate Server:* Teamcenter service node at the center of a Teamcenter network
- *Web-tier application server:* Teamcenter service node that contains an installation of the Teamcenter Web tier application deployed in a third-party application server.
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- *Teamcenter clients:* Hosts containing an installation of the Teamcenter rich client executables and connected to a Teamcenter corporate server or application server. Hosts accessing the Teamcenter thin client over the Web.
- *Database server:* Database service node that contains an installation of RDBMS software and services queries from several Teamcenter servers
- Teamcenter necessitates a relational database management system (RDBMS) for the storage of Teamcenter data. Prior to the installation of Teamcenter, it is essential to install IBM DB2, Oracle, or Microsoft SQL Server database server and ensure that the Teamcenter corporate server host has access to the server.

a) Limitations:

- Teamcenter servers and two-tier rich clients operating on UNIX or Linux hosts are incompatible with Microsoft SQL Server database servers.
- If the Teamcenter database server utilizes IBM DB2, all Teamcenter servers and two-tier rich clients within the network must operate on operating systems that are compatible with Teamcenter and IBM DB2. IBM DB2 databases are exclusively supported on Teamcenter servers operating on Microsoft Windows, IBM AIX, or SUSE Linux platforms.

Below is the hard disk space estimation for Teamcenter configuration (calculations are based on Teamcenter 9.1 configuration).

Table 1: Hard Disk Space Estimation

Platform	Corporate Server	Two-Tier Rich Client	Web Tier
Hewlett-Packard HP-UX6	3.0 GB	Not Supported	3 GB
IBM AIX	2.0 GB	450 MB	3 GB
SUSE Linux	2.0 GB	300 MB	3 GB
Red Hat Linux	2.0 GB	300 MB	3 GB
Sun Solaris	2.5 GB	Not Supported	3 GB
Microsoft Windows	1.5 GB	450 MB	4.5 GB

III. DATA MODEL SYNCHRONIZATION

The consolidation of data models is a vital component of the overall consolidation process. The various sites may own distinct schemas that require meticulous examination and integration. User involvement from all sites is essential, and a consensus on a new data model must be reached among all engineers across different locations, which will serve as the data model for the centralized PLM system.

- This entails the collaboration of many essential qualities within the system. The business objects and their properties, including custom attributes, need to be consolidated.
- The list of values requires analysis and consolidation.
- Distinct bespoke business objects and attributes pertaining to certain sites must also be transferred to the new data model.
- Relation objects and Generic Relationship Management (GRM) settings for diverse relations must be migrated to the new data model.
- The definitions of pre-action and post-action concerning the qualities and activities of the business object must be analyzed and agreed upon.
- The configuration of runtime attributes and their associated setter and getter definitions must be consolidated.
- The definitions of extensions for each business object and property should be consolidated or incorporated.
- Conditions regarding the out-of-the-box attribute should be examined and consolidated.
- Release status management should be conferred.
- Icon management facilitates consensus on the selection of an existing icon or the creation of a novel one based on user recommendations.
- Business Object constants and Global constants must be exported to the new data model.
- SOA services, customization definitions, and service library definitions must also be exported to the new data model.
- Naming conventions with Naming rules constitute an essential component of the data model definition, significantly influencing the data migration process.

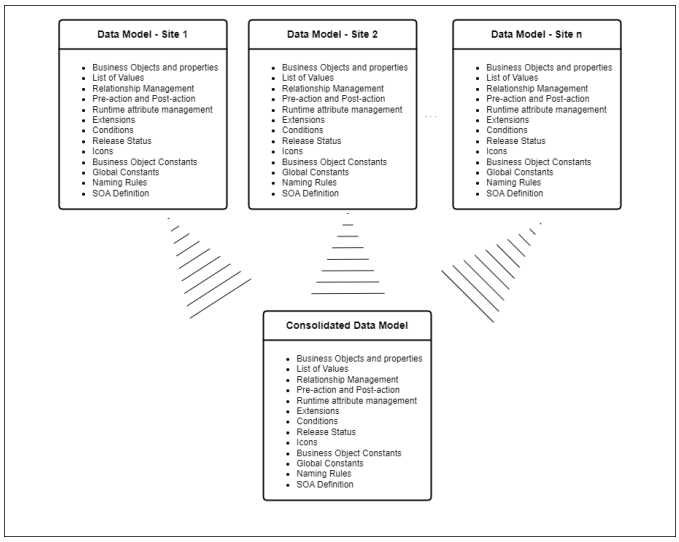

Figure 3: Data Model Consolidation

A. Site Ownership Change

During the consolidation process, it is crucial to note that ownership of all objects and entities will transfer to the centralized site. Ownership of designs, drawings, and any bill of materials is accessible from all regions. Design sharing and recommendation can be a quotidian task, eliminating any supplementary effort in data transfer. Global information can be retrieved as localized data.

