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Research Issues on Collaborative Product Design and Development

Jiun-Yan Shiau
Department of Logistics Management
National Kaohsiung First University of Science and Technology
Taiwan

1. Introduction

1.1 What is collaborative product design and development

Collaborative product design and development (CPD) is also known as collaborative product definition management (cPDM). It is about business strategy, workflow and collection of software applications that facilitates different vendors to work together on development/design of a product. The early participation of vendors in the design process is considered critical in order to improve the product quality and reduce the development cycle time. CPD is becoming more valuable because of the increasing coordination and management complexity of organizational information, responsibilities, schedules, deliverables, product information, and business process. As outsourcing and globalization increase the number of design chain participants, a CPD speeds up the decision-making of trusted partners, employees, suppliers, and customers in design chains. Design chain is a subset of supply chain. The major collaborative activities between suppliers and manufacturers are design activities. Therefore, how to manage the design flow in a design chain is as important as how to manage the material flow in a supply chain.

1.2 What are the main phases of product design and development

Before discuss the collaboration issues for product design and development, we need to briefly review the phases of product design and development. The major phases of product design and development are normally defined as conceptual design, preliminary design, and detail design and development (Blanchard, 2004). During the conceptual design phase, the concepts, which are also called scheme, are built in order to completely and efficiently design the transceiver. The concepts may include such as product operational requirements and maintenance, current product problem (or deficiency), functional analysis for the product, applicable technical performance measures (TPMs), and specific performance measures and design-to criteria. Preliminary design phase begins with a "functional baseline" product configuration described in the product specification prepared during conceptual design phase. The functional baseline is translated into detailed qualitative and quantitative design requirements for allocating applicable elements of the product. An "allocated baseline" configuration in the form of development, product, and process specifications is established during this phase. At the beginning of detail design and

development phase, a rough product configuration has been defined, a functional analysis has been accomplished, and the requirements for detail design have been included in the appropriate specifications. The information above must be converted into the proper mix of hardware, software, people, data, and specific items of support during the detail design and development.

1.3 What is the core technology of collaborative product design and development

The core technology comes for CPD does vary depending on who you ask. However, it usually consists of the product lifecycle management (PLM), product data management (PDM), product visualization, team collaboration and conferencing tools, supplier sourcing software, and data translation technology. It is generally not including CAD geometry authoring tools. In this chapter, we will concentrate on PLM and PDM.

1.4 What is PLM/PDM

PLM, which is known as PDM formerly, is the process of managing the entire lifecycle of a product from its conception, through design and manufacture, to service and disposal. PDM systems first appeared in the 1980s. The early PDM systems were effective in the engineering domain, but failed to encompass non-engineering activities, such as sales, marketing, and supply and customer management. With development of newer information technologies, web-based PDM systems were introduced and better accessibilities to suppliers and customers were provided. PDM, however, was still confined to engineering information management (Ameri & Dutta, 2005). Around 2003, PDM was expected to focus on product lifecycle stages in general; an improved support of engineering collaboration functionality, the name of PLM was thus given.

1.5 How to apply PLM/PDM to collaborative product design and development

The purpose of this chapter is to discuss research issues on how PLM/PDM is applied to CPD. From collaborative environment perspective, we categorize CPD into (1) single firm or multiple firms, (2) centralized managed or distributed managed, and (3) localized or global. From strategy perspective, Krishnan and Ulrich (2001) categorized product design and development as (1) marking, (2) organizations, (3) engineering design, and (4) operations management. From project management perspective, product design and development can be categorized as (1) conceptual design, (2) design chain, (3) detail design, and (4) production ramp-up. Based on these three perspectives (i.e., collaborative environment, strategy and project management), this chapter surveys related literatures on PLM/PDM and proposes a research issue cube (as shown in Figure 1) for CPD.

