Web-based Engineering Portal for Collaborative Product Development

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Abstract. Nowadays, collaborative product development has become a strategic necessity to develop high quality products at low cost and with quick response time to market demand. Past decades have seen significant advances to collaborative product development. However, Enterprises are still confronted with some problems. Firstly, the research in strategic level of collaborative product development is lacking. There are no formal processes and models for collaborative product development. On the other hand, the full alignment between information system and collaborative business is still missing. The information system cannot adapt to the fast changed business. This paper aims to provide the strategy and reference business model for collaborative product development. And then, to support the implementation of strategy and model, a workflow and web service based engineering collaboration portal is developed. The workflow is used to model and execute the collaborative product development processes, and the web service is the implementing technology of the portal. The combination of workflow and web service can fit the gap between business and information system and achieve on-demand business.

Keywords: Web-based, portal, collaborative product development, web service

1 Introduction

The advancement of information technology, dynamic market, and global environment has set a new stage for manufacturing. In order to remain competitive and to maintain their competitive advantage, enterprises must be able to 1)manage increasing product complexity and product innovation from market demands, 2) have faster and more flexible product development cycle, and 3) control globally distributed/outsourced operations[1]. One strategy for enterprises to succeed in this environment is Collaborative Product Development (CPD). Several similar terms already exist in the literatures, such as collaborative engineering [2], collaborative design [3], and collaborative product commerce [4]. Each term emphasizes different aspects and applications. In this paper, CPD is defined as: ‘‘an Internet based computational architecture that supports the sharing and transferring of knowledge and information of the product life cycle amongst geographically distributed companies to aid taking right decisions in a collaborative environment’’ [5]. The main

goal of CPD is to integrate and leverage knowledge, technologies, and resources among all the collaborators through the full life cycle of product development. In the last decades, significant efforts have been made in the research of CPD. Most of them have been focused on enhanced collaboration by leveraging information technologies, such as how to develop a collaborative information platform [6], what is an acceptable standard for information/knowledge exchange and presentation [7], what is an efficient information/knowledge schema to be shared among collaborators [8], how to improve detailed functionalities of the CPD system [9].

However, technology is not the whole of CPD anyway. Regarding collaboration processes between dislocated partners, collaborating companies still manage their product development processes in a highly inconsistent and inefficient way because there is no common model to specify the collaborative process to be shared in partners especially in cultural backgrounds (language, education, rules of behaviour etc.).

The past studies pay more attention to the research of theories and technologies. There have been very few reports concerning the best practices and the reference processes of CPD deployment in industry settings, especially inter-organization and cross-culture collaborations. Due to lacking knowledge of deploying CPD in current industrial settings, the research efforts may thus fail to fulfill practical needs [10].

On the other hand, in IT perspective, although numerous IT technologies and tools have been developed to facilitate the collaborative product development, they are simply the fraction of the software functions required to enable the collaboration process in the full lifecycle of CPD. Most of them focus on the engineering development, which is in the later phase of CPD. Few technologies and tools are developed to facilitate the early phase of CPD, such as contact initiation and collaboration establishment.

Furthermore, the alignment between business processes and supported IT system is largely missing. The current CPD system can not adapt to the fast changed requirements and business processes due to the architecture, implementation technologies, and control mechanism of the system. How to align the CPD requirements and processes with the supported IT systems is one of the key challenges of CPD.

In order to solve the above mentioned difficulties, in this paper, a web-based engineering portal is developed and implemented to enable value-added collaboration between European and Chinese partners by providing new technical solutions, best practices, and collaboration tools. The Engineering Portal represents a virtual, process-driven and service-oriented integration platform accessible to the involved companies within a heterogeneous IT-infrastructure.

The paper is organized as follows: In section 2, a structural top-down analysis approach is used to derive all the necessary business objectives and processes that must be achieved in CPD. Based on reference model, the strategy of CPD is proposed. In section 3, the development and implementation of a web based engineering portal for CPD is discussed. The web service is used to wrap all the components of the portal into services. Different services are provided by the portal to facilitate the full life cycle processes of CPD. In section 4, the scenario validation of the portal is described. The contributions of the portal in this scenario are introduced. Finally, the conclusions of the paper are summarized in section 5.

