Research on the Distributed Concurrent and Collaborative Design Platform Architecture Based on SOA

Jia-qing Yu[a,1] ,Jian-zhong Cha[b], Yi-ping Lu[b], and Nan Li[b]

[a]Ph.D. Student, School of Mechanical, Electronic and control Engineering, Beijing Jiaotong University, Beijing 100044, China.
[b]School of Mechanical, Electronic and control Engineering, Beijing Jiaotong University, China.

Abstract. The design and development of the complex product has become a bottleneck restricting the economic development of countries. The concurrent and collaborative design for complex product is a new mode of design and develop based on concurrent engineering and multidisciplinary collaborative design using various fields of Cax. At present, the most advanced collaborative technology in the world is based on the Service-Oriented Architecture (SOA) –an important stratagem of the USA to seize the high ground of international strategy in the 21st century. According to the theory of knowledge flow, concurrent engineering and the optimization theory in the multidisciplinary collaborative design, the paper defines the concept of Distributed Concurrent and Collaborative Design (DCCD). Based on SOA and the distributed intelligent resources environment, this paper first presents a novel DCCD design platform architecture. The architecture based on SOA integrates some large-scale commercial engineering software tools and expert systems so as to quickly accomplish the design and analysis of complex product such as the railway bogies in this paper, which proves the feasibility of the platform architecture. Take the design and development of the railway bogies as an example to demonstrate the application and advancement of the new architecture.

Keywords. Concurrent and collaborative design, SOA, Distributed intelligent resources

1 Introduction

Design is seen by many as the area most in need of collaborative working and where the advantages of concurrent activity will be most prevalent. As engineering design and construction is growing in complexity, bigger teams of engineers with widespread, complementary expertise are needed to complete the design task. Co-location of these teams is rare and yet shared decision making is of paramount

[1] Ph.D. Student, School of Mechanical, Electronic and control Engineering, Beijing Jiaotong University, No. 3 of Shangyuan Residence Haidian District in Beijing, China; Tel: 8610-51685335; Email: 06116256@bjtu.edu.cn; http://www.bjtu.edu.cn/en

importance. Hence, communication and collaboration have become key issues in terms of efficiency and cost and distributed design has become a necessity for the future of engineering.

Along with the enhancement of product complexity in the field of aviation, aerospace, shipbuilding and railway rolling stock, the development process in essence not only considers the distributed intelligent resources environment and the concurrent design process in the entire life cycle of the manufacturing and assembly, but also the integrated concurrent and collaborative design in the mechanical, control, dynamics, etc. However, the traditional product design theory can’t meet the current design for complex products. Concurrent engineering, collaborative design and the optimization theory in the multidisciplinary design are popping up in this area. Similarly, for the cross-sectoral, cross-region and cross-country alliance of virtual enterprises develop quickly, the design and develop environment has changed a lot, and many designs for complex product have to be collaboratively completed by the product design staffs and the other related staffs distributed in different places, then the distributed collaborative design technology came into being.

The research for the distributed collaborative design started in the 1990s, and Cutkosty from the design institute of Stanford firstly began the research in this area [1]. In 1990, National Institute of Standards and Technology invested 21.5 million dollars for a develop team in a project called Federated Intelligent Product Environment (FIPER) planning to exploit a collaborative supported work environment architecture in five years. General Electric Company successfully find good application of FIPER to develop the American key weapon equipment [4, 5].

One researcher proposed a product data model and an Web-based open architecture of product data management [8]; another paper introduced a software distributed collaborative exploitation environment and discussed the architecture and the distributed parallel exploitation model [7]; Some researchers presented a distributed collaborative product customization system based on Web3D, which provides distributed collaborative product customization for product users in a virtual environment [10]. Aimed at the application actuality of CAD system in corporation, concurrent design will expedite the product's development Someone researched Intelligence Concurrent Design System under network [6].