2. Research issues on applying PLM/PDM to collaborative product design and development

2.1 Configuration management theory

Before further discussion on how to apply PLM/PDM to each cell inside the research issue cube (as shown in Figure 1), the preliminary background about the theory behind PLM/PDM is required. Configuration management (CM) is the theory behind a PDM system. Some researchers considered PDM as an implementation of CM principles (Lyon, 2002). There are also some researchers developed distributed CM principles or web-based PDM for distributed collaborative environment.
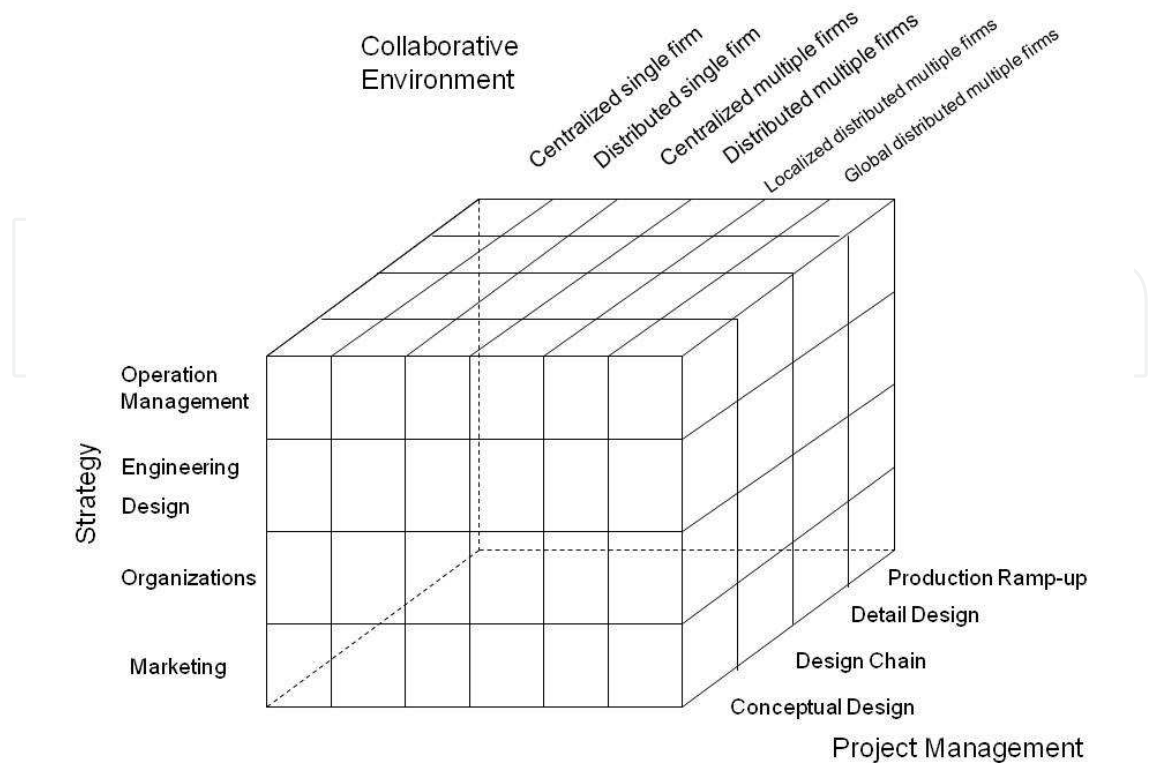
Fig. 1. Research Issue Cube on Collaborative Product Design and Development

Configuration management was first introduced by US Department of Defense in 1992 (Lyon, 2002). It is a discipline applying technical and administrative direction, and a surveillance over the life cycle of configuration items (CI's) to:

- Identify and document the functional and physical characteristics of CI's.
- Control change to CI's and their related documentation.
- Record and report information needed to manage CI's effectively, including the status of proposed and approved changes.
- Audit CI's to verify conformance to documented requirements

Some forms such as ECR (enterprise change request) and ECN (enterprise change notice) are commonly used in the configuration management. The forms, used in the configuration management process, serve two purposes.

- To provide authorization to do work.
- To provide a historical record plus proof of conformance.

Also configuration management is a theory proposed for tracing and maintaining the integrity among valuable outputs during the lifecycle of product development. According to IEEE standard for software configuration management plans, a configuration includes configuration items and their structures at each project control point. Configuration items of software could be physical and functional characteristics of the code, specifications, design, data elements, outputs of the development process, and elements of the support environment. Structures mean the way of combinations among configuration items. Shiau et al. (2008) proposed a formulization of configuration management. Let's denote a structure among configuration items as a matrix *S*. The equation below represents the concept of a configuration.

$$Configuration = (CI_i, S) \quad where \ i = 1, 2, \ldots, n \ and \ n \ is \ a \ constant \ number$$

Normally structure (*S*) utilized in a configuration management plan should be static and unchangeable during the development cycle (Gruhn et. al., 2003). When different versions of CI's with static structure are created, approved and finally released, they form a new version of configuration. The equation below represents the concept of a version of configuration.

$$Version(Configuration)$$
$$= Version(CI_i, S)$$
$$= (Version(CI_1) , Version(CI_2) , \ldots, Version(CI_n), S)$$

When different versions of configurations are based on a static structure, they are defined as a version-aware configuration and the changing history of the configurations are then traceable. However, if two versions of configurations have different structures, they are defined as non-version-aware configurations. For example below, *Version(Configuration₁)* and *Version(Configuration₂)* have structures, S_1 and S_2, respectively. The changing history of the two configurations may be unable linked and therefore untraceable.

$$Version(Configuration_1) = (Version(CI_1) , Version(CI_2) , Version(CI_3), S_1)$$

$$Version(Configuration_2) = (Version(CI_2) , Version(CI_4) , Version(CI_5), S_2)$$

