A Software System Infrastructure and Integrated Service Implementation
Model of Manufacturing Integrated Service Platform

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Abstract

For expediently integrating service partners and software modules to enhance the openness and service level of the manufacturing integrated service platform, the browser/server/database architecture is presented as its software architecture, on this basis, its function structure is divided into preponderant manufacturing resource sharing system, intelligentized and independent design system for the industry, virtual design and manufacture center, electronic business and logistics service system etc, some of these modules are emphatically described. And based on SOA service model and Web Service architecture, integrated service implementation model of manufacturing integrated service platform is established. This solution has effectively integrated hardware and software, service providers, service consumers, service supporters and function modules of the platform. So the third-party operators can provide manufacturing enterprises with many integrated services, example for innovative design and manufacture of key products, merchandise catalogue services, security and authentication services, electronic payment services, logistics information services, sharing and utilizing of preponderant manufacturing resources. It is easily learning, using and extending in the future, and breaks through the traditional service mode which is based on information delivery model.

Keywords: Distributed Software Architecture, Integrated Service, Virtual Design and Manufacture, Preponderant Resource Sharing, Electronic Business Service, Implementation Model, Service-Oriented Architecture, Web Service

1. Introduction

The less advanced modern manufacturing service industry [1] in China has become an important gap between our country and other countries such as United States, Japan, Korea, Singapore, and India. Although equipments of large manufacturing enterprises are advanced, they are only used internally and their efficiency does not perform well which results in the waste of resources. The level of professional technicians is high, but did not fully play their potential.

In contrast, small and medium manufacturing enterprises are lacking of operating capitals, advanced equipment, high-level technicians, especially the ability to get and deal with the information timely. The management level is relatively low. All these lead to the fact that is laggard design and manufacturing method, weak comprehensive competition ability, the greater risk in the operation of the market. They need a specialized manufacturing service platform urgently.

The manufacturing integrated service platform (abbr. MISP) based on SOA (Service Oriented Architecture) [2] references the center idea of SOI (Service Oriented Integration), which is to realize the application service, integrate related technology, tools and resources. It can provide some integrated services for small and medium manufacturing enterprises, to nicely meet their informationize needs.

However, using what kind of software architecture will impact on the cost performance of the platform. Because software architecture is the first class important design objects in software development, it served as a bridge between the software requirements and software design, provides a common language to communicate for software developers, embodies and tries out the early design decisions for system [3]. As an abstraction of the system design, it provides strong support for realizing sharing and reuse of the framework and component in the architecture-based software development process [4].
In addition, how to integrate innovative design and manufacture services of key products, merchandise catalogue services, security and authentication services, electronic payment services, logistics information services, sharing and utilizing of preponderant manufacturing resources, enterprise informationize software services, on-line three-dimensional display services of products, on-line technical consultation and remote technician training services etc into MISP in the building process; After the platform is built, how to implement and provide these services, how to operate and profit will decide whether MISP can provide high quality services for small and medium manufacturing enterprises and sustainable development itself. Therefore, that design software system infrastructure and establish integrated service implementation model for the platform are the important work of the research group in the design stage.

2. Software System Infrastructure of MISP

2.1 Advantages of Browser/Server Architecture

In recent years, Client/Server (abbr. C/S) or Browser/Server (abbr. B/S, as shown in Figure 1) has become one of the more popular software architecture [5].

![A Typical B/S Software Architecture](image)

Figure 1 shows that the software architecture is composed of the client, web server and database server [6]. The Client is usually a browser, mainly responsible for interaction with the user, and thus became a simple graphical interactive tool. All applications, application logic and control are deployed in the web server, access the database and execute applications are done in this layer. The database server is used to store a large amount of data information and the data logic, the security and safeguard, integrity control, consistency checking and concurrent operation with relation to data are done in this layer.

Although the traditional C/S architecture uses an open mode, but this is only the openness of the system development level, in a particular application, whether client-side or server-side still need specific software, failed to provide an open environment which is the user really expect; The B/S architecture is different, it's front-end is based on TCP/IP protocol, WWW server within the enterprise can accept access from the Internet terminal where a Web browser software is installed, as the end user, only through a Web browser, a variety of processing tasks can be done by calling the system resources, this greatly simplifies the client-side, to lighten the workload and cost of system maintenance and upgrade, finally the user's total cost will be reduced.

