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A Service-Oriented Secure Infrastructure for Feature-based Data Exchange in Cloud-based Design and Manufacture

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Abstract

Under the impact of service-oriented architecture (SOA) and cloud computing, Cloud-Based Design and Manufacture (CBDM) has been a flexible and effective way for Collaborative Product Development (CPD). As a crucial issue in sharing CAD models for CPD, Feature-Based Data Exchange (FBDE) among heterogeneous CAD systems should be adapted in CBDM. On the other hand, the sensitive information and intellectual property of CAD models should be protected in the process of FBDE and CBDM. This paper presents a service-oriented architecture for secure FBDE in CBDM. This architecture replaces traditional data exchange and secure process, which are based on client sides, with a service-oriented data exchange and secure process on clouds. In this way, feature-based CAD models could be exchanged among collaborative designers with the sensitive information protected in CBDM. The service-oriented infrastructure provides cost-effective, flexible and scalable solutions for secure FBDE. The case study and experiments demonstrate the proposed idea and method.

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Keywords: Collaborative Product Development; Cloud-Based Design and Manufacture; Feature-Based Data Exchange; information security

1. Introduction

Nowadays, manufacture companies are confronting the challenge of the highly competitive global environment. Collaborative Product Development (CPD) offers a rapid response to customer needs and technology changes at low prices, which makes it becomes the core of modern manufacturing industry[1]. Along with this trend, the network-hosted collaborative design is considered as a character of next generation CAD systems[2].

In CPD, designers and developers require massive data sharing and interoperate the design data among each other[3]. Main stream modern CAD systems use parametric feature-based modeling paradigm. Feature-based CAD model which contains the design intent, design history, parameters and constraints is the main carrier of the sharing design data. So the feature-based data exchange (FBDE) is very significant for collaborative CAD. On the other hand, how to protect intellectual property rights and sensitive information of CAD model becomes an emergency issue for collaborative design because of the interoperation and data sharing [4, 5].

Inspired by the concept and technology of cloud computing and Service-Oriented Computing(SOC) /Service-Oriented Architecture(SOA) [6-8], the ideas and characteristics of "cloud" and "service" are being brought to CPD to form the Cloud-Based Design and Manufacturing (CBDM)[9]. CBDM-enabled CPD provides cost-effective, flexible and scalable solutions to collaborative partners by sharing the resources in the applications of design and manufacturing.

This paper focuses on the secure FBDE method with the consideration of sensitive information security in CBDM. The rest of this paper is organized as follows: in section 2, the related work of collaborative design and CAD model security is briefly reviewed; the FBDE and model information security

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method are introduced and the service-oriented secure FBDE architecture is proposed in section 3; section 4 discusses the implementation case of the service-oriented secure FBDE; Finally, section 5 summaries the contributions of the paper and indicates some future works.

2. Related work

SOA was first proposed in the middle of 1990s [7, 8]. The use of Web Services [10, 11] became the main trend to achieve SOA. After adopting the ideas of SOA and taking computing resources as services from cloud, cloud computing became a hot research area and was applied widely[12, 13].Using technology of SOA, Web Services and Cloud Computing, CBDM were proposed and applied as technologies and methodologies to enable CPD[14-16].

In the CBDM, various CAD systems are used by different collaborative partners. FBDE solution for heterogeneous CAD model is needed in CBDM. He et al. established a CSCW based CAD system for CPD to realize CAD data exchange[17, 18]. Li et al. proposed the concept of Dynamic Feature which are used as the basis for integrating machining, monitoring, and on-line inspection operations and establish a set of integrated information models to address the dynamics of machining conditions[19, 20].

Zhang, He, Han and Li presents a new asymmetric strategy to enrich the theory of feature-based interoperability, particularly when addressing a singular feature or singular sketch [21]. Our previous researches presented a procedure recovery approach, which extended the existing researches[22, 23]. Later we present a service-oriented FBDE architecture for CBDM, in which FBDE was registered as service among heterogeneous CAD systems [24].

While the network gives convenience to collaborative work, it also brings security risks to the private sensitive information of each collaborative partner. The security risks has become a main obstacle of collaborative design implementation[25, 26] and these risks become more prominent in CBDM.

The sensitive model information hiding method for feature based CAD model is lacking, which increases the risk of sensitive information leakage while collaborative partners sharing information, such as doing FBDE. Moreover, it is an emerging trend that users require resources as service from cloud in nowadays cloud-based CPD. Under this impact, the function based FBDE and model information protection method should be transferred in to services-oriented.

3. Service-Oriented Secure FBDE

In collaborative design, designers need to share parametrical models while protecting their own sensitive information. To provide a secure FBDE schema and taking advantages of CBDM, this paper takes FBDE and a model information protection method as services from cloud. Designers request the FBDE services to accomplish the model data exchange and require security service to hiding sensitive information of the model, as shown in Fig.1.

When FBDE and model security method are developed as services in cloud, designers could require the FBDE service to achieve the parametrical model sharing directly between heterogeneous CAD systems. If the CAD model contains sensitive parts, user could require the security service to hide this information based on the model information hiding method introduced in this paper.

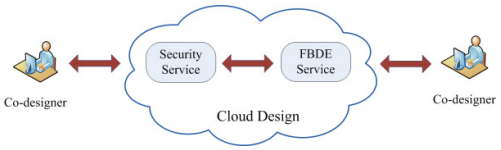

Fig.1 service oriented secure FBDE.

3.1. Model information security method

3.2.1 Deformation based model information hiding

The basic modeling process of common parametric CAD system is: first, create the sketch of the model based on sketch parameters; then select modeling features and adjust feature parameters to finish the modeling process[17].

When creating a sketch, some points with geometry means can be retrieved by APIs of the CAD systems. These points control the position and shape of sketch by their coordinates. We name these points as the sketch control points. For example, the center of the circular, control points of the spline, endpoints of the long/short axis and center of the ellipse.

When the parameters of the sketch control points are modified, the position and shape of the sketch are changed. The position and shape of the feature are modified along with the deformation of the sketch. Finally, the CAD model is deformed. When the parameters of the sketch control points are modified back to original value, the model would be deformed to the original shape as shown in Fig.2.

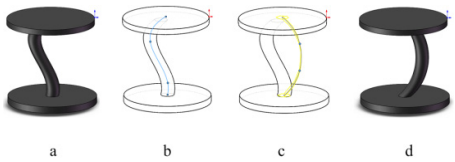

Fig.2. model shape affected by sketch control points: a. original model; b. partial model sketch; c. modify parameters of sketch; d. model deformation

3.2.2 FFD based model encryption

Sederberg proposed free-form deformation (FFD) of solid geometric models [27-29].The main idea of the FFD is putting the geometry model into a uniform dissected parallelepiped lattice and the vertices of the lattice are seen as the control points of a trivariate tensor product Bézier body. Then, by moving these control points, the vertices of the geometry model are moved and the model is deformed.

The FFD idea could be introduced into feature based CAD model. We create the encryption control lattice for feature sketch and take the sketch control points as the internal vertices in the deformation lattice of the FFD as shown in Fig.3 (a). Then the FFD based encryption can be applied.