A version-aware configuration at a specific project control point is called a baseline. The concept of a baseline concentrates on the status of configurations. The equation below represents the concept of a baseline of configuration.

$$Baseline(Configuration)$$
$$= Status(CI_i, S)$$
$$= (Status(CI_1) , Status(CI_2) , \ldots , Status(CI_n), Status(S))$$

When two baselines are established at two specific project control points, the status of configurations is recoverable. For example below, *Baseline(Configuration₁)* and *Baseline (Configuration₂)* are two configurations with different structures at two project control points. It is able to recover the status back to either *configuration₁* or *configuration₂* once the two baselines are established.

$$Baseline(Configuration_1) = (Status(CI_1) , Status(CI_2) , Status(CI_3), Status(S_1))$$

$$Baseline(Configuration_2) = (Status(CI_2) , Status(CI_4) , Status(CI_5), Status(S_2))$$

Based on these two concepts (i.e., version control and baseline management) plus a set of automated computer modules (for example, a workflow management module, an authorization module, status accounting module, configuration auditing module, and so on), configuration management can help an enterprise to maintain the consistency among CI status while changes occur.

2.2 Issues in each dimension
2.2.1 Research issues on configuration items identification related to collaborative environment

A CI identification principle expressed in EIA/IS-649 is that each CI, which is usually represented in electronic document format, must have a unique identifier so that it can be

associated correctly with the configuration of the physical item to which it relates. The US Department of Defense and all military components use the following three elements to assure the unique identity of any document: CAGE code, document type and document identifier. A configuration items identification activity guide is provided in Table 1.

Preferred Identifier Element	Definition
Document Identifier	
CAGE Code or NSCM (NATO Supply Code for Mfg.)	CAGE (and NSCM) Codes identify the source of the document. The codes are provided in **Defense Logistic Agency (DLA) Cataloging Handbook H4/H8 Series**. The codes are affixed to all CIs, and their *replaceable* subordinate parts and assemblies. They are also part of the identification marking of each item of configuration documentation, software media and software product.
Document Identifier	The document Identifier distinguishes one document produced by the organization referenced by the CAGE code from another. Each document and each revision thereto, requires the document identifier. There are as many schemes for identifying documents as there are organizations producing them, so there is no standard format for all documents. There are however, a few common sense constraints on the numbering content for some specifications, and engineering drawings, as defined in applicable standards
Revision/Version identifier	
Revision Identifier	Revision Identifier clearly establishes which issue of a particular document is current or applicable.
Version Identifier	Conceptually the same as revision, version is the term typically used for files
Date	Date is an additional discriminator. It is good common sense business practice to date every document and every revision
Restrictive Markings: *These requirements apply to digital data files and digital media as well as to paper documents and are all intended to limit the access to such data to those entitled to access them.* [Ref: DoD FAR Supplements 252.227-7015, 7018, 7052 and -7057]	
Security Markings	Security markings are required to be clearly marked on all classified data and special handling requirements apply. Each contract contains classification guidance and direction, which must be strictly adhered to.
Distribution Statements	Specific distribution statements and export restrictions must be marked on information subject to secondary distribution limitations as prescribed by law and as indicated by the contract. The purpose of these markings is to inform the secondary distributor, such as a Government repository whether they can legally provide the subject information to third parties, and if the data are allowed to be exported to foreign countries.
Data Rights	Documents which contain data for which the Government or other parties do not have unlimited rights, must be appropriately labeled to indicate the data rights limitations, so that proprietary information disclosed to the Government for specific purposes is protected.

Table 1. Document Identification Activity Guide (MIL-HDBK-61A, 2008)

Research issues on configuration items identification for a single firm are related to the activities shown in Table 1 plus a systematically process to generate product configurations. Normally, a company will not generate any product configuration (such as functional baseline, allocated baseline, etc.) from scratch. Therefore, a systematical normalization process is required. With such process, one can normalize all the collected data/documents into several hierarchical styles of configurations (such as functional baseline, allocated baseline, E-BOM, M-BOM etc.) systematically. This is similar to normalization processes of relational database. Database engineers can decompose all collected persistent attributes into several relational tables in order to fulfill criteria of 1st, 2nd, or 3rd normalization

forms. The aspect oriented configuration identification model presented in (Shiau et al., 2008) is one example in configuration items identification area. Jiao and Zhang (2005) presented an association rule mining approach for product portfolio identification is another example. Wang and Lin (2003) proposed a fuzzy multicriteria group approach for selecting configuration items is also an example in this area.

In addition to the issues above, research issues on configuration items identification for multiple firms or distributed single firm include zoning and partition procedures for further categorizing those hierarchical styles of configurations. The inter-company configuration and intra-company configuration presented in (Shaiu & Wee, 2008) is an example of the outcomes of such procedures.