2 Reference model and strategy for CPD

In order to derive all the necessary business objectives that enterprise users must achieve in CPD processes, a structural top-down analysis approach is used. The approach started with the overall objective of CPD, i.e. to collaborate with other enterprises based on core competence and economic benefit, therefore, to be able to quickly delivery high quality product to customers with low cost. In general, the objectives of enterprises utilizing CPD fall into three categories: seeking collaboration opportunities by publishing their products and/or services, outsourcing some engineering tasks by selecting suitable collaboration partners, and performing engineering collaboration with the partners. From the perspectives of enterprises, the overall objective is broken into more tangible objectives that can be realized in certain stages of the whole collaboration process. Within this paper, the overall objective is realized in two stages, i.e. the earlier phase of the collaboration process and the later phase of the collaboration process. The respective objectives of the two stages are:

- To facilitate the establishment of OEM-supplier or joint venture collaborative relationships
- To facilitate collaborative product development

The two stages are referred to as the medium-level objectives in the structural analysis approach. The medium-level objectives are further broken into detailed-level objectives, which can be realized through the execution of the respective business processes. The reference model for CPD is illustrated in figure 1.

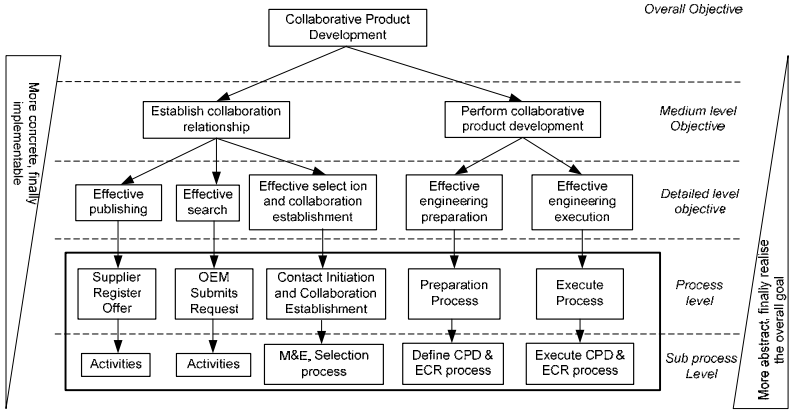

Fig. 1. The reference model for CPD

In order to support the implementation of the above mentioned objectives, the strategy for CPD is proposed to provide an overall framework to enable common, tightly integrated product development processes between distributed companies based on given IT-technologies and software tools as well as Internet technologies [11]. Figure 2 shows the conceptual architecture of the strategy. Five basic requirements in CPD were addressed in the strategy:

1) Locate collaboration partners in markets, to initiate contact and to establish a collaboration,

2) Support the dynamic integration of development processes based on consistent information models,
3) Support the handling, visualization and validation of product data,
4) Facilitate a requirement driven product development process, and
5) Identify and solve problems caused by cultural differences.