The biggest advantage of B/S architecture is: it can achieve real-time network operation of cross-platform in any way access (wired or wireless connection) at any time and any place (not differentiate between LAN and WAN). It does not limit the number of users, the costs of development and use are very low, with outstanding ease of use, its client adopts the international standardized browser (e.g. Internet Explorer), so basically no need for user training, whether decision maker or operation staff can operate directly without training. The client is exempted from maintenance, installation and development to save internal store and memory space and development time, and also reduce costs.

In short, the B/S architecture has achieved distributed application and centralized management about the system, any Internet user who is authorized and has installed a standard web browser can be used as a client-side of the system, and does not need to install a large number of application software on the client like C/S architecture, and even paying more economic cost for this purpose, so the B/S architecture has become a popular architecture of software system based on web in a current period of time, and will develop rapidly and drastically.

2.2 Distributed Software Architecture based on B/S/D of MISP
Because MISP provides small and medium manufacturing enterprises with a series of integrated services, and the platform operators, other service provider, service customer and service supporter located in different places, in addition, it also need to store and manage large amounts of data. So the browser/server/database (abbr. B/S/D) based on multi-level distributed web computing model is very suitable for its software architecture, as shown in Figure 2.

The client layer runs in a Web browser, through the HTTP and the HTTPS (Hypertext Transfer Protocol over Secure Socket Layer) [7], information is transmitted between the client layer and the Web layer. The computer codes focus on the server so that the deployment of the system more convenient, and also the costs of system maintenance and update costs is reduced. The client layer is used to display and collect information, and is implemented by the HTML and XML technology mainly. JavaScript code in the client-side can be used to test the validity of form data.

The service providers, service consumers and service supporters, such as manufacturing enterprises, logistics companies, manufacturing service alliance, certificate authority, bank and so on, they close ranks the platform operators of MISP all around by means of the Web browser in the client. Thus they have formed the wheel-axle type service industrial agglomeration [8] whose core is the third-party platform operators, which used their professional ability to lay a solid foundation of the division of work and cooperation.

The Web layer implements business logic. In the process of designing the Web layer, Servlet is used to implement control logic, it is responsible for handling HTTP requests; JavaBeans component is used to implement business logic and access database; JSP (Java Server Pages) is used to achieve presentation function [9].

The modular principle and top-down decomposition method [10] was used to divide the software function structure of MISP, a complex function is further decomposed into a series of relatively simple functions from an implementation viewpoint, as shown in Figure 3, the modules are organized into a good level of relations, the top module calls its underlayer module, to achieve the complete system functions, each of the underlayer module then calls the lower layer module, thereby completing a subfunction of the system, the lowest layer module completes the specific function.
Figure 3. Function Structure of MISP

The above-mentioned function modules are deployed in the web server, so the third-party operators can conveniently provide authority, fair and professional services, to reduce the development and maintenance costs and improve the speed, efficiency and quality of small and medium enterprise informationization.

In addition, some other applications come from the multiple cross-boundary and uncertain organizations are deployed in the Web server. It is conducive to realizing dynamic integration of business on the platform. By separating the application logic and presentation logic, application logic components have better independence, to bring a great convenience to code reuse. The advantage of this separation is that creates more components with platform-independent and reusability and portability, to greatly improve extendibility, maintainability, and integrated function of the system.

The data layer adopts current DBMS. The project team has developed several databases that involve enterprise information, equipment resources, technology resources, human resources, product information and system management etc, and has established a data center, large amount of data can be dynamically integrated and managed in the database server, so as to support the stable operation of the platform, and ensure that the third-party operators can uninterruptedly provide excellent services.

JavaBeans components in the Web layer connect to the database by JDBC (Java Database Connectivity) [11], to complete data access and storage logic. JDBC defines class libraries for interface between Java and the database; it is a general underlying application program interface of JAVA, which supports basic SQL function. The combination of JavaBeans and JDBC makes the system has good reusability and cross-platform.

Using this model to build the platform, its costs of development, maintenance and upgrades can be greatly saved, and to avoid enormous waste caused by blindly upgrading hardware. It provides a consistent user interface, which can reduce the difficulty of learning software. It has a strong openness and platform-independent, thereby the platform is easily extended.

3. Description of Main Functional Module for MISP

3.1 Intelligentized and independent design system for the industry

A hybrid knowledge representation method, hierarchical knowledge base model, multilevel knowledge acquisition strategies and object oriented reasoning mechanism [12, 13] were studied, so as to provide effective methods and tools for building knowledge base. These research findings helps the project team to develop an intelligentized and independent design system for some specific industries (abbr. I3DS), it is helpful to design customized products in the shortest possible time.