Data exchange and format conversion are critical research issues for localized and global firms. The differences among international currencies, metrologies and regulations cause the needs of data exchange and/or format conversion among configuration items. The data exchange issues will be even more complex if structures of a configuration are diverted due to globalization

2.2.2 Research issues on change control workflow related to collaborative environment

A change control workflow is a logistic procedure to control and coordinate changes among configuration items for ensuring the consistency of a configuration. The Institute of Configuration Management (2002) proposed a closed-loop change control workflow (see Figure 2) within the CMII principles as a reference model for managing changes. In addition to CM principles, CMII shifts the emphasis of CM to (1) accommodate change, (2) accommodate the reuse of standards and best practices, (3) assure that all requirements remain clear, concise and valid, (4) communicate (1), (2) and (3) to each user promptly and precisely and (5) assure conformance in each case. As shown in Figure 2, an enterprise change request (ECR) is provided and passed to Change Administration I, when a document in the baseline is intended to be changed (i.e, an engineering change is requested).
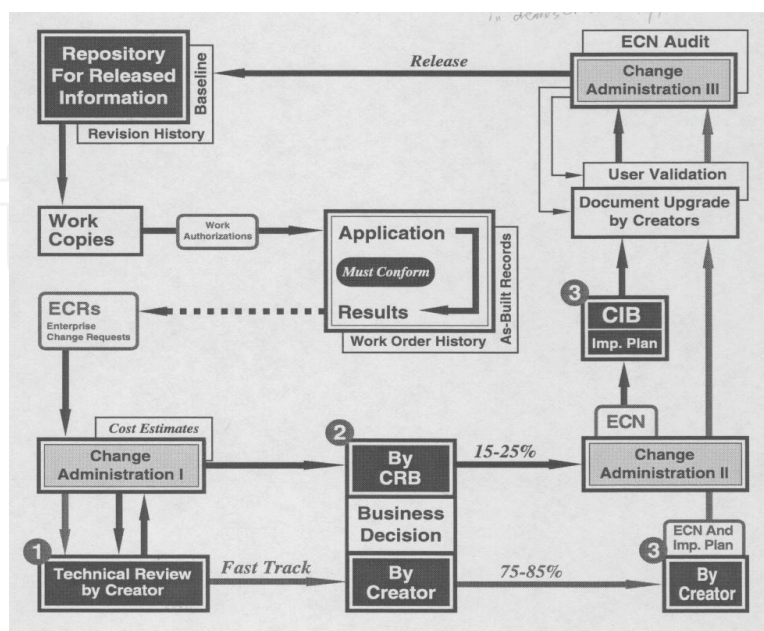

Fig. 2. Closed-Loop Change Control Workflow (Institute of Configuration Management, 2002)

ECR is a kind of document that records what to change, the reason to change and the priority of changes. Change Administration I accepts or denies the ECRs based on the results consulted from professionals in charge with each configuration item (CI). Accepted ECRs are then passed to change review board (CRB) or original creators for approval and then for making business decision based on further discussion in CRB meetings. Approved ECRs are organized as enterprise change notices (ECNs) by Change Administration II. ECN is a document recording how to change and when to change. Change implementation board (CIB) is held by Change Administration II for planning the detail of ECN implementations. Finally, Change Administration III audits the consistencies of ECNs, releases the revised documents, and updates new states to the baseline. CRB and CIB together are so called change control board (CCB).

Research issues on change control workflow for a single firm are about minimal disruption to services, reduction in back-out activities, and economic utilization of resources involved in implementing change. Techniques of workflow management are helpful while building such workflow. A closed-loop design change control workflow (see Figure 3) during conceptual design phase proposed by (Shiau and Li, 2007) relates to this area.
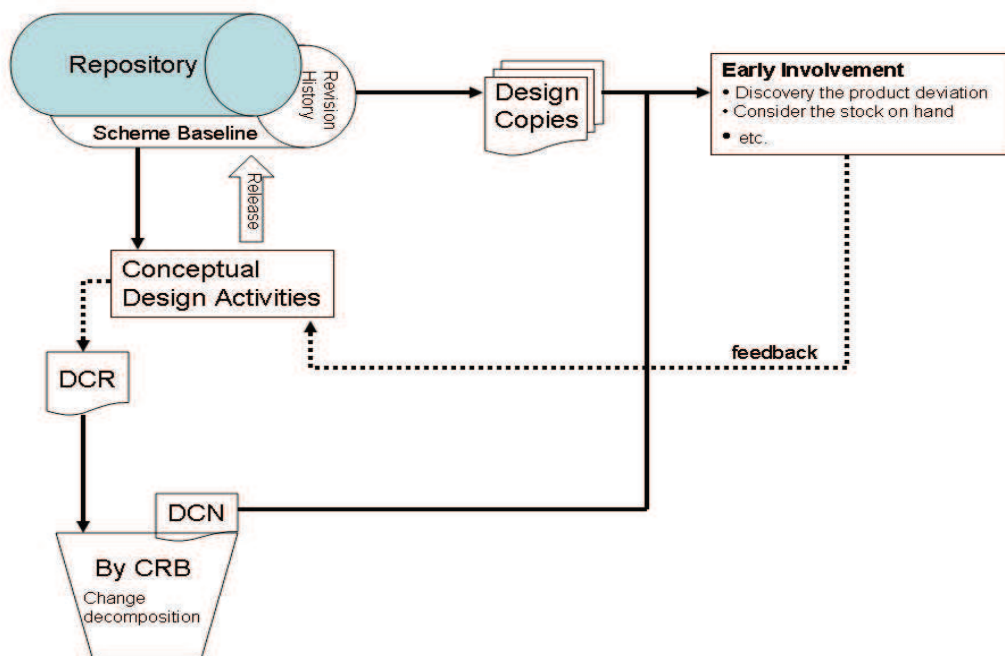

