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Federated integration of networked manufacturing service platforms

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Abstract

Networked manufacturing is an advanced manufacturing pattern that was born of information technologies and suits the networked economic environment. Networked manufacturing service platforms have been widely established to support this new pattern. Since the island problems are retarding further development of networked manufacturing, integration of existing networked manufacturing platforms is in demand. A federated integration mode is proposed to integrate the existing networked manufacturing platforms and provide a large-scale distributed resource sharing and cooperative environment. The nature of federated integration is discussed, and the architecture of federated integration system was put forward along with a set of rules and three types of integration services. Two key issues in federated integration are discussed in detail. One is the federation management, including the hierarchy of federations, the basic states of federations and the state-keeping mechanism using factory/instance pattern. The other issue is the authentication, authorization and access control in across-platform applications. Finally, an implementation is presented.

Keywords: Networked manufacturing; Networked manufacturing service platform; Federated integration; Cooperative environment; Application service provider; System architecture

1. Introduction

Over the last ten years, information technologies have significantly influenced the manufacturing pattern in every aspect. Networked manufacturing is an advanced manufacturing pattern that was born of information technologies and suits the networked and globalized economic environment. The primary goal of networked manufacturing is to speed up an enterprise's response to the market and to improve the competence of the enterprise. By applying network technology and other manufacturing related technologies, a networked manufacturing system can be constructed to help enterprises carry out business activities in the whole product lifecycle while alleviating the limitations caused by the dispersion of geographical locations [1]. Networked manufacturing can take its form in various configurations and employ a variety of subsystems with different functions, depending on the situations and requirements of a particular enterprise. A networked manufacturing system can provide numerous network-based application services, such as collaborative design, collaborative manufacturing, e-business and information service.

Large enterprises are often capable of establishing networked manufacturing systems on their own, but small/medium-sized enterprises need a more cost-efficient way due to their lack of money and technology. Additionally, they are still experiencing growth, and their information system may vary with their changing scale, goals, production and management modes. A sound solution to this challenge is a networked manufacturing service platform (NMSP), which supports the implementation and operation of networked manufacturing systems to allow resource sharing and collaboration among enterprises. The service platforms supply a wide variety of enabling tools, common services, application services so that enterprises can buy what's needed of networked manufacturing.

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Since 2000, the research of networked manufacturing techniques has been conducted in Chinese National CIMS ERC, including several research projects and typical applications projects [2]. Six networked manufacturing service platforms were established in Beijing and more in other cities of China. Lots of enterprises, particularly the small/medium-sized enterprises, have benefited from networked manufacturing service platforms by accessing important information from on-line databases, designing productions with on-line computer aided design software, implementing the e-business, etc [3,4].

Because of the absence of a common integration standard, it is difficult for the platforms to interconnect, intercommunicate and interoperate with each other. As a result, it is hard to collaborate among multi-platforms due to the difficulty in sharing distributed resources (public resources and professional resources). The great number of platforms is puzzling the users on how to search for all related services in a special field, how to select the most appropriate service by comparing it to the others, how to access a series of services provided by different platforms without repeating boring logins, and how to cooperate with users belonging to other platforms. On the other side, the platform providers want to expand the range of services, but each individual platform is not able to include all kinds of service resources. All these problems need a solution: to integrate the existing networked manufacturing platforms and build a distributed resource sharing and cooperation environment.

The remainder of this paper is organized as follows: Section 2 introduces related works on promoting interoperability among computer systems and several standard technologies, such as Web services, the high level architecture (HLA) and the Grid technologies, which were referenced in our research. Section 3 discusses the nature of the federated integration and proposes a architecture for the integration of ASP(Application Service Provider) based networked manufacturing service platforms. Section 4 discusses the federation management issues. The hierarchy of federations, the basic states of federations, and a state-keeping mechanism using factory/instance pattern are presented. In Section 5, authentication, authorization and access control in across-platform applications are proposed with two authorization mechanics – role mapping and role delegation. In Section 6, a consistent implementation called Federation Executive Infrastructure (FEI) is presented and the structure of a federated node is illustrated to show how the system works. The last section summarizes our work.

2. Related works

Researchers have noticed the need for a large-scale networked resource sharing and corporation environment in manufacturing enterprises. Liu [5], Fan [6], Qiu [7] presented a concept of manufacturing grid (MG) which is an integrated supporting environment both for the sharing of resources in enterprise and for the cooperating operation of the enterprises. Users could obtain various manufacturing services from the MG as conveniently as getting water, electricity and gas in daily life. Several frameworks of MG were proposed, but no one was totally implemented due to the complexity of manufacturing services. Since there have been lots of networked manufacturing platforms, we think it's a better idea to approach manufacturing grid starting with integrating the existing platforms.

The agent technology has been studied to integrate manufacturing software systems. Feng [8], Tian [9] and Sikora [10] presented some agent-based system examples on product design and manufacturing, in which the agents communicated with each other to find the best utilization of resources such as computer aided design software, machine tools, product models, etc. A comprehensive state-of-the-art survey on agent applications in intelligent design and manufacturing can be found in [11,12]. However, the agent can help to harmonize semantic differences only after the format differences are resolved, and the development of an agent-based industrial application is not an easy task [13].

In the field of simulation, the High Level Architecture has been realized to provide a common architecture for simulation [14]. The purpose of this architecture is to facilitate interoperability among simulation systems and to promote reuse of simulation models and their components. Simulation developers can structure and describe their simulation applications within the framework of HLA. Although the HLA is architecture, not software, use of runtime infrastructure (RTI) software is required to support operations of a federation execution. The RTI software provides a set of services, as defined by the Federate Interface Specification. The HLA has become an IEEE standard and an amount of RTI software was developed.

The "Grid" technologies have emerged to achieve coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organizations [15,16]. They have been rapidly adopted in scientific computing, large-scale data management, and collaborative work. The shared resources of grid applications are mostly computers, data and sensors. But in the field of manufacturing, the application of grid is just at the beginning. Both the variety of manufacturing resources and the complexity of manufacturing systems are challenging the application of the grid technology.

As a new inter-operating standard, the Web service technology is widely applied nowadays. Web services can be advertised, located, and accessed through messages that are encoded according to XML-based standards and transmitted using Internet protocols. Although an operable overall framework for the integration of existing services is still not available, the family of Web-service-related standards is continuously expanding [17]. As using Web services makes the system more extensible, Web services are the technology of choice for Internet-based applications with loosely coupled clients and servers.