From the description above, it can be seen that the researches in the area of distributed collaborative design focus on the research of the method and model of the collaborative design. Until now, there has been no effective supported technology and technique available for the integrated application of the concurrent and collaborative design in the distributed intelligent resources. Therefore this paper defines the concept DCCD to support the new architecture what’ll be introduced below. Then this paper presents a novel DCCD platform architecture in the distributed intelligent resources environment based on SOA for the first time in this area.

2 The Architecture Design of the SOA-based Distributed Concurrent and Collaborative Design Platform

2.1 The Methodology of Service Oriented Architecture

SOA is a new paradigm in distributed systems aiming at building loosely-coupled systems that are extendible, flexible and fit well with existing legacy systems. By promoting the re-use of basic components called services, SOA will be able to offer solutions that are both cost-efficient and flexible. SOA presents an approach for building distributed systems that deliver application functionality as services to either end-user applications or other services. It is comprised of elements that can be categorized into functional and quality of service [3].

With a SOA, we can realize several benefits to help organizations succeed in the dynamic business landscape of today:

- Leverage existing assets
- Easier to integrate and manage complexity
- More responsive and faster time-to-market
- Reduce cost and increase reuse
- Be ready for what lies ahead.

2.2 The Architecture Design of the SOA-based Distributed Concurrent and Collaborative Design Platform

For the purpose of achieve one mission, developers must work together and utilize the distributed resources simultaneously in the world-wide. Allowing engineers to work together regardless of geography is a huge potential advantage in an increasingly global market. Similarly, enabling engineers to concurrently design will dramatically increase efficiency whilst reducing errors currently made due to communication breakdowns. That means that all parties to be involved throughout the design process. On the base of the existing concept Concurrent and Collaborative Design [2], this paper defines the concept DCCD in the distributed intelligent resources environment. It’s illustrated in Figure 1 below.

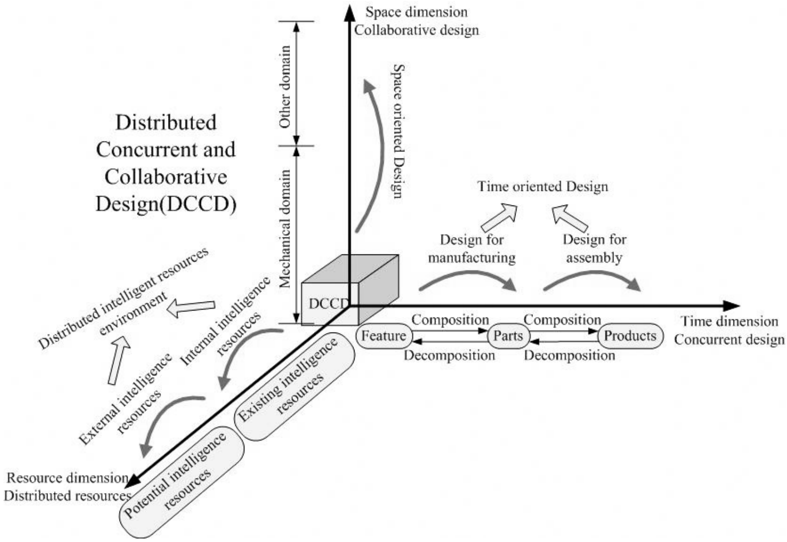

Figure 1. Approach of DCCD

Definition 1. Distributed concurrent and collaborative design. In the design process of product, the developer not only need to consider the design process in the time dimension, but also collaboratively consider the cooperation of the different research group regardless of geography in the space dimension, and the distributed intelligent resources environment in the resource dimension. It can be seen that the process of design is a whole tridimensional distributed concurrent and collaborative design based on the distributed intelligent environment, i.e. DCCD.