Fig. 3. A Closed-loop Design Change Control Workflow

Research issues on change control workflow for multiple firms either reside in local area or global areas are more depending on distributed workflow management and technology. The distributed change control workflow demonstrated in (Shiau and Wee, 2008) is probably the first one in this area. The distributed change control workflow, which is also a kind of distributed algorithm, is illustrated as below:

Send: Every t days or when collaborative design table, Tl, changes, send Tl to each related companies
Receive: whenever Tr is received from another company via interface n:
For all rows Rr in Tr {
  Determine if ($Rr.C_{ij} <> Rl.C_{ji}$) {

```
// calculate new utility of Cji
if (Rr.company is not in Tl) {add Rr to Tl }
else for all rows Rl .Cji.utility in Tl {
            if (Rr.company = Rl.company and Rr.Cij.utility > Rl.Cji.utility) {
                        Rl = Rr
            }
      }
}
}
```

Every t days or when collaborative design table (Tl) changes, Tl is send to each outgoing interface. When a collaborative design table (Tr) is received on interface n, it compares all rows (Rr) in Tr with it's own collaborative design table (Tl). If an integration checking table, C_{ij}, in any Rr is not equal to the integration checking table, C_{ji} in Rl, calculate the utility of Rr in the integration checking table and set the interface of Rr to n. If any company in Rr is not in Tl, add Rr to Tl. Compare all Rl in Tl, if the company in Rr is equal to the company in Rl and the utility of collaborative design table in Rr is less than the utility of collaborative design table in Rl, then replace Rl with Rr. A collaborative design table records the information of how a company determines which assembly interface to deal with when a design change occurs. The recorded information includes the company names, the assembly interfaces of end-products, and the integration checking tables. An integration checking table contains a list of preference values, called utilities, to every assembly interfaces for a company.

2.2.3 Research issues on configuration status accounting related to collaborative environment

Configuration status accounting is a task of CM concerned with recording the state of a CI at any point in time, past, present or future. There are three distinct but overlapping areas in configuration status accounting activities. They are configuration status accounting data capture, configuration status accounting data processing, and configuration status accounting data reporting (Lyon, 2002). The aim of configuration status accounting is to ensure that not only the physical configuration item, but also the configuration documentation describing that physical configuration item, is always at a known state commensurate with the grade of CM being applied.

Research issues on configuration status accounting for single firm are about the implementation of system modules to track the location and actual build state of individual CI or whole configurations. Burgess et. al. (2003) explored how the European aerospace industry views and practices 'configuration status accounting' is an example in this area.

2.2.4 Research issues on configuration auditing related to collaborative environment

An audit is an independent evaluation of a configuration to ascertain compliance with specifications, standards, contractual agreements or other authorized criteria. As such, audits are a quality assurance function, and all configuration auditing processes must be integrated with existing quality assurance/management procedures. There are three categories of configuration audits. They are functional configuration audits, physical configuration audits, and configuration verification audits (Lyon, 2002). Configuration

audits should not be viewed simply as a test for compliance; they should be considered as method for determining the level of compliance achieved, with the aim being to identify any areas requiring additional effort. Significant pre-audit checks and consultation should be carried out prior to official configuration audit activities. There is lack of research and case study in this area today.

2.2.5 Research issues on configuration management related to strategy of product design and development

As shown in Table 2, Krishnan and Ulrich (2001) did a comprehensive survey of papers in design and development research according to the four common perspectives, which are marketing, organizations, engineering design, and operations management. Research issue on this area is to develop new strategies for collaboration among venders in terms of marketing, organizations, engineering design, and operations management. For example, the concept of vendor managed inventory (VMI) could be borrowed for CPD among joint development manufacturers (JDMs). VMI is a kind of business model in which the buyer of a product provides certain information to a supplier of that product and the supplier takes full responsibility for maintaining an agreed inventory level of that product, and sometimes even responsibility for maintaining agreed inventory levels of related products, called product family. Borrow such strategy, a JDM might consider to provide vendor managed change control service. Besides providing services of design and manufacturing, a JDM may now provide design logistics management for its client. Any change among components of a product from other JDMs could cause the integrity issue and require design logistics management. A modification of today's PDM/PLM for such collaborative strategy could be an interesting topic. A prototype of conceptual design information system proposed in (Shiau et. al., 2004; Lin et. al., 2004; Huang et. al., 2006) is partial of such system.