This also entails consolidating the organizational components of the several sites. Users, persons, roles, and groups will be transferred to the centralized system. Group consolidation would facilitate access to many aspects in a generic manner. This would render the approval process worldwide, allowing engineers and designers from many locations and offices to inspect and approve the design. The industry would therefore be regarded as a singular entity regardless of its geographical location.

B. Management of Access

Access to the items is a crucial subject to be addressed in the preliminary conversations. PLM systems have the capability to either grant or limit access. The engineers and site managers may opt to preserve locally patented designs within the geographical area, while certain designs and products are standardized global designs for the organization overall. Access Manager can facilitate these variances. The Access Control regulations facilitate the administration of these measures.

- Rule tree panel: Facilitates the visualization of your access rules' structure through the expansion and contraction of branches.
- Rule properties: Exhibits the condition and value associated with the selected rule in the rule tree. A rule may be established, amended, or rescinded.
- Named ACL table: Exhibits the ACL name and access entries corresponding to the selected rule in the rule tree.

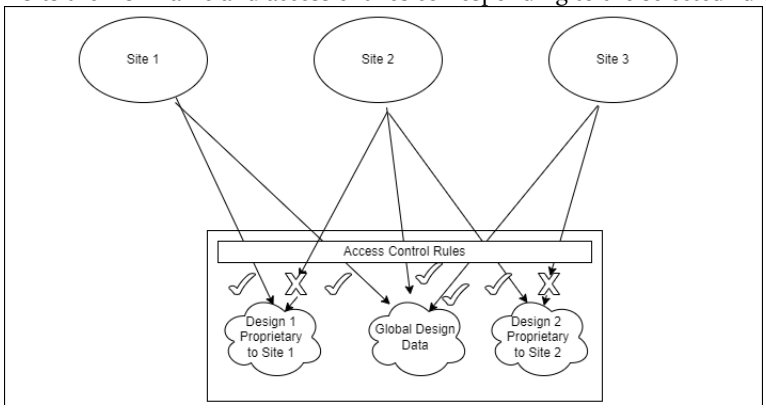

Figure 4: Access Consolidation

C. Preferences and Environment Variables

The functionality and display of Teamcenter can be modified using environment variables and preferences.Environment variables are executed in script files to configure and regulate several features of Teamcenter. By establishing these variables for each site, Teamcenter may be swiftly tailored and modified to fulfill any site's requirements. A multitude of these variables indicate certain network nodes and/or directories, enabling Teamcenter to function effectively in both extensive and limited homogeneous and heterogeneous settings.

Preferences constitute a fundamental component of the PLM system. A multitude of controls can be augmented by setup in Preferences. Preferences are specific environment variables maintained within the Teamcenter database. They are accessed during the utilization of the Teamcenter application. Each application may own corresponding preferences. Preferences enable the configuration of several aspects of application behavior throughout a session, including the revision of assemblies, the circumvention of extension rules for designated operations, and the visibility of specific Teamcenter objects in integrations. TC Preferences enables the administrator to modify the configuration without incurring system downtime. Teamcenter administrators often configure site workstations and PCs so that users can log on without explicitly establishing the environment. Upon site consolidation, a revision of the environment variables must be executed across all local environments to prevent conflicts. Centralized preference management is an effective mechanism for protecting sites against denial of service attacks.

D. Consolidation of Design Approval process

In the realm of PLM, the essence of the process hinges on design development and approval. PLM systems facilitate the integration of diverse design development technologies. The endorsement of designs by the design engineering team, which ultimately arrives at the production floor, entails many reviews, certifications, verifications, validations, rework, cost analysis, availability analysis, vendor management, and final approval for the work floor. All of these can be administered in Teamcenter through a workflow procedure, which can be constructed using a workflow designer.
Workflows in Teamcenter can be utilized to oversee procedures and modifications across many apps.

- Change Manager: Workflows are optimal for overseeing the change process, as problem reports generate change requests, which then result in change notices. A meticulously crafted change process and corresponding workflow template ensure that the appropriate individuals execute the necessary activities in the proper sequence.
- Systems Engineering: A standard Systems Engineering workflow encompasses the requirements, functional, logical, and physical design (RFLP) approach. The procedure is iterative and may be reiterated throughout the design or development of a product.

Teamcenter facilitates the convergence of processes across various sites, enabling both a global workflow and site-specific processes. Conditional tasks may be incorporated inside the global workflow process to execute supplementary validations or approvals pertinent to a specific site. This will guarantee that the centralized system addresses the specific needs of geographical requirements as well.

E. Aggregation of Inquiries across Locations

Query Builder facilitates the formulation of tailored searches for entities within both local and remote Teamcenter databases. Constructing query definitions necessitates an understanding of the Teamcenter POM (Persistent Object Manager) schema, which is a hierarchical structure of classes, subclasses, and attributes. Query definitions, commonly referred to as stored queries, specify the search criteria employed to locate information in Teamcenter. Administrators establish query definitions for end users.

