

Licentiate Thesis Proposal:

Product Data Management and Software Data Management Integration

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Abstract

Today products are often complex systems consisting of hardware, software, and accompanied with documents, developed by several groups. This complex system development demands an integrated support on several levels, both for the system and included component levels for all development groups. The need for an integrated support implies integration of tools providing this support. One of the today's key factors for an integrated product information management is the possibility of integrated and uniform use of Product Data Management (PDM) and Software Configuration Management (SCM). These tools provide support for managing infrastructure for products (PDM for hardware products and SCM for software products). These tools are in many aspects similar, but experience has shown that many companies have large problems to use both PDM and SCM in product development.

The primary objects of the study in this thesis are the analysis of the main characteristics of PDM and SCM and their key functionality. Further it analysis a feasibility of using only PDM for system development including software, or using only SCM for system development including product management.

The main contributions are following: From the analysis of basic characteristics of PDM and SCM tools, we found that there are similarities in them, but the underlying concepts are quite different. Integration between PDM and SCM can lead to a more efficient development and maintenance support of today's complex products. Three main factors play a crucial role for a successful integration: tools and technologies, processes, and people. For integration purposes, terminology and cultural differences are one of the key factors to highlight.

The research is primarily based on literature studies, industrial case studies, and long experience from work in industry.

1 Background and Motivation

Traditionally, hardware development has been separated from software development. The development processes have been separated and different tools have been used to support these processes. In fact, software products have been clearly separated from hardware products during development, and they have not been integrated before the start of system verification. Today this border between hardware and software begins to vanish. The final product is a result of tight integration of hardware and software components and the decision whether a specific function should be implemented in hardware or software may come late in the project and may even change during the products life cycle. When the border become vague it is no longer possible to keep the development organizations separated and to use different life cycle processes. On the opposite there is a need for their integration. However, the requirements for such integration points out a number of problems: process adjustments, information exchange, data access and information flow, infrastructure support, tool integration, cultural differences, etc. To integrate the processes and the tools have been difficult problems and challenges for many companies. Several attempts to integrate tools from these domains exist, but they all show small visible success [1, 2, 3, 4, 5]. The reason for this is that integration goes far beyond tool integration issues only. According to our experiences, three main factors play a crucial role for a successful integration: *tools and technologies, processes, and people*.

We focus on infrastructural support for development and maintenance of products that include both hardware and software provided by Product data management (PDM) and Software Configuration Management (SCM) tools.

PDM is used for managing product information, especially information used in the production phase. Computer systems managing this product data are called PDM systems.

A definition of PDM among a number of different definitions with the same meaning is [13]:

PDM is the discipline of controlling the evolution of a product and providing other procedures and tools with the accurate product information at the right time in the right format during the entire product life cycle.

PDM is an engineering discipline that includes different methods, standards, and tools. PDM (i) manages the data related to products, (ii) supports procedures during the product lifecycle, and (iii) deals with the development and production infrastructure [1], [2], [6], [7]. Traditionally, PDM deals with hardware components only.

The development of complex and large software is characterized by collaboration and coordination of many developers. The objective of SCM is to ensure a systematic and traceable development process, so that a system is in a well-defined state with accurate specifications and verified quality attributes at all times [8], [9]. Traditionally, SCM deals with software components only.

A definition of SCM is [11]:

Configuration management is the art of identifying, organizing, and controlling modifications to the software being built by a programming team.

The scope of SCM is to (i) keep track of items and their versions, which are used in the product development and maintenance, (ii) manage all the changes made to these items during their entire life, and (iii) keep track of all documentation related to the product.

The difference is that PDM is focused on hardware products, while SCM has aimed to support software development [6], [8], [9].

Complex products consisting of hardware and software use both PDM and SCM for managing the products and the components during the entire life cycle. On the system level, where hardware and software components are integrated into the final product, the goal is to control the product for the entire product life cycle. To effectively manage a complex system on the system level, adjustments of all included processes are needed [4], [6]. Different stakeholders, such as Project Manager, System Engineers, Integration and verification team, and Configuration Managers, are all demanding to follow up the development of the entire product and of both hardware and software components.

PDM and SCM have similar purpose and similar functions. Since PDM and SCM systems have evolved in different development domains and have various degree of maturity they have been developed on different technologies fulfilling the domains functionality demands and processes. The tools in respective area are completely different from a technical point of view. Consequently, product information in one system, either the PDM or the SCM, has to manually be introduced into the other system, which is a cumbersome and not efficient process. The risks with this time consuming manual transferring of data, is either the data is incidentally wrongly introduced or never done.