	Marketing	Organizations	Engineering Design	Operations Management
Perspective on Product	A product is a bundle of attributes	A product is an artifact resulting from an organizational process	A product is a complex assembly of interacting components	A product is a sequence of development and/or production process steps
Typical Performance Metrics	"Fit with market" Market Share Consumer utility (Sometimes profits)	"Project success"	"Form and function" Technical performance Innovativeness (Sometimes direct cost)	"Efficiency" Total cost Service level Lead time Capacity utilization
Dominant Representational Paradigm	Customer utility as a function of product attributes.	No dominant paradigm. Organizational network sometimes used.	Geometric models. Parametric models of technical performance.	Process flow diagram Parametric models of process performance.
Example Decision Variables	Product attribute levels, price	Product development team structure, incentives	Product size, shape, configuration, function, dimensions	Development process sequence and schedule Point of differentiation in production process
Critical Success Factors	Product positioning and pricing Collecting and meeting customer needs	Organizational alignment Team characteristics	Creative concept and configuration Performance optimization	Supplier and material selection Design of production sequence Project Management

Table 2. Comparison of Perspectives of the Academic Communities in Marketing, Organizations, Engineering Design, and Operations Management (Krishnan & Ulrich, 2001)

2.2.6 Research issues on configuration items identification related to project management

Project management is the discipline of planning, organizing, and managing resources under constraints such as scope, quality, time, and budget to bring about the successful completion of specific project goals and objectives. Different phases of product design and development usually own different types of projects. Research issues on configuration items identification in this area are about establishing As-Planned and As-Released baselines during each phase of CPD. Baseline is the compilation and accumulation of all documentation plus digital design files that represent a product at a specific point in time. Gruhn et. al. (2003) presented a case study about how to apply software CM while developing a software application is an example in this domain.

Configuration items related to project management are also categorized as resource oriented or activity oriented. Depend on types of projects (i.e., conceptual design project, detail design project, production ramp-up project, or design chain project), the configuration items are very diverse. For example, CI's for production ramp-up project might be more resource oriented. Materials in E-BOM and materials in M-BOM are examples of CI's in production ramp-up project. Oppositely, CI's for conceptual design project might be more activity oriented since the resources (or outputs) of conceptual design is unable to define during the early stage of conceptual design.

Research issues in this domain are about when to identify project resources as CI's and when to identify project activities as CI's. Sometimes, if it is hard or impossible to identify project resources, one might needs to identify them in the dual plane of original configuration. The aspect oriented configuration identification model presented in (Shiau et al., 2008) is an example of identifying CI's in dual plane. Similar to the Fourier analysis in mathematics, if a line in x and y plane (see Figure 4) is:
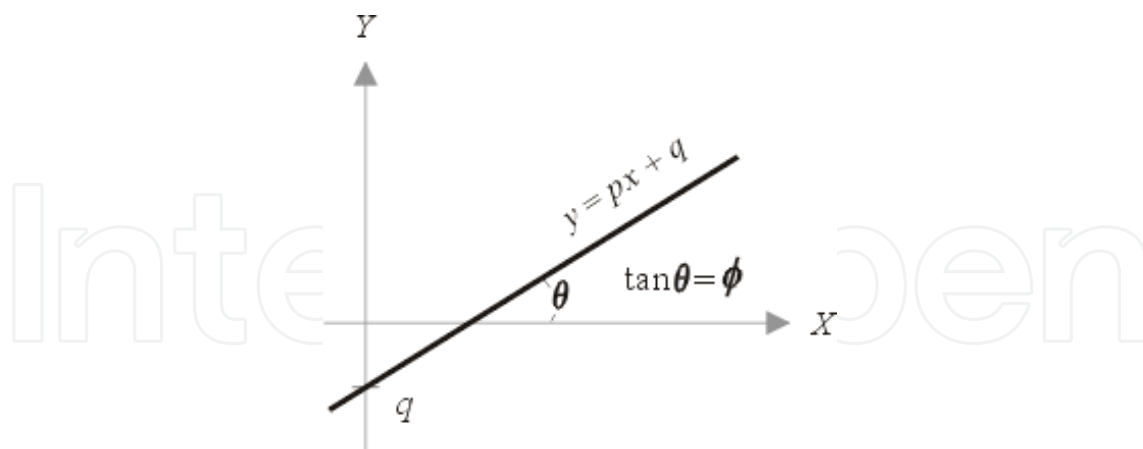
$$y = px + q$$

