INTERNATIONAL DESIGN CONFERENCE - DESIGN 2006
Dubrovnik - Croatia, May 15 - 18, 2006.

DESIGN 2006

POSSIBLE EXPLANATIONS TO THE LIMITED USE OF PRODUCT PLATFORMS IN INDUSTRY

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Keywords: product platforms, modular product architecture, product family

1. Introduction

Extensive research activities have been aimed at describing the nature and contents of product platforms and modular product architectures. The interest in this research area is driven forward by the globalisation of competition among manufacturing firms and the ever increasing demand for highly customised products at low costs. Most researchers agree that modular product architectures and platforms can help companies utilise their resources to a much a more effective and efficient level, by making a split between those parts of the product and organisation that are generic and those that are specific to discrete products. Postponement of differentiation in the supply chain and a more lean engineering, production and sales performance are all benefits of platforms and modular designs.

The reason behind all this focus on product platforms is that "traditional" companies carry a large burden of complexity and inflexibility that keep them from releasing their full business potential. Globalisation has created a complex world inside and outside of companies and the lack of methods and tools to control the content and growth of this increasing complexity, creates a waste of resources such as time, material, engineering capacity, production capacity and thus off course money. Many product portfolios have grown over time without design templates and rules and consequently, sub-optimisation and old cost estimation models have driven the complexity to unprecedented heights. Almost any article or paper within this research area starts with an introduction much like the one you have just read. It will draw the attention of the reader to the possibilities in platform based development, the use of product architectures and the benefits a company may obtain from having a platform based strategy for the business and for the products.

However, little research seems to have been actually applied in companies, and the problems that initially drove some companies into the use of modular designs and platforms, remain to exist for many other companies. We have yet to see a wide and common application of the notion of product platforms in industry. The best cases are still those developed in industry for industry, driven by a concrete problem in a product line or production and not solely by researchers in academic communities.

This paper will discuss a widening of the focus of much of the ongoing research with an emphasis on product platform modelling and relate the lack of such a model to the lack of implementation. The discussions and conclusions are based on a review of present literature within the area and experience obtained from consultancy work in several Nordic companies ranging from large corporations to small and medium sized companies. The experience is gathered from the work of the Product Architecture Group at the Technical University of Denmark.

2. Why are platforms not used more frequently in industry?

We argue that the absence of a comprehensive and widely applicable platform modelling method is an issue of great importance. Those design methods, optimisation algorithms and tools that do exist are often made by engineering researchers or engineers with the intention to be used and understood by engineers. Also, most concrete platform representations and design methods are product based, yet the most important parts of a platform system seems to be much more than the physical products. We do need to be able to hold information about design rules, responsibilities and ownership of design changes, acceptable possibilities in configuration and sales etc. Those aspects are not designed or even thought of when e.g. a modular design is optimised using a commonality index calculated from product related properties only. Product focused methods and modelling tools do not encompass the whole business and the whole organisation. Top management, sales personnel, marketing, and several other departments have to be involved in decisions regarding the platform throughout its life phases from design through use and "disposal" of the platform. That is true with all types of products and even more so in the case of platform based products, since it is often very costly and risky for the whole business unit and/or company to establish a platform and thus essential to do the right things and do things right. Companies are in need of a concrete model of a product platform that can represent and help *all* stakeholders in the process of developing, maintaining and using a product platform. Not only technical demands for a platform but also cognitive demands must thus be addressed when working with platforms and this area is largely neglected in the present research.
Lastly, the lack of research on how to implement the tools and methods described in literature is a problem. The gap between theoretical research communities and the ever changing reality in industry seems to be profound. Compared to the relatively large body of research in developing methods and tools, efforts spent on the actual *implementation* of them, seems to be sparse.
We do not yet have a well established solution to these problems and that is one of the most predominant reasons for the sparse implementation of platforms in industry.

