Template-Based Collaborative Design Task Management for Complex Products

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Abstract. The task template system of this system combines the business requirements of the work and provides the classification management function of work packages and work package templates. At the same time, data integration with other systems such as the main data system and resource library is realized. Through this system, users can instantiate a single work package to form a single work item, and can also establish the front and back relationship of the work package through the work package template, thereby realizing the instantiation of the work package process.

Keywords: Complex product collaborative design, task template system, industrial business requirements, task management system.

1. Introduction
Due to the increasing complexity of modern product design, involving a wide range of knowledge, difficult development, long cycle, and high cost, the entire product design can no longer be completed by the designer alone, but has become a multi-disciplinary and group collaboration. The project. Collaborative design can enable experts from different fields to participate in product development and design, make full use of collective wisdom and resources to make decision-making designs, improve product development quality, and shorten product development cycles. Collaborative design is the effective application of the concept and technology of Computer Supported Collaborative Work (CSCW) in the product development process of the manufacturing industry. It overcomes the shortcomings of traditional CAD technology and provides new ideas and technologies for enterprises to quickly respond to market research and development products [1]. The real-time collaborative design environment has the characteristics of interoperability, dynamic collaboration, resource sharing and consistency of multi-user data expression. At this stage, it is mainly used in the conceptual design phase of complex products. This system design is suitable for the task template system project itself. The design prototypes in the detailed design of custom development functions are all functional logic prototypes. Through this system, users can instantiate a single work package to form a single work item, and can also establish the front and back relationship of the work package through the work package template, thereby realizing the instantiation of the work package process.
2. System architecture design

2.1. System function framework
The system is divided into work package management, template management, and system management according to modules. The functional structure diagram is shown in Figure 1. Among them, the task template management system is developed based on JAVA, and its system architecture is divided into a collaboration layer, an application layer and a resource layer. The resource layer is used to integrate the resources used by users, mainly including system internal resources and integrated resources [2]. Task template data resources are managed uniformly at the resource layer, and the application layer only calls these data resources.

![Figure 1. System function architecture diagram](image)

2.2. Technical route

2.2.1. J2EE standard technical framework. J2EE is a standard technology platform launched by Sun for enterprise-level applications. It provides comprehensive support for EJB, Java Servlets API, JSP, XML, JDBC, JMS, JNDI, JCA and Web Service. It is a system suitable for large-scale enterprise application systems. Structure. This project should be implemented based on the J2EE platform. By using J2EE’s cross-platform, high speed, high performance, high security, high reliability, and easy expansion and expansion characteristics, it will ensure the performance, stability, Reliability and safety. Adopt J2EE standard-based technology and architecture, while using Web Service technology to reduce technical risks and dependence on specific suppliers; open system architecture should be adopted to achieve system backward compatibility, integration and scalability Sex [3]. as shown in picture 2.
2.2.2. Multi-level system architecture design. The system as a whole is constructed with a hybrid structure, complies with the J2EE architecture, and supports cross-platform applications. Aiming at the entire business model and IT environment, the system architecture is designed with a multi-layer architecture model based on the full consideration of the requirements of system scalability. The system should decompose the system into several levels in the order of service function granularity. Each level contains several functions and the software and hardware that realize these functions. Any service at a certain level can only use lower-level services or this level. For other services, higher-level services cannot be used, which makes the system easy to build and maintain [4].

2.2.3. Unstructured data storage. The data objects managed by the task template system include a large amount of unstructured data, such as full-text text, images, sound and other information. In order to realize all-round management and application of data, the platform system is using the basis of mainstream databases. The above should combine the use of technologically advanced unstructured databases. This system uses relational databases, such as Mysql database, for structured data; in addition, it also uses mature unstructured databases in the industry, such as MongoDB database.

2.3. Description of related data

| Attributes          | Description                                                                 |
|---------------------|-----------------------------------------------------------------------------|
| Work package name   |                                                                              |
| Work package number |                                                                              |
| Work package definition | Explain the main activities and processes of the work package                  |
| System options      | Level 1 work package: complex product system, XX product system, ground equipment, bomb-mounted equipment |
| Stage options       | ALL, M/C/S/D development stage                                               |
| Level               | System level/professional level/post level                                   |
| category            | Management/design/test/production/review                                     |
| Responsible node    | Associated with system unit modeling. The first-level work package corresponds to two complex product system totals and XX product totals. |
| Participating node   | Associated with system unit modeling. The first level work package corresponds to the ground system and the system node on the product. |
The data structure of the basic attributes of work package management is shown in Table 1. The basic attributes of work packages are common attributes of all work packages. Through the navigation tree, you can view the specific information of the work package. Work packages support classification by stage and category. Click the Add button to pop up the new work package page to attribute the basic properties of the work package instance. Responsible nodes and participating nodes are reference attributes, which are obtained from the tree structure of the cell library.