Figure 1 shows that DCCD is a three-dimensional design approach. The dimensions in a distributed concurrent and collaborative design approach are:

- Space dimension: one team should carry out the collaborative design in the space dimension. There are mechanical domain and other domain in space dimension
- Time dimension: one design should be done simultaneously in the time dimension. In the design for manufacturing, parts are decomposed according to their feature. In the design for assembly, parts compose products
- Resources dimension: Modern design is based on intelligent resources and mainly depends on the external intelligent resources and internal knowledge reserves [9]. In China, there are a lot of existing resources and potential resources which can support the knowledge acquisition in the process of product design. Most of these resources are in the scientific research institutes, universities, national and sectoral key laboratory or open laboratory, engineering research centers, etc.

Here, this paper presents a novel architecture for SOA-based DCCD systems is illustrated in Figure 2. The architecture is designed for the research of the development and design, not for the commercial application.

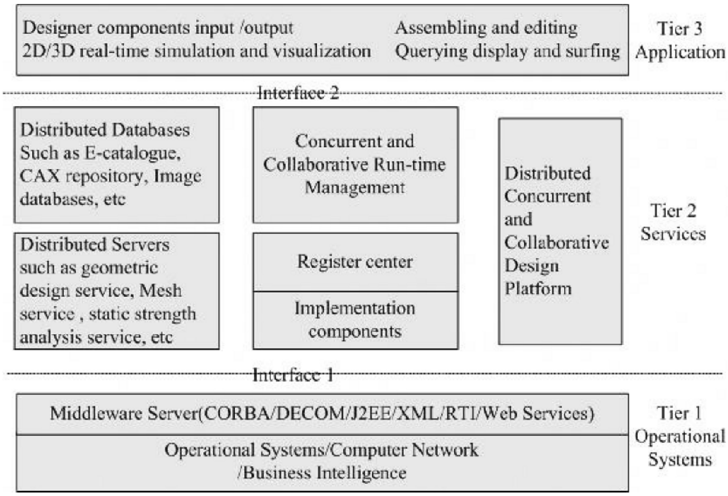

Figure 2. The architecture of the SOA-based DCCD platform

In the SOA-based DCCD platform architecture, it contains four tiers:

1) Tier 1 is the Operational Systems. This consists of existing custom built applications, otherwise called legacy systems, including existing CRM and ERP packaged applications, and older object-oriented system implementations, as well as business intelligent applications. The composite layered architecture of an SOA and leverage existing systems and integrate them using service-oriented integration techniques
2) Tier 2 is Services. The services the business chooses to fund and expose reside in this layer. They can be discovered or be statically bound and then invoked, or possibly, choreographed into a composite service. This service exposure layer also provides for the implementation components, and externalizes a subset of their interfaces in the form of service descriptions. Thus, the enterprise components provide service realization at runtime using the functionality provided by their interfaces. The interfaces get exported out as service descriptions in this layer, where they are exposed for use. They can exist in isolation or as a composite service
3) Tier 3 is the Application. Although this layer is usually out of scope for discussions around a SOA, it is gradually becoming more relevant. There is an increasing convergence of standards, such as Web Services for Remote Portlets Version 2.0 and other technologies, that seek to leverage Web services at the application interface or presentation level. It is also important to note that SOA decouples the user interface from the

components, and that you ultimately need to provide an end-to-end solution from an access channel to a service or composition of services.

3 Application of The New Platform

Take the design and development of the railway bogies as an application example of our new architecture presented above. The railway bogie design and analysis sequence (static strength) is shown in Figure 3.