Query Builder is an administrative application within Teamcenter utilized for executing the following tasks:

- Develop tailored queries for items in both local and remote Teamcenter databases.
- Preserve query suggestions in the query hints file.
- Export query definitions stored as XML files, which can be disseminated to other Teamcenter locations.
- Import query definitions into Teamcenter that are saved as XML files.
- During site consolidation, the import of existing custom queries can be executed using the rules established in the Teamcenter PLM XML Export Import module. Custom inquiries may frequently occur across sites, necessitating that consolidation engineers manage redundant queries integrated into the centralized system. Furthermore, the consistency of display names across the sites must be addressed with the site owners during the consolidation discussions.

F. Design Software Integrations

In the process of product lifecycle management (PLM), Teamcenter is able to integrate with a wide variety of software, such as popular computer-aided design (CAD) tools such as Siemens NX, Solid Edge, AutoCAD, CATIA, Creo, and SolidWorks. Additionally, it is able to integrate with enterprise resource planning (ERP) systems such as SAP and Oracle, as well as simulation software such as ANSYS and Simcenter. This allows for the exchange of data between different platforms in a seamless manner.

Every single one of these integrations will be transferred over to the centralized Taamcenter system that is being complied on. As part of the import-export translations, the datamodel translations for these softwares will be transmitted, which will reduce the amount of labor required and the number of interruptions caused by manual intervention. Additionally, the mapping of the dataset is carried over, and the consolidation of the data model would take care of any existing overlap in the behavior of the properties.

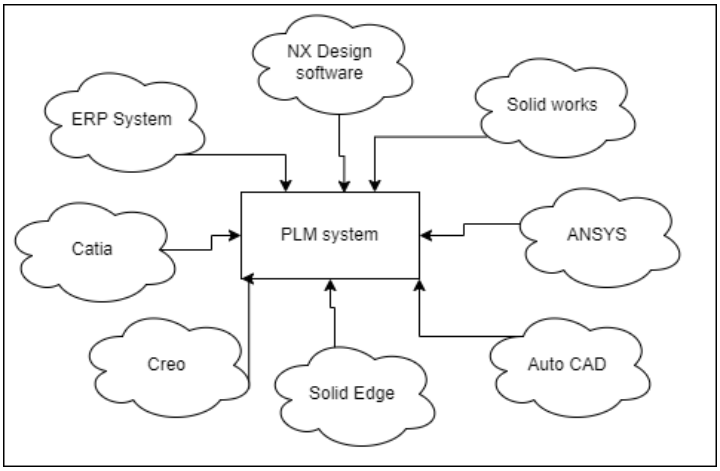

Figure 5: Integrations with External Software

G. Data Migration

Upon finalizing and approving the setup, the data model is delivered to the centralized system, which will receive data from all sites undergoing consolidation. The preliminary steps required prior to the data migration procedure are:

- Implementation of the data model to the centralized system
- Establishing the organizational configuration
- Configuring the Access Management System
- Importation of regulations and configurations
- Verifying the implementation of the integrations
- The data migration can then be executed with the Teamcenter tools designated for import and export. In the absence of auxiliary utilities, transfer protocols can be established to export data and securely send it to the centralized system.

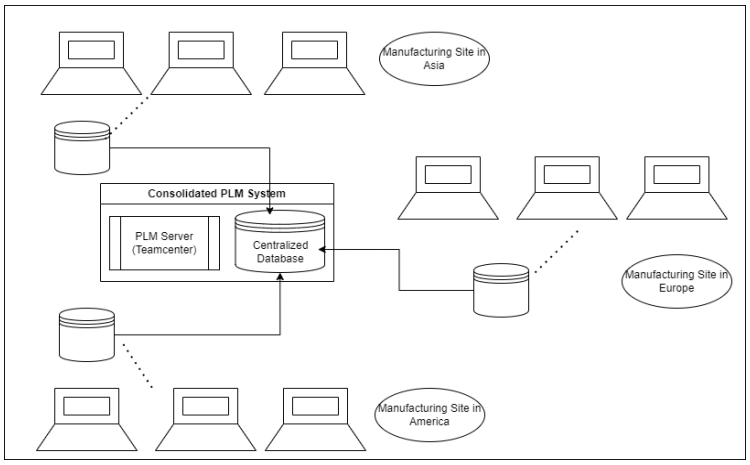

Figure 6: Data Migration from Site Databases to Centralized Database

IV. FUTURE STUDY AND ANALYSIS

This study possesses significant potential in the domain of industrial engineering. This will further advance the digitalization of the manufacturing sector optimally.

- The research will focus on the latency difficulties that may arise while accessing a large bill of materials from the centralized database. This includes techniques such as utilizing local volume to cache working data, hence preventing delays during file access.
- Extending the servers to several corporate servers would enhance horizontal scalability and facilitate the integration of new sites.
- Additionally, further integrations can be incorporated into the centralized server alongside the necessity for database growth.
- An evaluation of the utilization of non-relational databases is also a subject of discussion and investigation. A further problem that may arise is the participation of sites utilizing disparate PLM systems, necessitating transfer from an external system.
- Certain systems would also necessitate an upgrade.

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