3. Current literature

3.1 Engineering and management research

Research in the area of product platforms and modular architectures are performed mostly from either an engineering or management oriented perspective.
The engineering perspective is based in design engineering and manufacturing and industrial engineering research. Contributions from those areas address the subject of platforms and architectures from a system point of view. By describing the content and nature of either a product (or a family of products) or a manufacturing system, models, tools and procedures are derived in order to optimise designs. That is both optimisation procedures and synthesis procedures. Two reviews are given by [Simpson, 2004] and [Gershenson et. al., 2003] the first with a focus on platforms and customisation, the latter more on modularisation. [Kristjansson, 2004] provides a review of platform definitions from different authors.
Numerous definitions and explanations of product platforms and modular architectures can be found in literature and there are several streams of literature in which large bodies of research have similar origins.
The modelling and documentation techniques and notations are focused on technical and functional matters mostly on a form that is targeted solely on people with an engineering or technical background. Engineering design research papers tend to focus on a limited part of the whole platform aspect and often relates to solutions on a detailed level, e.g. how to optimize a modular product design from the basis of functional requirements. But many of the function and product based methods only optimise such aspects as the number of modules or interfaces. In other words these methods optimise the product from a product perspective. Alternative manufacturing, service, marketing or sales strategies are not covered in such design and optimisation methods.
It has to be stated that some of these researchers are trying to understand the nature of product architectures and the scope of their research has not been to explain the whole business chain. It is

unfair to say that the research is incomplete, but fair to say that the focus of much of this research has had too much of a product related focus.
On the other hand, management and business oriented papers and articles, are usually less concrete and contains fewer product models than the engineering design research papers and books [Meyer & Lehnerd, 1997], [Baldwin & Clark, 1997], [Sanchez, 2004], [Feitzinger & Lee, 1997]. They encompass a larger discussion of aspects and cover more than just the product itself. But, because of the not very concrete models, they are more useful for mindsets than for actual working procedures and tools. Yet these references do provide excellent mindsets for the use of product platforms and describe how they have been applied in industry.
Research and other sources in general from the management business point of view often describes cases from well known companies that have had success from the use of platforms and speak of the platform in a sales or organisational perspective. More strategic issues such as mass customization, the use of customer configuration systems and postponement are dealt with.
In his review, Simpson [Simpson, 2004] speaks of *top-down* and *bottom-up* approaches as the two ways a company can start a platform project, the first being a strategic decision of developing and managing a new family of related products from a common platform. The latter is more like a kind of "cleaning" process in which companies reduce complexity by streamlining one or more existing product line(s) and perform a change in the design so that the products are based on a common core of e.g. technology, design solutions, components and/or manufacturing processes. The platforms derived from these two approaches, does not have to be different in terms of content, yet one might draw a parallel to the engineering versus management discussion. The engineering methods are mostly cleaning procedures in a bottom up approach whilst management literature speaks of strategic top down approaches.
[Andreasen et. al. 2004] have dealt with the integration of bottom op and top down approaches when speaking of the alignment of architectures in the whole life phase system of the product platform. This idea is the foundation of the discussion that is to follow later in this paper.

3.2 Engineering versus management

In short, one might say that engineering methods are detailed, concrete and useful only for engineers in engineering tasks and mostly focused on the optimisation of existing products. Management research tells a broader version of the platform story and often from a strategic point of view but does not provide companies with operational tools and methods as to how they should develop or document a platform.
Yet, nowhere to be found in literature is a ready to use set of methodologies and languages in which to model, design, document and use a platform, suitable for a multitude of *different* stakeholders. There is no model in which both product-related and management-related aspects can be held.

4. Terminology used in this paper

4.1 Definitions of platform and architecture

Since there is no common understanding of the exact meaning of the words product platform and product architecture, it is necessary to state the meaning of the words in this paper. It is not the intention to come up with yet another definition but in order to make the first initial attempts to have a widely applicable platform model we need to rethink the concept of product platforms and product architectures.
[Kristjansson, 2004] lists several of the most cited definitions of platforms. Most of these speak of modules, interfaces, shared properties, shared assets and core technologies. One of these definitions (from McGrath, 2001) is very interesting in relation to the discussion of application of platforms:
A platform is a collection of common elements particularly the underlying technology elements, implemented across a range of products. An important comment is added to this idea of a platform, namely that the platform *is primarily a definition for planning, decision making and strategic thinking.*
The use of the platform will result in a variety of products in the market from a customer perspective and a common core of technologies, product constituents such as parts (machine elements) and