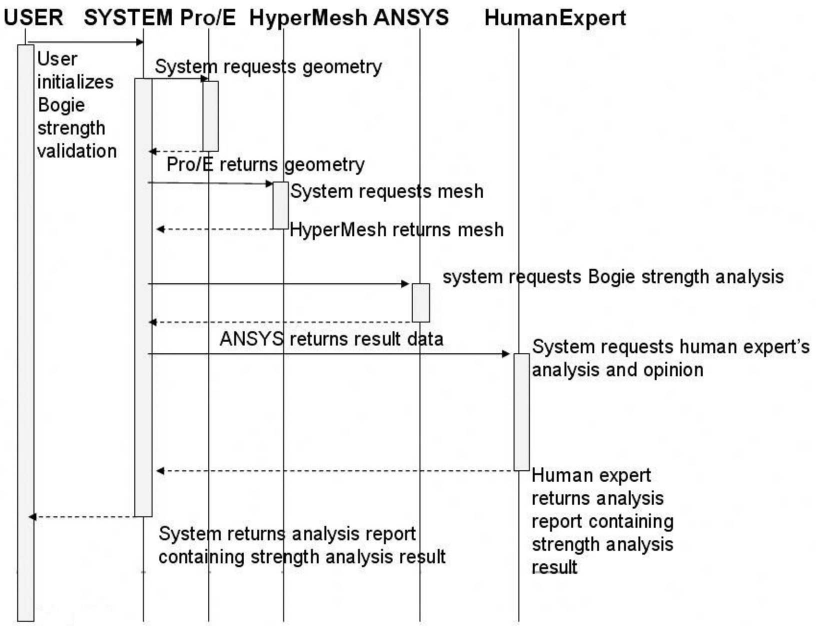

Figure 3. The railway bogie design and analysis sequence (static strength)

3.1 Services Identification

The design process for static strength analysis is shown as follows in Figure 4.

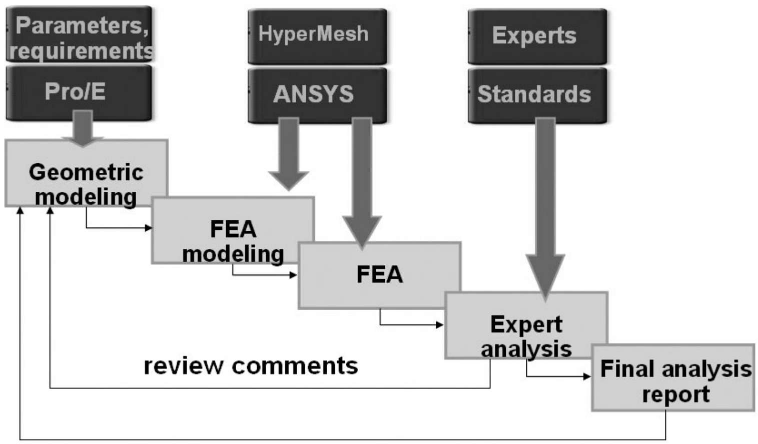

Figure 4. The design process for static strength analysis

We can identify the services in the design and analysis process by the client. There are four services as follow: 3D parameter design service, mesh service, static strength analysis service and human expert analysis service. Then we can wrap ansys as a DCCD architecture service provider, and ansys will be invoked as server mode with the input of APDL file and output of *.rst - resolution file, *.db - db file, etc.

Using the Java programming language, we define the interface descriptions of the four services mentioned above in the architecture.

3.2 Amendment and the Future Work

This platform architecture offers a way of allowing engineers to work together regardless of geography in the current increasingly global market. Meanwhile, enabling engineers to concurrently design noticeably increases efficiency whilst reducing errors currently made due to communication breakdowns. Enabling all parties to be involved throughout the design process will change the nature of design, spreading input and responsibility. However, the greater the level of concurrency the higher the level of co-ordination required to ensure a successful product. The tools required to facilitate these activities need to be robust yet sufficiently flexible to ensure their long term usage.

So, this platform will be mended in the process of application. Maybe some new function will be added and some unfair function will be removed. In the future, we will refine the user GUI, program the application programming interface for Pro/E and Mesh, provide the optimization service and at last combine process management system with service providers.

4 Conclusions

Firstly, this paper defines the concept DCCD. The process of design is a whole tridimensional distributed concurrent and collaborative design based on the distributed intelligent resources environment, i.e. DCCD.

Then, this paper presents a novel distributed DCCD platform architecture. The architecture integrates some large-scale commercial engineering software tools and expert systems to quickly accomplish the design and analysis of complex product such as the railway bogies in this paper, which offers a way of allowing engineers to work together regardless of geography in the current increasingly global market.

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