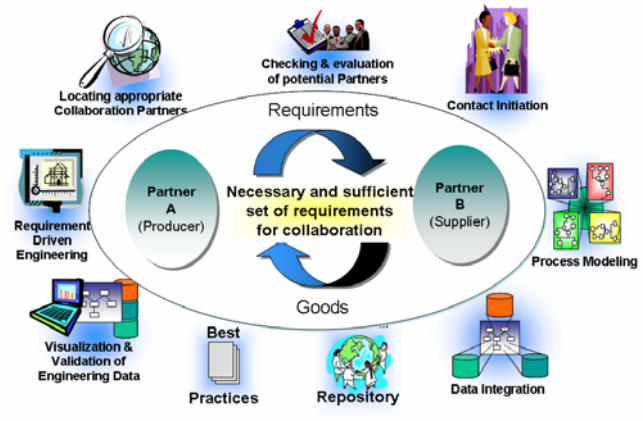

Fig. 2. Strategy for collaborative product development

3 Implementation of Web based engineering portal for CPD

In this paper, a web based engineering portal for CPD is developed and implemented. The engineering portal represents a process- and service-oriented integration platform accessible to the involved companies within a heterogeneous IT-infrastructure. The portal serves as a central point of access to a (virtually) common CPD process model and allows collaborating partners to share product information stored in various application systems transparently via the Web. The use of modern technologies, i.e. web service and workflow, enables not only the information collaboration from IT perspective, but also the process collaboration from business perspective [12].

As shown in figure 3, four major layers are identified in the portal's architecture: application service layer, infrastructure layer, collaboration service layer, and UI (user interface) service layer.

1) The application service (AS) layer provides functionalities to access proprietary information sources of the enterprises involved in a collaboration, like PDM-systems, ERP-systems, etc. The connection between portal and the application systems is realized with SOAP. Therefore an adapter must be implemented for every application, which assumes the mapping between the enterprises' applications and SOAP.
2) The Infrastructure Service (IS) layer: The infrastructure layer provides the basic data service and integration service for CPD. All data flows within portal are supported by the infrastructure. The data service manages

distributed data sources and offers a transparent view on the data for the portal services. The integration service provides the interaction mechanism between portal components. In order to provide these functionalities, the infrastructure has to provide functions/services to manipulate the data. These services could either rely directly on the meta data model or use a more high level business context. The Integrated Domain Data Models are derived from the meta data model and contain the data object types which are required by the business services provided by the components. The infrastructure provides the basic access function to data and components according to the meta data model and/or according to the integrated domain data model. The meta data model interface and the integrated domain data model interface together represents the data interface. This interface is accessible through Web Services.

3) The collaboration service layer provides the specific collaboration services. According to the CPD strategy mentioned in section 2, five basic collaboration components are provided by the portal in form of service:
   (1) Request & Navigation Component (RNC): The Request and Navigation Component offers functionalities to find a relevant partner, initiate contact with the found partner, and establish collaboration by defining universal conditions and arranging competences and responsibilities.
   (2) Check of Collaboration Partners Component (CCP): The Check of Collaboration Partner component is utilized to support the collaboration initiation phase of CPD. It is divided into three services: partner matching, evaluation of Matching Results, and evaluation of Offers during Negotiation.
   (3) Process Management Component (PMC): The Process Management Component provides functionalities for modeling and executing the CPD processes. The process models are saved in the portal in a certain process definiton format, which can be interpreted by the workflow engine, which coordinates the execution of these business processes.
   (4) Specification Modeler Component (SMC): The Specification Modeler Component lets users define and manage a necessary and sufficient subset of product requirements. It further provides functionality for the checking of consistency and completeness of requirements and product properties. It is also involved in the early phases, when initial product requirements are formulated and when requirements on potential partner companies are defined. The data is only shared by involved partners.
   (5) Visualization & Validation Component (VVC): The Visualization & Validation Component allows users to define different views on engineering data and to validate the data. The data is only shared by involved partners.
   (6) Cultural Repository Component (CR): In order to override the problems in collaborative processes between distributed companies caused by different cultural backgrounds and differences in language and education, a cultural repository is foreseen. Its functionality is going beyond simple request-based advisory systems and literature databases. It also intends to survey ongoing processes on the portal and intervene when necessary.

4) UI service layer: In portal, the service-specific UI service and generic UI service will be provided for browsing available information resources or navigating through networked data structures. The UI services interact with the other services via HTTP or SOAP.