The architecture of I3DS can be divided into five layers on the whole: basic calculation layer, application platform layer, functional modules layer, human-computer interaction layer and system management layer (as shown in Figure 4).
Figure 4. Multilayer Architecture of Intelligentized and independent design system

(1) Basic calculation layer
In order to make software convenient for transplantation and reuse, using language tool such as standard C to write some library function for basic geometry calculation, mathematical calculation, analysis and judge, and form the basic calculation layer of the system.

(2) Application platform layer
CAD system, database management system and expert system form the application platform of I3DS to implement its function.

CAD system offers an integrated basic platform for product design and expression of parts information data, it can integrate outstanding CAD system such as Pro/Engineer or Solidworks into I3DS, to create a good environment for establishment three-dimensional model of the product.

Database management system is the core to establishment and maintenance of databases and inputting, outputting, changing and allocation of data. The databases involve the industrial standard database, parts information database, and enterprise management database related to product design etc.

Expert system is a branch of the artificial intelligence [14], it utilize many professional knowledge to solve the problem that only the experts can solve. The project team develops an expert system based on artificial intelligence for three-dimension design of key products in petroleum machinery, and to support function implementation of the whole system at prophase.

(3) Functional modules layer
Although product design is very important to an enterprise, it is not full of all, and various kinds of management are involved, from stock up, distribution, warehouse to such problems as the allocation of personnel and resource etc. So I3DS mainly includes three major functional modules: CAD module, database management module and artificial intelligence module. Every functional module was divides into some correlative sub-modules.

The artificial intelligence module was divided into intelligent design flow, intelligent workflow, intelligent search, knowledge base for machinery design domain, and expert system for industry domain; the CAD module was divided into search manual data, search correlative knowledge, extract correlative data, application design flow, computer drawing; the database management module was divided into workflow management, change and grant management, parts information management, manual data management, purchase, sales, and inventory management.

(4) Human-computer interaction layer
The design of user interface for I3DS follows several principles: keep consistency, use unanimous terms, unanimous steps and activity. Thus make it present a full Chinese Windows style, offer an interaction way by immediate menu, and have the characteristic of a friendly interaction, so that users can conveniently input and modify parameters at will.

(5) System management layer
System management layer implements the environmental management of the whole software, it mainly includes two parts: file management and user management.

The data conversions between different CAD data (include IGES, DWG, DXF, SAT, STL, etc. [15]) and the neutral mechanisms of STEP (Standard for the Exchange of Product Model Data) [16] are fully considered in the file management process.
User management implements some management such as access authority, special adjustment, user roles and link etc., involves document, parts, circulating package and metadata, and monitors the status of compliance with cooperation.

### 3.2 Virtual Design and Manufacture Center

The main function of virtual design and manufacture center is to build three-dimension CAD model and complete network-based manufacture of key products, its system structure is shown in Figure 5.

![System Structure of Virtual Design and Manufacture Center](image)

**Figure 5.** System Structure of Virtual Design and Manufacture Center

Figure 5 shows that, the conversion server is used for identifying and converting information provided by design and manufacture system, allowing the target recognition system can recognize it, so that every design and manufacture system is no longer to add excess processing program, can realize the NC (Numerical Control) program conversion from CAD system to CAM (Computer Aided Manufacturing) system [17], it is convenient for user to realize unified maintenance.

The control server [18] is used for implementation control of selection machining equipment, machining process and performance, so as to ensure accuracy, timeliness and validity of information transmission between CAD and CAM, it is favour to connect remote CAD and CAM system, effectively save manufacturing resources, and greatly shorten the production cycle of the products, as a result the cost of production was cut.

RS232 communication interface can realize the bidirectional transmission of NC program between computer and NC machine tool, and configure the communication parameters with regard to NC program format, communication interface, transmission speed, odd-even check, data bits, stop bits and transmission delay etc.

### 3.3 Electronic Business and Logistics Service System

Electronic business can create the fourth source of profit [19] for the enterprise, therefore, the project team has established an e-business service system, its functions are merchandise catalogue management, security and authentication management, electronic payment interface management, logistics information management, customer service management, market decision-making etc, as shown in Figure 6, it is conducive to realize operation and profit of MISP.
By dint of computer technology, network technology, photoelectric technology, communication technology, bar code equipment and so on, logistics information management subsystem was built and integrated into the e-business service system, which can manage operation flow of production enterprises, logistics companies, warehousing enterprises, and sales outlets in the whole process of supply chain.