Fig. 4. XY Plane

One can solve the equation above by solving its dual plane (see Figure 5) below:

$$q = -px + y$$

Let's formulate component configuration for a system as:

$$configuration = (vertical\ viewpoint)\ CI's + static\ structure$$
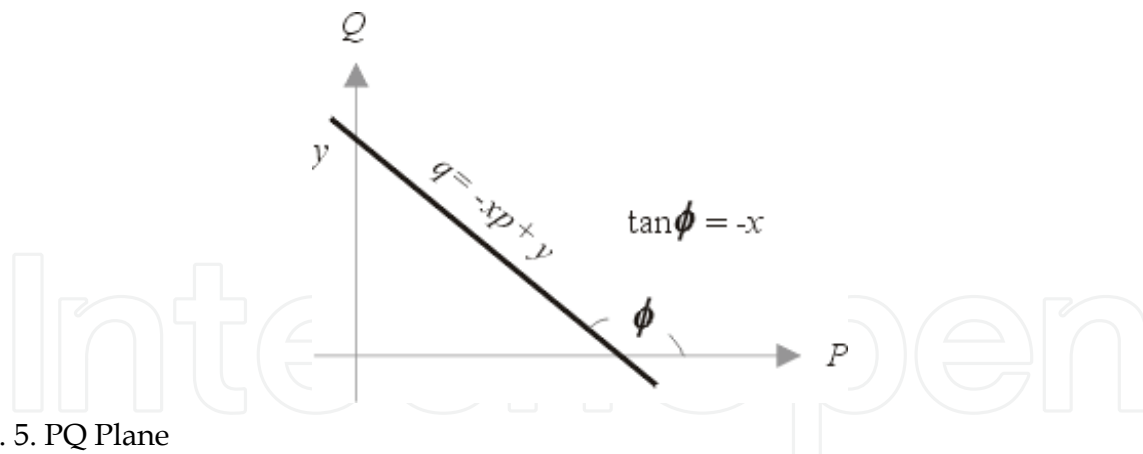
Fig. 5. PQ Plane

If we could not find a static component configuration from the vertical viewpoint (for example, class perspective in software applications), we can try to find one from the horizontal viewpoint (for example, crosscut-classes perspective in software applications). The dual plane is as below:

static structure
= -(vertical viewpoint) CI's + configuration
= (horizontal viewpoint) CI's + configuration

2.2.7 Research issues on change control workflow related to project management

There are two types of change control workflow for product design and development. One is called engineering change control; the other is called design change control. Normally, the change control process is launched while the first edition of manufacturing bill of materials (M-BOM) is generated and recorded in the repository. Due to continuous changes in production engineering in nature, and inevitable errors and changes in products, ECR is not avoidable during the whole product lifecycle. Engineering change control is designed for in-time feedback from production phase to product design phase. A common misunderstanding of this change control model is to launch engineering change management during the conceptual design phase.

Design change request (DCR) and design change notice (DCN) are the forms designed to give in-time feedback from conceptual design phase to production phase and service phase. These are opposite to the directions of feedback of engineering change control. Although DCR and DCN forms are similar to ECR and ECN forms, the change control workflow for engineering change is no longer suitable for design changes. Therefore there is a need to develop aother change control workflow for phases before detail design. A design change control workflow (as shown in Figure 3) is different from an engineering change control workflow in two essential aspects:

- The "feedback" here is a forward notification mechanism that goes from the upstream conceptual design to downstream activities including detailed design, production planning, etc. Such changes are mostly useful when they occur at the early development stages of a product, i.e. when most efforts are spent in conceptual design.
- The working forms or messages and their functions are, largely due to the above difference, very different from the ECR and ECN. In this sense these forms should function more as active triggers rather than passive responses. This requires special

attention to the control and synchronization of the lifecycle, authorization and structure workflows in terms of project, document and scheme configuration management.

A closed-loop design change control workflow (Shiau & Li, 2007) was developed for the purpose of continuous improvement of conceptual design. It is also a workflow adapting concept of early involvement of concurrent engineering.

Depend on performance indexes (i.e., quality, time, or budget) of a project, the analysis and evaluation approaches in CRB (see Figure 2), which is part of change control workflow, are very diverse and also time-consuming. The decisions of the CRB are about when a change is to be made (effectivity) and what should be done to the existing inventory of the old configuration assemblies and components. In practice, CRB members have to fill in a planned effectivity in each ECR during analyzing and evaluation phase of an engineering change. In the survey of (Huang et. al., 2003), shop floor workshop, design office, and quality control department are the major representatives in the CRB. Habhouba et. al. (2006) reported that most PDMs do not offer any intelligence or decision-making assistance during change control. Shiau (2007) presented an effectivity date maintenance model for PDM is an example in this domain.