subsystems, production processes and procedures throughout the company from an internal company perspective. From the platform *discrete* or *derivative* products are thus developed. Discrete products are products that comply with the rules of the platform system and they form what is often referred to as a product family. In this paper we see the platform as a system of procedures and documented designs. The procedures encompass design rules as well as organisational matters and in particular responsibilities regarding the different design elements of the product and production system. These organisational rules are introduced in order to ensure that change management takes place in accordance with the overall strategy of the company. Many companies that do not have such procedures suffer from sub-optimisation. The term architecture is used to describe the documentation of the product family, the standardised designs within the family, the interfaces between these. Thus, the architecture has to do with the way the products look, and the platform is the system used to develop the products.
From this and from many other definitions of a platform, several questions emerge. Those are questions that are not described in totality in any of the present research contributions. They are questions regarding the nature of the platform model and the media in which the company will document and use the platform model;
(1) What will a model of such a system look like – is it a computer model, a repository of reports and standards, a database, a CAD system? (2) What are the demands for the underlying model in order to ensure that it can actually represent all the very different aspects of a platform into one united system? In other words how can we ensure that all the stakeholders can use the model? (3) Is it even realistic to make such a model? Today we have PDM systems, CAD systems, marketing information systems and so on and most of these are not well integrated if integrated at all. Is it crucial to unite these into one system and how does a widely applicable platform model fit such different existing systems?
The *product architecture* is often used to denote the rules regarding the products in a product family. [Ulrich, 1993] is probably the mostly used definition of the term, defining the product architecture as *the arrangement of functional elements, the mapping from functional elements to physical components* and *the specification of the interfaces among interacting physical components*.
Some research also speaks of an architecture that describes the manufacturing systems and processes. In this paper we will use the word *Product Architecture* to denote the design rules of the product (function, structure, product model, interface description), and the word *Process Architecture* to denote the rules of the production system.
The product and process architectures have to be aligned, which means that the features and parameters of the products have to have a fit to the production equipment [Andreasen et. al, 2004], e.g. that the product architecture will ensure that the product design can be produced within the limits of the present production system.

4.2 The architecture and platform as a parametric template for design

There is one important comment to add to the above discussion of platforms and architectures. We do not see platform based development only as an activity in which a combination of existing physical modules or standard designs, say a kind of configuration, takes place. The platform can also be seen as a parametric template for design in which design engineers or even customers can change *parameters* of possible designs within an acceptable solution space, once the platform is ready. This idea somehow contributes to the notion of product architectures. Parametric CAD systems provide companies with an excellent opportunity to make platforms parametric and expand the platform based design process so that is not just a combination of ready-made subsystems. Instead it is a task of designing parts and systems within the limits of the platform. [Johanneson & Claesson, 2005] have done extensive and interesting work on this issue.

4.3 Terminology and ontology versus modelling

The scope of this paper is not to discuss the terminology itself, nor to present an ontology. The scope is to discuss the necessary elements of research and therefore also the receivers of that research. The potential users of a platform system in the different life phases will have to have influence on how the research is focused. Therefore a platform will have to accommodate how these users will "see" such a

system. When trying to set up the foundation for platform model it is also crucial to think of potential users throughout the life phases of such a model.

5. The platform model

5.1 The life phases of a platform

In order to reflect on the situations in which a platform model is to be used, a discussion of the life phases of the platform itself might be beneficial. Like products, platforms have several life phases, yet these life phases are not the same as the derivative products of the platform or traditionally developed "single" products, see figure 1.