Because of similarities in their functions and because of overlap of information stored in both PDM and SCM, there is a questions if only one of these tools can be used for all development and maintenance processes, for both software and hardware parts? If not, would a seamless integration of these tools enable an integrated support for the development and maintenance process?

To answer to these questions in the proposed thesis, we intend to describe the basic characteristics and key functionality of PDM and SCM domains, the main similarities and differences between them, and discuss the possibility of using one of the domains for the system development including hardware and software components development.

The problems described in the thesis originate from work experiences, integration project sponsored by Ericsson AB, several case studies performed in different Swedish companies in a project sponsored by Teknikföretagen (former Sveriges Verkstadsindustrier), extended case studies in companies in other countries, and case studies performed in Telecom and a company developing software products.

2 Research Objectives

2.1 Hypothesis and Research Questions

We have formulated the following two hypotheses:

- (H1) Efficient integration between PDM and SCM can lead to a more efficient development and maintenance of modern products.*
- (H2) For a successful integration of PDM and SCM three integration factors are necessary: successful tool integration, process integration, and removing cultural differences between PDM and SCM stakeholders.*

To justify the first hypothesis (H1), we state the following research questions:

- Is it possible to use PDM for system development including software development? (Is PDM sufficient?)
- Is it possible to use SCM for system development including product management? (Is SCM sufficient?)

To answer these questions we state the following questions:

- (Q1) What are the similarities and differences between PDM and SCM?
- (Q2) Can integration between PDM and SCM lead to a more efficient support during development and maintenance?

To justify the second hypothesis (H2), we have investigated PDM and SCM usage in different companies. PDM and SCM tools have been integrated both in house built and commercial. We have studied two different initiatives in integration, both on commercial tools.

2.2 Research Methods

The research for this thesis is mainly based on literature surveys, tools analysis, case studies, discussions with researchers, vendors, and end-users, and work experience. Following have been accomplished:

1. Understanding the methods, theory, and tools in PDM and SCM.

a. PDM

This part of the research project is done through literature study and study of different tools and case studies of use of PDM. The focus is on understanding the domain in general, e.g. who is using it and for what purposes, definition, processes, key players, commercial tools, business model, basic functions, system architecture, information architecture, applications, and integration with other tools. I have participated in several conferences and workshops to understand the driving mechanism, and end-users needs. In addition, internal discussions regarding requirements and implementation of PDM at Ericsson AB, have given me a picture on how the company processes, infrastructure and tools are tightly connected to each other together with changing of peoples behaviour and thinking.

Several case studies based on interviews, mail exchanges, and workshops have been performed. Case studies have been done in several companies both in Sweden and abroad. The company we did case studies at were Sun Microsystems Inc., Mentor Graphics Corporation, Ericsson Radio Systems AB, Ericsson Mobile Communications AB, ABB Automation Technology Products, SabbTech Electronics AB, Industrial and Financial Systems, and SonyEricsson. The information gathered in the different cases, was acquired through interviews and discussions with one or more persons in the companies who had responsibility for or experience using their PDM or SCM solutions. The case studies were performed by a core group of three researchers. This group formed questions that were used as basis for the interviews. The questions were explicit sent out to a contact person at each company before we met and did the interview. In some cases, e.g. Sun Microsystems Inc. and Mentor Graphics Corporation were interviewed by several phone meetings. This information was formed into text, which the authors reviewed. In some cases more information were gathered through mail discussions and the case were more described. When the final text was ready, the different companies reviewed the content and approved it for publication. I was responsible for the case study at Sun Microsystems Inc., Mentor Graphics Corporation, Ericsson Radio Systems AB, and Industrial and Financial Systems.

b. *SCM*

This part of the research project is done through literature study and study of different tools and case studies of use of SCM in different companies. The focus on understanding the domain in general, e.g. who is using it and for what purposes, definition, processes, key players, commercial and free tools, basic functions, and integration with tools. Case studies have been performed in the same companies as case studies in PDM were performed. In addition to this I have been involved as main responsible for CM in several projects at Ericsson AB, where SCM methods, and infrastructure have been discussed, implemented, tested, and documented. I also have been a program committee member for six SCM workshops where SCM has been discussed. This has given me experiences on end-user demands, processes used, and usage and demands on the infrastructure and distributed developments.