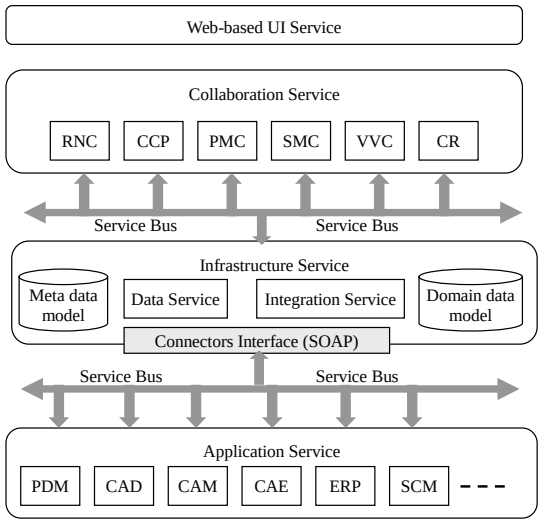

Fig. 3. The Architecture of engineering portal

4 Scenario validation for engineering portal

The scenario selected in this paper is about the collaborative development of a new variant of a car in Mercedes-Benz. There is an existing type: Mercedes-Benz "A-Class A 210". The new variant should be bullet proofed. Only parts, concerning the bullet resistance have to be modified. In this scenario only the left rear door is modified. The scenario demonstrates the whole development process beginning with the search for a new supplier for a window motor and ending with a certified prototype of a bullet proofed. Table 1 shows the stakeholders in this scenario.

Table 1. Stakeholders in the scenario of Mercedes-Benz

Shortcut	Name	Description
OEM	Mercedes-Benz	Development of the whole car, management of the suppliers and development partners.
SUP 1	Car Engineering Solutions	Development (design) of the modified door, including the window glass.
SUP 2	Electric-Motor-Corporation	Supplier of the window motor.
BOA	Shelling Office	Official institution, tests the new guard variant, before it gets the sign of authorization to be called "bullet proofed". They also provide guidelines to reach the authorization.

* OEM: Original Equipment Manufacturer. SUP: Supplier. BOA: Official Board

The scenario contains the following general steps:

1) User login and registration,
2) Search for a new supplier, matching of possible suppliers,
3) Sign the contract,
4) Define a new product by using a template,
5) Definition of initial requirements,
6) Consistence check,
7) Start of the development process
8) Definition of detailed requirements,
9) Consistence checking, CAD visualization
10) Data exchange (using the security tool for CAD data, DMU, simulation)
11) Testing, release,
12) End of development project

Several components of the portal are used to support the implementation of the scenario. Table 2 shows the contributions of the portal components in the scenario.

Table 2. The contributions of the portal components

Name	Phase	Description
IS, UI	SP, CE, CPD	Showing and handling of the distributed data (Requirements, CATIA V5-files, pictures, "pdf" and "Word"-documents). Integration of the portal components.
RNC	SP, CE	Search for a new supplier for the window motor.
CCP	SP, CE	Locating of a new supplier for the window motor.
PMC	CPD	Modelling and Management the development processes between the project partners.
VVC	SP, CE, CPD	Visualisation of the CAD model and data (product requirements, pictures, "pdf"- and "Word"-documents).
SMC	SP, CE, CPD	Definition of the initial (process and product) and detailed requirements, use of templates, consistency check of the requirements including an automated generating of new requirements, interactions between OEM and Supplier according the requirements.
CR	SP, CE, CPD	Notification of the users about differences between some countries according norms and laws.

* SP: Searching Partner, CE: Collaboration Establishment, CPD: Collaborative Product Development

5 Conclusions

Enterprises are driven by the world market to seek global engineering opportunities, which can be for example joint ventures, subsidiaries or relations with foreign suppliers. In order to ensure an efficient and reliable partnership with cooperators in distributed environments, the common processes of collaboration must be modeled and controlled, and the necessary information to be passed between business partners must be defined and provided. The research results of this paper enable the collaborative product development by providing the common CPD processes and the new technical solutions for the engineering portal. The activities and business processes supported by the engineering portal cover the full life cycle of CPD, from

the searching of potential partners, establishing collaboration to the engineering development of product. Through the scenario validation, the portal can effectively support the whole processes in CPD. Both manufacturer and supplier are enabled to collaborate via the portal.

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