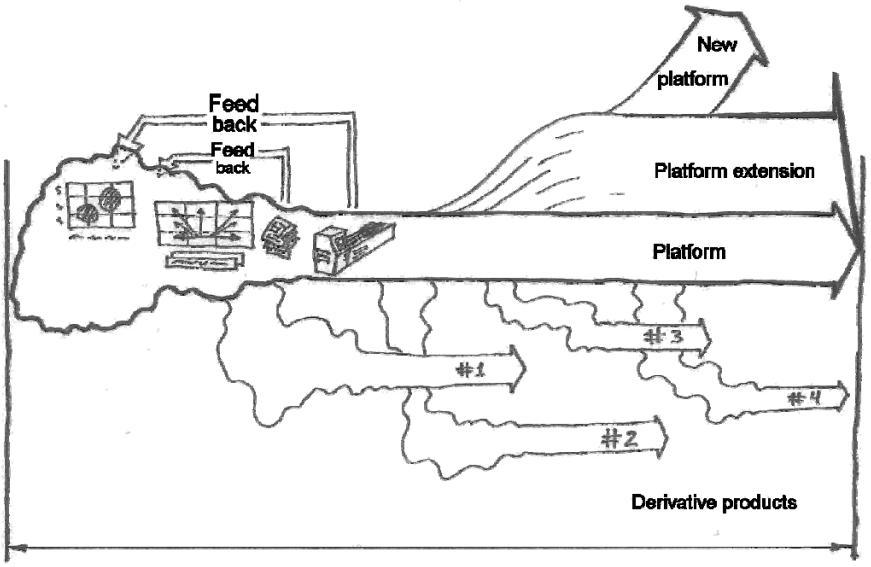

Figure 1. The life phases of a platform

The platform exists before the discrete products (at least in the top-down approach) and several product generations are likely to die out before the platform itself is taken out of use. In the beginning of a platform project, marketing research and related activities are followed by conceptual development and the work with the product and process architectures. From this work an iterative process is started in order to end up with the final platform design. Rather than seeing the platform life phases as sequential phases one can see the life phases as activities that happen in an iterative an ongoing process. In both bottom up and top down approaches, the company will have to establish an explicit overview of markets, customers and the possible functionalities of products. In this part of the work marketing and sales personnel play an important role.

From this overview the project team can separate generic and variable properties. This work has to be done as an iterative process by employees engaged in development, marketing and production. The product architecture and process architecture will be developed and feed back loops performed in order to streamline customer needs with product properties and production capabilities, in figure 1 shown as feed back loops from process and product architectures to the initial overviews of markets and customers. From this the first generation of derivative products can be made, primarily with engineering departments. In the following phases when new product generations and alterations are developed, another very important task will emerge: Maintenance and governance of the platform. Someone will have to be in charge of the platform on a high level and others on a more detailed discrete level. If there are no rules and no one in charge of those rules, then – over time – the

complexity of the product portfolio is likely to rise. This is a clear conclusion from what we have seen in industry. The lack of rules governing the use and maintenance of platforms is absolutely crucial.
Platform extensions may be made, and then agreement from top management would then be compulsory. If possible even new platforms can be developed, not necessarily from the basis of the initial platform but potentially from emerging market trends. Finally the platform is "killed" once the market becomes mature and sales have declined enough to make that particular product range outdated. Then the company will have to decide on how to service their customers in the future, how to provide them with alternatives or perhaps not to do so.
The traditional life phases of a product also applies for derivative platform based products yet the planning, conceptual design, embodiment design, and production establishment is done more or less once and for all when the platform is planned and the product and process architectures are developed. Later stages of product life such as distribution, installation, use, service, disposal, and recycling can be different and affected by the platform in different ways that will not be discussed further in this paper.

5.2 The users of a platform model

A comprehensive platform model will be used by many different stakeholders inside and perhaps even outside the company. Sub-suppliers and customers may somehow have to have access to the platform model throughout the whole life of the platform as shown in figure 1. In figure 2 these users are shown.

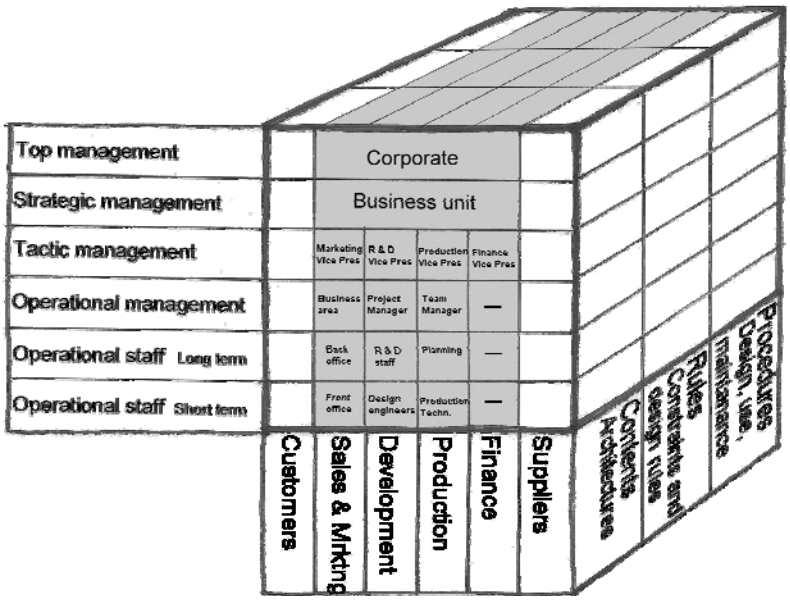

Figure 2. The users of platform model and the dimensions in which they will have to work

