Research on Product Lifecycle Model-Based on UML

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Abstract. Aiming at the difficulties of data integration and consistency maintenance caused by product BOM differences, based on the analysis of product data meta-models and product requirements, the data meta models in the stages of product design, process manufacturing, sales and operation, and maintenance services are Foundation, put forward a unified meta-model that supports the full life cycle of the product, and verify the validity of the model through product examples.

1. Preface
With the development of networked manufacturing technology, modern integrated manufacturing system CIMS (Contemporary Integrated Manufacturing System), manufacturing execution system MES (Manufacturing Execution System), enterprise resource planning ERP (Enterprise Resource Planning), product data management PDM (Product Data Management) and another representative enterprise information technology has also been steadily improved. These systems provide the basis for the data of each stage through different bills of material (BOM) in the product life cycle and realize the digital information management of the system. However, because each BOM is isolated in different application systems, the product data is integrated and Data consistency maintenance has brought adverse effects.

Unified Modeling Language UML (Unified Modeling Language) is a general graphical modeling language that combines the three modeling methods of Booch, OMT, and OOSE. This article establishes a meta-model of product business processes through UML visual symbols, maps physical product data to logical models, and then connects the model through a single product data source (SSPD (Single Source of Product Data)) to improve from the meta-model layer Product data consistency issues.

2. Product data metamodel
In Product Lifecycle Management PLM (Product Lifecycle Management), the product information behavior model is the backbone to define and manage product data. Similarly, the meta-model is a model used to describe the model, and the establishment of a product data meta-model is the basis for UML-based product life cycle modeling.

2.1. Establishment of product data meta-model
Manufacturing products usually require different parts to be assembled, and each part involves different types of product design, production, assembly, and other links. The information of its products needs to go through several stages of creation, management, distribution, and use to determine the basic framework of information. In this process, the data originates from different business processes and
collaborates through these processes. There are higher requirements for structural and process integrity. This article abstracts the artifacts that have the same structure in the product and exist independently within the product as product types, and then extracts the information expressed by the product-specific types and inherent attributes, and describes the association between product types with different attribution relationships to form a unified product data metamodel. To maintain the consistency of the model on the meta-model layer and provide a basis for data integration on the meta-model layer, as shown in Figure 1.

![Figure 1. Product data metamodel.](image)

2.2. Product life cycle needs analysis

Based on the product data meta-model, designers need to establish a product life cycle data model based on the actual business of the product, as shown in Figure 2. According to the business process of a manufactured product, the product design is classified into the design system in three types of conceptual design, detailed design, and process design, and then the product manufacturing is described through external parts and raw materials through the source of parts data.

Among them, according to the different functional structures of products in the life cycle, they are classified into different associations. For example, enterprise managers need to complete the tasks of design, production, assembly, operation, and maintenance. At the same time, on the one hand, each subsystem expands the product business sub-processes and components through related personnel, and on the other hand, it is associated with other business processes to improve the consistency and synergy of products in the industrial chain.

The purpose of demand analysis is to build the functional model to be completed by the system into an understandable model in the real world based on satisfying customer needs. Among them, BOM is the basic way of product data transmission in different departments and different stages. It describes the characteristics of each stage of the process by describing the attribute information of each stage of the product and then forms product development through different information management systems within the enterprise. Main production line. Therefore, the product model is divided into four parts according
to requirements: product BOM set, product set, attribute set, and relationship set. These different types of data modules are associated with different stages of meta-models to form a complete product data meta-model.

![Product full link use case diagram.](image)

**Figure 2.** Product full link use case diagram.

The BOM set describes the main data of the product in the life cycle. Through the two modules of attribute set and relationship set, it describes the product data with common characteristics, such as the process node information and structure information of the product in the full life cycle, which represents the product in the full link Unity. The product set mainly describes the characteristics of the product in the life cycle. Through the two modules of attribute set and relationship set, it describes the product data with characteristics, such as product attributes, relationship attributes, etc., which represents the particularity of the product in the entire link. The product set reflects a part of the product BOM set, and at the same time is distinguished by the attribute set and the relationship set.

3. **Product life cycle model based on a meta-model**

To establish specific product data models for specific products at different stages, this paper proposes a unified data model that supports the full life cycle of the product. The model refers to the PTC Company to divide the whole life cycle, mainly analyzes several sub-models such as product design, process manufacturing, sales service and operation, and maintenance service.

3.1. **The meta-model of each phase of the product life cycle**

Product design BOM is designed by the product design department and describes the design structure of the product through the assembly relationship of the product and the bill of materials of the product parts. Among them, the product assembly relationship is based on the customer's order contract for
product function requirements, combined with relevant design specifications, to form a design document, and determine the structural relationship between components during the product design stage. The product parts bill of materials specifies the types of design parts, which parts need to be included, and represents the main data information in the product design stage, as shown in Figure 3.

![Figure 3. Product Design Metamodel.](image)

The product process BOM mainly consists of two parts. One part is to build a part manufacturing process that conforms to the enterprise's manufacturing based on process decomposition of the product design structure, and the other part completes the assembly and processing of each production component. The product characteristics and the technological procedures of the company's production capacity clarify the manufacturing relationship between each part, as shown in Figure 4. Manufacturing BOM is the manufacturing department of an enterprise. Based on the production process BOM, the production process items, tooling resources, and raw materials of the product are added to describe the product manufacturing process in more detail.

Product design, process, and manufacturing BOM reflect the structural information of product design, process, and manufacturing stage respectively. Among them, the design BOM forms the process BOM through process decomposition. The process BOM forms the manufacturing BOM based on the company's production situation and process regulations. This logical relationship not only reflects the connection between each BOM but also provides product data consistency maintenance. Theoretical support.
Figure 4. Product process manufacturing metamodel.

Product sales BOM determines the material demand plan of the final product and its parts through customer demand information and enterprise sales plan, as shown in Figure 5. The product structure at this stage is distinguished from the product information of other stages by the customer's requirements. The particularity of the stage is reflected by the particularity of the customer's needs and the production capacity of the enterprise.
The product operation and maintenance service BOM is mainly based on product information and operation and maintenance information. It is related to customers in the design stage and material demand planning in the sales stage through order contracts and material demand plans. Product sales and operation and maintenance services are the specific applications of products in design and process manufacturing. They are based on the collection, refining, and secondary processing of certain aspects of information. Their data structure is relatively simple.

3.2. **Unified Model of Product Life Cycle**

Combining the product data meta-model with the product life cycle meta-model forms a unified product meta-model for the entire value chain, see Figure 6. Each part of the meta-model of each stage in the product life cycle is associated with the product data meta-model, so that the entire product life-cycle data meta-model is defined in the corresponding data set of the unified product meta-model. Through the continuous interaction between the sub-BOM and the Core BOM in each stage, the Core BOM finally forms the centralized management of the product data model and then uses the SSPD to centralize all the information generated in each stage that needs to be managed uniformly, restricting the use of...
relevant information at each stage. Can be extracted from the SSPD database to ensure the uniqueness, completeness, validity, coordination, and no redundancy of the information.

Figure 6. Unified product meta-model.

4. Conclusion
In this paper, given the difficulties in data integration caused by the differences in the BOM of different products, after analyzing the business process of a manufacturer, the information at each stage is classified with the product and BOM as the core, and a metadata model for each stage of the product is established. Finally, the meta-model is integrated with the attribute set and the relationship set. However, due to the lack of strict semantics and syntax in the unified modeling language, the examples in the text are not fully verified. Next, we will address this problem and combine the workflow modeling method. Make further improvements.

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