

Collaborative process planning and manufacturing in product lifecycle management

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Abstract

Companies are moving towards quickly providing better customer-centric products and services improve market share and market size with continuously growing revenue. As such, the effective collaboration among customers, developers, suppliers, and manufacturers throughout the entire product lifecycle is becoming much more important for the most advanced competitiveness. To address this need, a framework for product lifecycle collaboration is proposed in this study. The details of these collaboration models throughout the entire product lifecycle are depicted. As one of the key elements in product lifecycle collaboration, technology to support collaborative product manufacturing is proposed, developed and implemented in this study. It is hoped that the developed technology for collaborative product manufacturing will lay a frontier basis for further research and development in product lifecycle management.

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1. Introduction

Manufacturers are facing increasing challenges of better product quality with tighter delivery requirements for customers, more profitability shareholders. Global competition is increasing with pressure on prices, smaller orders, shorter life cycles, more suppliers, more governmental regulations, and increasing material and energy costs. These new business drivers make manufacturers pursue more competitive business model, such as collaborative manufacturing, to closely collaborate with their customers, suppliers, manufacturers and partners for the most advanced competitiveness by leveraging core competencies throughout the entire product lifecycle [1].

In collaborative manufacturing, product lifecycle management (PLM) has recently been recognized as a new strategic

business model to support collaborative creation, management, dissemination, and use of product assets, including data, information, knowledge, etc., across extended enterprise from concept to end of life—integrating people, processes, and technology. PLM systems support the management of a portfolio of products, processes and services from initial concept, through design, engineering, launch, production and use to final disposal. They coordinate and collaborate products, project and process information throughout the entire product value chain among various players, internal and external to enterprise. They also support a product-centric business solution that unifies product lifecycle by enabling online sharing of product knowledge and business applications [2–4].

As such, PLM enables manufacturing organizations to obtain competitive advantages by creating better products in less time, at lower cost, and with fewer defects than ever before. In summary, PLM not only provides process management throughout the entire product lifecycle, but also enables effective collaboration among networked participants in product value chain, which distinguishes it from other

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enterprise application systems, such as enterprise resource planning (ERP), supply chain management (SCM), customer relationship management (CRM), etc.

To tackle the collaboration challenges in PLM, this study begins with recent status review and gap analysis in Section 2. Based on the analyzed gap, a model for product lifecycle collaboration is proposed in Section 3. As one of the most important parts of in product lifecycle collaboration, the key technology to enable collaborative product manufacturing, which is collaborative process planning and manufacturing, is developed in Section 4. The detailed system design of such a collaborative process planning and manufacturing is developed in Section 5. A demonstration is given in Section 6. Finally, conclusions are made and future perspectives are given.

2. State-of-the-art review

Modern enterprises are facing ever increasing challenges of shorter product lifecycles, increased outsourcing, mass customization demands, more complex products, geographically dispersed design teams, inventories subject to rapid depreciation, and rapid fulfillment needs.

To effectively tackle these challenges in modern collaborative business environment, new industrial capabilities are required in order to obtain competitive advantages in today's Internet economy:

- (1) Geographically scattered design teams and supply chain partners need to collaboratively design products on a virtual basis.
- (2) Static designs need to be replaced by mass customization, often using predefined modules or building blocks to rapidly configure new product platforms that can be flexibly managed through their lifecycle.
- (3) To exchange and control product information and to perform real-time program/project management.
- (4) A system needs to emerge as the dominant technology for managing inter-enterprise data, information and knowledge, and providing design teams with a virtual design space.

To meet these addressed requirements, new technology solutions are imperatively required:

- (1) To provide an information continuum to deliver pervasive, real-time analytics, querying and reporting throughout the entire product lifecycle.
- (2) To provide a collaborative environment bringing together multiple roles, constituents and stake-holders in threaded discussions beyond four walls of enterprise.
- (3) To enable interactive viewing and commentary upon product lifecycle through multiple devices, channels and systems involved with product lifecycle.
- (4) To be an open but integrated solution supporting key enterprise value disciplines of product leadership, customer intimacy, and operational excellence.

Such a new system will provide customers, developers, manufacturers, suppliers and partners with following capabilities:

- (1) Product lifecycle collaboration across virtual enterprises.
- (2) Effective management of product lifecycle activities.
- (3) Convenient integration with other enterprise systems.

To satisfy continuously emerging new business challenges, in several past decades, both academic and industrial researchers have engaged tremendous efforts in research and development of industrial information technologies to pursue the most competitive business advantages in product lifecycle.

A recent academic state-of-the-art review or the research effort related to PLM reveals that the academic pioneer in product lifecycle research is the product life cycle modeling group at University of Tokyo [5], focusing on the topics of life cycle engineering, life cycle design based on simulation, life cycle planning, life cycle optimization, reuse and rapid life cycle, eco-design, service-quality, etc. The other effort includes center for design research at Stanford University [6], center for innovation for product development at Massachusetts Institute of Technology [7], web based design, process planning and manufacturing system at University of California at Berkeley [8], systems realization laboratory at Georgia Institute of Technology [9], design process and knowledge management at engineering design center of Cambridge University, computer aided concept design at engineering design center of Lancaster University, FIPER project funded by National Institute of Standard and Technology in USA [10], iViP project funded by Fraunhofer in Germany [11]. Such research effort focused on product design and development activities by using modern computing and Internet technologies to facilitate design collaboration and potential innovation. These reported achievement forms the strong basis for further research and development in product lifecycle management. However, little effort has been documented on product lifecycle technology, as what Tokyo University reported, and the result obtained is still far from satisfactory.

The recent industrial status of PLM solutions from world leading vendors shows that UGS PLM solution provides the capability of collaboration platform, collaborative project management and so on based on Teamcenter infrastructure [12]. PTC provides the solution extended from traditional product data management (PDM) to link with supplier and project management [13]. IBM supports extended PDM solution for both multi-national companies (MNCs) via Enovia and small and medium-sized enterprises (SMEs) via Smarteam [14]. MatrixOne supports solutions of collaborative application, lifecycle application, and modeling studio [15]. Agile Soft [16] provides solutions of product definition, product collaboration, product sourcing, etc. These solutions from different vendors, particularly the PDM solutions, have been widely applied in manufacturing industry and created beneficial impact to enterprises.

However, current product design and development in most companies still encounter a lot of difficulties, such as

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