Figure 2 has three dimensions: Organisational level, Functional Area and Content of the model. In each functional department (e.g. development or production) employees on different hierarchical levels will have to address different questions regarding the contents, the rules of use and the rules of design. Throughout the life phases the model will have to support the activities listed in the previous section (5.1). Each functional department in the company will perform tasks and make decisions on different organisational levels, as predicted by the vertical organisational and the horizontal departmental axes. Each task and decision will have to do with any of the three aspects and the "third" dimension i.e. the contents of the platform, the rules of the platform contents and the rules of the use of platform. Two of the "departments" are not company internal, as they represent the rest of the

supply chain before and after the company, in other words customers and suppliers. Whether customers and suppliers will have access to a platform model is depending on the actual business and strategy of the company, but the company will have to communicate the platform in both directions and why not think of customers and suppliers as very important stakeholders. A problem that we see in some companies is the fact that they do have a platform-like setup in their organisation but no one have told the customers, so they keep asking for products "outside" the limits of the platform. An important part of such a model is thus the *communication* of the platform towards customers as well as all the other stakeholders.

5.3 The layers in a platform modelling system

Many layers are needed in the platform model to accommodate the different stakeholders. Engineers have another language of communication than those of the marketing people. Therefore, the model needs to support the different perceptions of a platform and yet unite the efforts of those using the platform. The model has to contain some sort of **market representation** and hold information about the decisions taken. It is perhaps the most important part of a platform model, namely the answers to the two questions; *what do we do* and *why do we do it*? That will keep the platform projects on track and help avoid numerous discussions and chances in the course of the business activities. A **functional view** or engineering view is needed in order to discuss how to accommodate the needs of customers along with a view containing the means to those functions, probably a **CAD representation** with information on **geometries** and **parameters** and the constraints among elements. Today's CAD systems have little integration with PDM and ERP systems. The Bill of Material and the structure of products will have to be determined by the architecture. These constraints might also be maintained in standards and have their own **rules** view. Moreover, and very important, the model has to contain clear **rules on the use** of the platform. Who is entitled to change geometry, a production process or to close a derivative product and tell the customer that it will no longer be produced? A **data view** is probably also needed in order to host the data for bills of materials, production processes and so on.

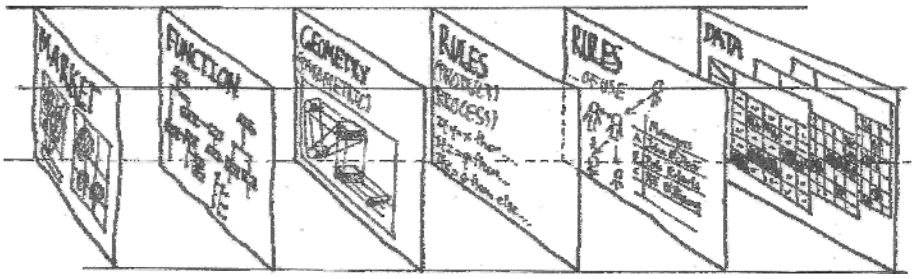

Figure 3. The possible layers of a platform model as a function of the users from figure 2

These different views are all necessary representations that such a model and subsequently IT system will have to contain in order full fill the needs addresses in the former discussion of narrow research focus. In order to secure engagement from a wide variety of employees the tool used to develop products will have to accommodate the needs and habits of such relatively different employees as marketing personnel and engineers.

6. Conclusions

We need to better understanding that the core of a platform is not only the products, the technologies and the functions but all the activities "surrounding" the products as well. It is also the procedures with which we choose target markets and customers, the procedures with which we design the product families, the procedures to maintain and use the platform. Having accepted that, we then need to support the decision making in design, maintenance and reuse of platforms by developing a comprehensive model for platforms that can be used and understood not only by engineers but a whole range of important stakeholders within and outside the company from top management to the design

engineers that play an operative role in the use of the platform in their everyday working life. Such a model is nowhere to be found within the research communities and there is no joint research going on to solve the totality of the problem.
The organisational implications of a platform is dealt with in management research but there are no tools to support the links between engineering decision making and the strategic decisions of higher level management. Much research has had the scope to optimise platform and modular designs through the use of product related metrics and mathematical optimisation tools. Why not broaden the scope of these tools and try to support industry with a model that combines strategic decision making with product related problems more thoroughly than today's models? Present methods do not fully support these activities and do not provide a concrete and ready to use palette of tools.
That is probably one the most important reasons why so many companies still have yet to explore the benefits of product platforms.

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