2. *Common activities for PDM and SCM*

- a. *Investigation of key functionality in PDM and SCM.* This part is done through literature study, experience of using a commercial PDM system at work, discussions with PDM and SCM vendors and researchers, and reading different manuals from different commercial PDM systems. I have participated in three different projects and several different case studies on which experiences, and conclusions are used. In one of the projects, the project team, members from both PDM and SCM domain, were discussing the key functionality, visited by Eurostep for the Step standard knowledge, demonstrations on different PDM tools, and received PDM information from vendors.
- b. *Analysis of similarities and differences in key functionality.* This part is done through literature study, experiences, and discussions with several researchers from both domains, discussions with end-users, discussions with vendors, comparing system architectures, and information architectures. I have been involved in integration of PDM and SCM in an earlier project. I will use these experiences in to understand the similarities and differences of functionality. This topic was also discussed in a project, where both PDM and SCM people were involved. Analysis of similarities and differences were made in connection to the publishing of the book.

3 Research Result – Publications

Research results have been published in the following publications:

Conferences and workshops:

1. *Managing Complex Systems – Challenges for PDM and SCM*
In *Software Configuration Management, SCM10, 23rd ICSE*, Toronto, Canada, May 2001.
Authors: Annita Persson Dahlqvist, Ivica Crnkovic, Magnus Larsson

Abstract: In this paper we discuss the industry's need of controlling the whole product development process including both hardware and software components. The integration of development processes meets many problems partially because of the different nature of the processes and partially because of the different approaches. A typical example of overlapping processes is Software Configuration Management (SCM) and Product Data Management (PDM). Both SCM and PDM try to solve similar problems but in different ways. To get a more efficient development process, the companies try to integrate PDM and SCM systems, which has not yet been very successful. This paper gives a brief overview of common characteristics of SCM and PDM and gives an analysis of a possible integration. An example of an early attempt of integration is depicted. Finally, the paper presents an initiative by the Swedish industry to provide better understanding of SCM and PDM integration problems and to give directions for the possible integrations.

My Contribution: I was the main author of this paper. I contributed with part of section 3 Integration Possibilities, all in section 4 Integration Experiences and all in section 5 Investigation Initiative PDM/SCM. I reviewed and commented the rest of the sections in the paper.

2. *Quality Improvements by Integrating Development Processes*
In *11th Asia-Pacific Software Engineering Conference*, Busan, Korea, November 2004, IEEE

Authors: Annita Persson Dahlqvist, Ivica Crnkovic, Ulf Asklund

Abstract: Software is an increasing and important part of many products and systems. Software, hardware, and system level components have been developed and produced following separate processes. However, in order to improve the quality of the final complex product, requirements and prospects for an automatic integrated process support are called for. Product Data Management (PDM) has focused on hardware products, while Software Configuration Management (SCM) has aimed to support software development. Several attempts to integrate tools from these domains exist, but they all show small visible success. The reason for this is that integration goes far beyond tool issues only. According to our experiences, three main factors play a crucial role for a successful integration: tools and technologies, processes, and people. This paper analyses the main characteristics of PDM and SCM, describes the three integration factors, identifies a model for the integration process, and pin-points the main challenges to achieve a successful integration of hardware and software development. The complexity of the problems is shown through several case studies.

My contribution: I was the main author of this paper. I contributed with all sections (1, 2, 3, 4, and part of 6 Conclusions and Future Work) except the section 5 Integration. I reviewed section 5.

3. *Implementing and Integrating Product Data Management and Software Configuration management*, Artech House Publishers 2003 ISBN: 1-58053-498-8
Authors: Ivica Crnkovic, Ulf Asklund, Annita Persson Dahlqvist

Abstract: Because today's products rely on tight integrated hardware and software components, system and software engineers need to have an understanding of both product data management (PDM) and software configuration management (SCM). This book offers knowledge by: (i) showing how the integration of PDM and SCM can help organizations quickly and efficiently develop new products and efficiently maintain and update existing products, (ii) providing comprehensive coverage of PDM/SCM principles, pointing out the similarities and differences of these two processes, (iii) presenting the immense range of PDM/SCM tools to professionals in the field, and (iv) including in-depth case studies that provide practical knowledge for successful PDM and SCM usage and integration.

My contribution: I was the main author of the PDM analysis, similarities and differences of PDM and SCM, and I did the most of the case studies. I reviewed the rest of the chapters. I will combine the selected parts about similarities and differences of PDM and SCM and case study from Ericsson into the MRTC report, described in 4.

4. *Important Factors for a Successful Integration of Product Data Management and Software Configuration Management Systems*

Authors: Annita Persson Dahlqvist, Ivica Crnkovic, Ulf Asklund

This MRTC report is to be written. It will be a summary from selected parts of the book, *Implementing and Integrating Product Data Management and Software Configuration management*.