The work package template is used to create the work package process. The work package template itself contains basic attributes. At the same time, the work package template can be used to define the front and back relationship of the work package. The basic attributes of the work package template are shown in Table 2 below.

### Table 2. Basic attributes of the work package template

| Attributes                  | Description                                                                 |
|-----------------------------|----------------------------------------------------------------------------|
| Responsible department      |                                                                            |
| Responsible plan start time |                                                                            |
| Planned completion time     | Refer to the “time limit” in the work package template                     |
| Actual start time           |                                                                            |
| The actual completion time  |                                                                            |
| Status                      | The status generally includes: (1) operating conditions; (2) operating links.|

The technical file is used as the input data of the document type. At this stage, the technology list content is integrated through data import. Later, data synchronization can be realized by integrating with master data. Technology can be cited in the form of a single file or in the form of a package of files.

### 3. Product collaborative design task algorithm

For a product performance design problem, each performance seeks a design solution that maximizes the overall satisfaction level of the overall target under the premise of achieving the satisfaction level of each performance target through mutual cooperation, negotiation and coordination. For the space with multiple performance requirements, due to the existence of the coupling relationship, it is difficult to simultaneously obtain the optimal solution for each performance that meets the constraints.

Through the satisfaction function, multiple performance requirements are mapped to the satisfaction space, so that the evaluation scale of each performance is mapped to the range of [0, 1]. The satisfaction degree of each performance corresponds to the "optimization" degree of the corresponding performance. After the weighted summation of the various satisfaction degrees, the group evaluation index of the multi-performance satisfaction space is obtained. The mapping method is shown in Figure 3. The third quadrant represents a certain performance \( r_i = f(x) \), and the first quadrant is the satisfaction function (membership function) corresponding to \( r \). It represents the degree of satisfaction when \( f(x) \) is in different intervals, and has a certain degree of ambiguity. The semantic level is determined according to the demand level of performance \( f(x) \) and the application background. In the figure, the semantic level \( m=4 \), which means {unsatisfied, feasible, satisfied, very satisfied}. If the demand satisfaction level \( \lambda \), that is, \( \mu(f(x)) > \lambda \), \( f(x) \) is given, the design is transformed into \( f(x) \leq \lambda \), so the solution of performance is finally transformed into a process of fully constrained optimization.
Figure 3. Optimization design model based on satisfaction

After establishing the parallel optimization design model, select the appropriate optimization algorithm for calculation. Since the pseudo-parallel genetic algorithm does not require gradient information, iterative optimization search is performed on a group composed of multiple initial points, which has strong global optimization ability and maintains the difference between search groups. Therefore, the choice of pseudo-parallel genetic algorithm can handle coupling performance design issues more conveniently and quickly [5]. There are m required performances, each performance has k public design parameters, and $x_j^*$ is used to denote the jth public parameter in the performance during the coordination process. Generally speaking, before coordination, different properties correspond to different initial values of common parameters. On the basis of the initial value, the consistent value of the common parameter is obtained by determining the coordination value and coordination direction. Introduce optimized coordination function:

$$\min F = \sum_{i=1}^{m} \sum_{j=1}^{k} (z_j - x_j^*)^2$$ \hspace{1cm} (1)

Therefore, an optimization model is established in the coordination layer to coordinate the common design parameters. The optimized solution $z$ of the objective function F is the coordinated solution, and the optimized value $\min F$ of F represents the overall performance of the coordinated solution and the inconsistent solution of the common parameters of each performance the degree of inconsistency. Obviously, when $\min F = 0$ is the solution of each performance is coordinated, if it is greater than 0, coordinate processing through a single performance. For performance i:

$$\min F_i = \sum_{j=1}^{k} (z_j - x_j^*)^2$$ \hspace{1cm} (2)
The optimized value $\min F_i$ of $F_i$ represents the distance between $r_i$, the coordinated solution of performance and the design feasible region [6]. If it is equal to zero, it means that the coordinated solution satisfies the constraint of the performance, and the optimal point is the coordinated point.

4. System Test
In the different stages of the iterative development cycle, the synchronous and progressive testing of intermediate products or final products is consistent with the project development life cycle model, that is, from unit testing, to integration testing, and finally to system testing., And finally carry out the acceptance test of the project together with the customer.

5. Conclusion
The paper develops a classification management function system for work packages and work package templates, and provides a network-based system that combines computers, networks, databases, knowledge bases, model libraries, and some special EJBs, Java Servlets API, JSP, XML, JDBC, JMS, JNDI, JCA, Web Service tools, system simulation tools, etc. are integrated to form a prototype system framework suitable for the collaborative design and simulation of virtual prototypes of complex products. The purpose is to integrate multidisciplinary team members who are in different locations and use different subsystems. Together, it forms a distributed virtual prototype collaborative work platform, shares data and knowledge, and provides corresponding virtual prototype collaborative design and simulation support tools.

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