2.2.8 Research issues on configuration status accounting and configuration auditing related to project management

Research issues on configuration status accounting and auditing in this area are similar to issues for single firm describted before. Burgess et. al. (2003) explored how the European aerospace industry views and practices 'configuration status accounting' is an example. Procedures of configuration status accounting and auditing proposed in (Lyon, 2002) probably is one of the most compreshesive approaches in this area.

3. Discussion and further research

Table 3 shows the overview of research issues on CPD in terms of collaborative environment, strategy, and project management. To solve those research issues, it requires the wide spectrum of CM or PDM/PLM knowledge. The major problem in apply CM to CPD is lack of standard procedures for identifying configuration, controlling changes, accounting configuration status, and auditing configurations (Schuh, 2008). Most researches available today are about the principles and guidelines in applying CM. In this chapter, we reviewed several specific procedures for identifying configuration, controlling changes, accounting configuration status, and auditing configurations from previous researches.

There are still some undiscovered cells inside our proposed research issue cube. There is also no generic procedure discovered till the date this chapter is written. Despite these shortages, we believe the generic procedures will be inducted in the near future with more and more specific implementations of CM to industries. For example, the idea of apply PLM to maintenance services in aerospace industry (Lee et. al., 2008).

4. Conclusion

The trend of component manufacturing has been changed from EMS (electronic manufacturing services) provider to JDM (joint development manufacturer). EMS is an

Dimension	CM area	Research Issues	References
Collaborative Environment	Configuration Identification	systematically normalization process; zoning and partition procedures; data exchange and format conversion	(Jiao and Zhang, 2005); (Shaiu & Wee, 2008); (Shiau et al., 2008); (Shaiu & Wee, 2008); (Wang & Lin, 2003)
	Change Control	centralized and distributed workflow design and management	(Institute of Configuration Management, 2002); (Shiau and Li, 2007); (Shaiu & Wee, 2008)
	Configuration Status Accounting	data capture, data processing, and data reporting	(Burgess et. al., 2003); (Lyon, 2002)
	Configuration Audits	quality assurance function	(Lyon, 2002)
Strategy	Configuration Management	New strategies on marketing, organizations, engineering design, and operations management	(Huang et. al., 2006); (Lin et. al., 2004); (Shiau et. al., 2004)
Project Management	Configuration Identification	baseline establish, resource oriented and activity oriented configuration items	(Gruhn et. al., 2003); (Shiau et al., 2008); (Wang & Lin, 2003)
	Change Control	forward and backward oriented notifications, decision making models	(Huang et. al., 2003); (Shiau, 2007); (Shiau and Li, 2007)
	Configuration Status Accounting	data capture, data processing, and data reporting	(Burgess et. al., 2003); (Lyon, 2002)
	Configuration Audits	quality assurance function	(Lyon, 2002)

Table 3. Overview of Research Issues on Collaborative Product Design and Development

industry based on providing contract design, manufacturing and product support services on behalf of OEMs (original equipment manufacturers). However, all intellectual property of the new product belongs to the OEM. JDM is a company that helps design parts of a product for OEM customers. Unlike EMS, JDM may own the copyright of its design and provide joint design services to its OEM customer. The core competitions of JDM are joint design and productivity of manufacturing. Once basis requirement is hand-off from customer, JDM takes the job of completing the design, performs design verification, assembles and tests prototypes, assembles and tests qualification units, assembles and test

proof manufacturing units, and finally produces the production units (Kaylor, 2004). Lots of stakeholders have recognized that the earlier the manufacturer becomes involved in the design process, the better the product. When a product is outsourcing to OEM and OEM outsource it to down tiers of JDMs, a design chain is formed. In order to design a product, a JDM has to joint design with its OEM customer and also collaborate design with other JDMs in a design chain environment. With the trend above, CPD is becoming more valuable.

In this chapter, the research issues of collaborative product design and development based on CM principles are explored. The four major CM areas, which are configuration identification, configuration change control, configuration status accounting, and configuration audits, were introduced under three dimensions (see Figure 1). Although this chapter may not provide the exhaustive review for all research issues of applying CM/PDM/PLM to CPD, we think that our work has laid the cornerstone of CM/PDM/PLM and CPD studies.

5. Acknowledgements

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Supply Chain the Way to Flat Organisation

Edited by Julio Ponce and Adem Karahoca

With the ever-increasing levels of volatility in demand and more and more turbulent market conditions, there is a growing acceptance that individual businesses can no longer compete as stand-alone entities but rather as supply chains. Supply chain management (SCM) has been both an emergent field of practice and an academic domain to help firms satisfy customer needs more responsively with improved quality, reduction cost and higher flexibility. This book discusses some of the latest development and findings addressing a number of key areas of aspect of supply chain management, including the application and development ICT and the RFID technique in SCM, SCM modeling and control, and number of emerging trends and issues.

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