4. Integrated Service Implementation Model Based on SOA and Web Service

4.1 SOA Service Model

SOA treats the applications of platform as some service sets which can cross the boundary of platform, self-describe and realize a particular function [20]. It makes the best of standards, methods, criterions, various toolkit of web services and open grid services infrastructure (abbr. OGSI) [21], to create and cancel dynamically temporary service instance and manage life cycle of service components, on this basis, it combines database and state resources such as enterprise java beans (abbr. EJB) component and Microsoft transaction server (abbr. MTS) component to establish the state model of service components [22]. Through standardized mechanism and method, it registers these services in public database so as to interested requester can find them; service provider and requester can bind dynamically and interact directly [23]. SOA service model is shown in Figure 7.

Service provider is responsible for concrete realization of service function. It publishes the service to service register center by service operation, performs the requested service when receiving the service request from service requester. Service requester is the initiator of service execution. First of all, it needs to find qualified service from service register center. Then it binds or calls the service according to service information in order to obtain the useful functions. Service register center is used to provide registered services by providers, the function of classifying and searching out the services, and so service requester can find requisite services easily.

4.2 Web Service Architecture

Web Service has a hierarchical architecture, which includes network, xml based messaging, service description, service publication, service discovery and service flow. This architecture makes it have...
some characteristics [24]: service-oriented, good encapsulation, loose coupling, standardized protocol, extensive support, and high integration.

Web Service provides a standard interface based on XML and completely breaks through the traditional closed implementation method. When running the client applications using different languages development on different platforms, it can obtain the required application seamlessly and achieve maximize resource efficiency. It helps to reduce the implementation complexity and also increase the flexibility and extensibility of Web Service. The requirements of SOA applications mode are well satisfied.

4.3 Integrated service implementation model of MISP

By using Web Service and SOA, and combining with the services provided by MISP, an integrated service implementation model can be formed, as shown in Figure 8.

Figure 8. Integrated Service Implementation Model of MISP

Figure 8 shows, service providers such as the platform operators of MISP, manufacturing service alliance, certificate authority, and bank, they use uniform WSDL (Web service description language) [25] based on XML to describe their services. WSDL is a description standard for service interface. It is used for describing abstract service interface, their binding protocol and language of arranged details. WSDL defines web service as a set of communication endpoints for exchanging messages.
In WSDL, the abstract definition for endpoints and messages are separated from their concrete network implementation and data format binding. This allows these abstract definitions can be reused.

Service providers register and publish Web service in register center through service UDDI (Uniform description discovery and integration) [26] bus. As the unity of service description, service requesters such as manufacturing enterprise, and logistics companies etc, they can find and search the services they need in UDDI register center through service query bus.

UDDI is a discovery standard for uniform service register. It is used to create catalogue information of Web service parts. It defines the data structure of description and classification business services and the SOAP interface to access this information. So Web service can be found and searched on the Internet. When an enterprise registers in an instance of UDDI business registry center, its registration information will be automatically copied to the other UDDI root point, so it can be obtained by people who want to find these Web service.

After that, they can use SOAP (Simple object access protocol) [27] to bind and call these services. SOAP is a protocol standard for communication. It also is a simple and lightweight communication mechanism XML-based. It is used for exchanging structured data among network applications. SOAP can be used in the various systems from message passing to remote process call (abbr. RPC), and conjunction with a variety of network protocols such as HTTP, SMTP, FTP and others.

This integrated model realizes a complete separation of services and technologies so as to attain the reusability of services [28]. It also enables MISP to integrate service providers, service consumers and the functional modules of the platform effectively, and to provide a series of services, such as innovative design and manufacture services of key products, preponderant resource sharing services, merchandise catalogue services, security authentication services, electronic payment services, logistics information services, 4CP/CRM/SCM and other enterprise informationize software services and so on.

5. Conclusion

This solution ensures that the third-party operators can uninterruptedly provide excellent services, such as innovative design and manufacture of key products, merchandise catalogue services, security and authentication services, electronic payment services, logistics information services, sharing of preponderant manufacturing resources, enterprise informationize software services, on-line three-dimensional display services of products, on-line technical consultation and remote technician training services and so on. It breaks through the traditional service mode whose mainly function is information delivery. It is helpful to develop and grow in strength the third party operators of MISP.

However, in the construction process of the virtual design and manufacture center, the following problems have not been solved with great satisfaction: how to quickly build the three-dimensional digital model of key product with complex structure and control the accuracy of surface reconstruction; how to guarantee the security exchange and reliable transmission of various manufacturing information and data on the Internet.

6. References


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