Abstract: Since PDM and SCM have been developed in their respective domain solving the domain specific requirements using different technology; on a higher level they seem to be similar in functionality, support and infrastructure. The similarities and differences, however, are found on practical lower levels such as in the product, evolution, and process model. The main characteristics of PDM and SCM are described more in detail. We have found in our investigations, that three factors are important to achieve a successful integration: processes, tools and technology, and people and culture. These three factors are discussed more in detail.

Finally, the report presents two case studies done at SonyEricsson and Industrial and Financial systems. The case studies are focusing on how the companies are using PDM and SCM, their processes, any need for integration between PDM and SCM, and conclusions. The new elements in these cases studies are the starting assumptions that are based on the experiences and findings from the pervious case studies.

My Contribution: I was the main author of this report. I contributed with main characteristics of PDM and SCM, similarities and differences, processes and one of the case studies, and specified and classified the interview questions.

4 Contributions

4.1 Research Questions

The two research questions are:

- (Q1) What are the similarities and differences between PDM and SCM?
- (Q2) Can integration between PDM and SCM lead to a more efficient support during development and maintenance?

In answering (Q1) all similarities and differences are stated (Elaborated in publications 1 and 3):

Similarities:

- Both PDM and SCM have version control management, but in SCM supported with branch and merge facilities. PDM has a simpler version management model.
- Both support change management.
- Both support release management.
- Both support workflow and process management.
- Both manage large amount of data. The formats of data are however different.
- Both PDM and SCM are used during the total product life cycle (of hardware or software)

Differences:

- PDM manages objects represented in an object-relational database, while SCM manages files and directories.
- PDM uses revisions for major changes. SCM uses versions for all changes.
- SCM has branches and supports merge functionality. PDM does not.
- In SCM several people can work on the same file at the same time using the branch facility, which is not possible in PDM.
- Product structure management is a basic functionality and fundamental in PDM while SCM does not support product structures.

- Build management is vital functionality for software products and supported by SCM. Build is in no way supported by PDM.
- Some PDM tools use a standard to a certain degree, some not. There is no standard for SCM tools.
- PDM tools do not support configuration/selection management. SCM is strong on this.
- PDM does not support workspace management. SCM tools are strong in workspace management.
- Metadata and data in PDM can be distributed separately or in a combination. In SCM there is no distinction between the actual data and its metadata. Hence, when data is replicated in SCM all is replicated.

The development of hardware and software products seems on a high level to be very similar. Similar processes are used and the infrastructure and data flow used to manage all information are also similar. The development processes for hardware and software development, although similar, distinguish on a detailed, practical level. From the analysis of basic characteristics of PDM and SCM tools we find that there are similarities in them, but that the underlying concepts and structures are quite different. The conclusion is in comparing SCM and PDM, that SCM tools do not have the necessary functionality to support the development of a complex product during its entire life cycle and that PDM tools do not have sufficient functionality to support software management, particularly during the development phase. However, even though there is much functionality redundancy, SCM tools and PDM tools complement each other.

In (Q2) we ask if integration between PDM and SCM can lead to a more efficient support during development and maintenance. The answer is yes. PDM and SCM have different demand for their users, e.g. a software designer need to be able to work in parallel on a single file, need support for building the system, need to be able to work in isolation but still under the tool control. Hence, PDM is not suitable for system development including software components development. Hardware developers have other requirements on the tool to use compared to software designers. E.g. they need support for product structures, document management, visualization, and collaboration with manufacturing. Since none of these demands are fulfilled in SCM, SCM is not suitable for system development including hardware components development.

For (H2) we have done investigations at different companies, where we have found initiatives in integrating PDM and SCM where none of the integrations are used due to lack of efficient usage. The integrations lack of process support, and were PDM centric. SCM users had not enough PDM knowledge to use these integrations. No one of these integrations is used today. We have also found a social culture [12] difference in PDM and SCM, which e.g. reflects in different terminology, same terminology with different meaning, and PDM and SCM users are often located at different departments increasing the gap of their understanding. Furthermore, since hardware development processes are different from software development processes, integration points of the processes need to be established to achieve a successful integration and test of the final product.

5 Additional Results

Publications

1. *Managing Complex Systems – Challenges for PDM and SCM*, Projects & Profits, IV-7(Rs60):36-42, July 2004, ICFAI Press, Panjagutta, India, Authors: Annita Persson Dahlqvist, Ivica Crnkovic, Magnus Larsson
2. *Complex Systems Development Requirements - PDM and SCM Integration*, IEEE Asia-Pacific Conference on Quality Software, IEEE, 2001.
Authors: Crnkovic I., Persson-Dahlqvist A., and Svensson D

3. *Product Data Management and Software Configuration Management - Similarities and Differences*”, The Association of Swedish Engineering Industries, V040096, 2001.
Authors: U. Asklund, I. Crnkovic, A. Hedin, M. Larsson, A. Persson Dahlqvist, J. Ranby, and D. Svensson
4. *Experiences of Customization and Introduction of a CM Tool*, Software Configuration Management SCM5, Seattle, USA, ICSE 1995

Other activities related to the research:

Co-Organisation of the following events

- Program co-chair, SCM-12 symposium, and co-located event to ESEC/FSE Lisbon, Portugal, 2005. September
- *Konfigurationshantering (Configuration Management)*, The Association of Swedish Engineering Industries, V040047, 1996, Co-organisation
- *Distribuerad utveckling och Configuration Management för programvarusystem (Distributed Development and Configuration Management)*, The Association of Swedish Engineering Industries, V040073, 1999, Co-organisation
- *Product Data Management and Software Configuration Management - Similarities and Differences*”, The Association of Swedish Engineering Industries, V040096, 2001, Co-organisation

Attendance in program committees:

1. Member of the program committee for SCM workshops, 1997 – 1999, 2001, 2003, and 2005. Session chairman for the industrial session 1997, 1998, 1999, 2003. Conference chair 1998.
2. Organizer and chairman for the SCM 10 workshop in 2005.
3. Member of the program committee for ECBSE 2001 - 2005.
4. Organizer, chairman and presenter for CM seminar (internally at Ericsson). Gothenburg, Sweden 2004, Milan, Italy 2005.
5. Organizer, chairman, and presenter at CM West (internally at Ericsson) 5 conferences. Gothenburg, Sweden 1999 – 2001.

Presentations done at several companies:

1. Presentation on CM and SCM. Volvo IT, Gothenburg, Sweden 1999.
2. Presentation on CM. Volvo Aerotech, Trollhättan, Sweden 2000.

6 Thesis Outline

Following table shows the proposed tale of content.

Section Name	Estimated # of pages	Brief Description of Content
Abstract		
List of Publications		All published papers
Title		Product Data Management and Software Data management Integration
1. Introduction	15	
1.1 Background and Motivation		The background and rationale of research are introduced. Define PDM and SCM. Describe industrial problems.
1.2 Research Questions		State the research questions
1.3 The Research Methodology		State research methods used in this project.
1.4 Research results and contribution		Summarizes the main research contributions
1.5 Outline of the thesis		Briefly description of the thesis layout
2 Survey of the Research Area	15	
2.1 PDM		
2.2 SCM		
2.3 Processes		
2.4 People and Cultural Behaviours		
2.5 Standards		
2.6 Related Work		
3 Papers		
3.1 Paper A	8	<i>Managing Complex Systems – Challenges for PDM and SCM, SCM10</i>
3.2 Paper B	12	<i>Quality Improvements by Integrating Development Processes, APSEC2004</i>
3.3 MRTC Technical Report	30	<i>Important Factors for a Successful Integration of Product Data management and Software Configuration Management Systems</i>
4 Conclusions	4	
5 Future Work	1	
6 References	5	

7 Remaining Work and Time Schedule

The Thesis

To complete the thesis, remaining work is:

- The MRTC Technical Report will be based on the book.
- Write the MRTC Technical report to be included in the thesis.
- Chapter 1: will be based on an extended version of this paper and other material
- Chapter 2: will be based on other material
- Chapter 3: Paper A will be based on published paper on SCM10. Paper B will be based on published paper on APSEC 2004. The Technical report will be based on the book.
- Chapter 4: need to be written but will be based on other material
- Chapter 5: need to be written

Time Schedule

Following shows the time schedule for the thesis:

- 1st of April MRTC Technical Report ready
- 15th of April Draft Licentiate Thesis – find an opponent
- 29th of April Licentiate registered and opponent ready
- 25th of May Licentiate thesis camera-ready
- 15th of June Licentiate thesis defence

8 Future Work

Is it possible to do a generic integration concept for PDM and SCM? I will continue my work to find an answer on this question by close cooperation with some tool vendors, and research groups. One major PDM vendor has already asked for cooperation, suggestions, and presentations on the integration issue.

I will continue my work on how to integrate commercial tools in practice. Within Ericsson a project recently started with the aim to integrate commercial PDM and SCM tools. I will be part of this work.

9 References

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