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PLATFORMS AND ARCHITECTURES

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Abstract

This paper discusses the use and usage of the concepts of platforms and architectures. We provide some clarification about the relationship between platform and product architectures. Our on-going research support the understanding that the term 'platform' is used differently by different firms. This is also reflected in part of the academic literature. There is, however, only a small number of contributions focusing on configuring the "differences" when firms are implementing and managing platforms. In bringing theoretical and empirical research a step closer, we propose a dynamic research set up, which includes the following research activities: literature review, case studies, and action research. The paper also identifies some of the key factors for platform management in terms of a platform template.

1 Introduction

The two words – platform and architecture - in the title of this paper are often used synonymously or without clarification. This creates problems both for academia and in particular for industry. In academia the lack of clarification leaves certain important theoretical questions unsolved and the variation in research methodologies, research background, and applied terminology result in lack of qualitative accumulation of research findings.

In industry the lack of clarification leads to both ambiguous and redundant goals, tools, and methods in handling and managing platform development. The differences in academia reflect the views of the different organizational groups in industry. This raises an important question: *Is a platform basically an extended architecture?*

In the following we shall argue that the two terms have different meanings. They are close related but are different both in theoretical and practical sense. Our primary focus will be the practical industrial application of platforms and architectures but we will initially focus on the underlying theoretical problems and shortly discuss the practical implications in the final concluding part of the paper.

2 Framing the Theoretical Problem

The study of platforms and architectures is a multidisciplinary research area. Overall it can be divided into an engineering and a business perspective – underlying there are a great number of sub-disciplines. The many sub-disciplines have different foci, different research paradigms, and have developed different vocabulary. The engineering perspective is basically derived from a mechanical engineering tradition. It emphasizes the thinking in architectures due to the need for visualization of product structures and associated functionality. An important part of the architecture is the modularity aspect. In the engineering literature it is recognized that the architecture emerge during concept and product development. Until now there has been limited number of strong methods to handle architectures.

The business perspective takes naturally a broader view of the company including marketing, organization, supply chain, etc. The contributors within the business perspective have adopted the architectural thinking and operate with product architectures, knowledge architectures [Sanchez 1999], supply chain architectures [Fine 1998], etc. Modularity likewise plays an important role in a marketing and product planning perspective. In most business literature the existence of architectures are taken for granted. Both the engineering and the business disciplines incorporate the architectural way of thinking. In both disciplines there is a strong focus on the degree of modularity due to the many potential advantages in product development, operations, and strategic planning. These advantaged are, however, rarely realized only with one product architecture. They are mostly realized in the interplay between a number of architectures including product and various supply chain architectures.

In coping with this more complex interplay between architectures we need systematic concepts. In much literature and in many companies the concept of platform has become prevalent as a way to document and communicate this more complex whole. However, in order to have strong tools and methods we need to distinguish sharply between architectures and platforms.

When we explore this way of thinking to the best known and the most often cited platform – the A-platform of Volkswagen – we often view the platform as the physical and structural unit including the suspension, rear axel, brakes, engine, gearbox, etc. However, it might be relevant to remember the painted picture of a pipe by the Belgian painter, René Magritte. Magritte named the picture "Cesi n´est pas une pipe" – it is not a pipe it is a model of a pipe!

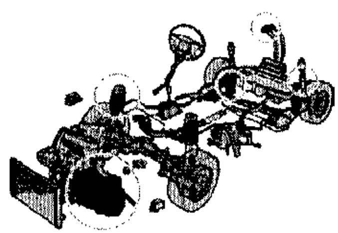

Figure 1. This is not a platform!

The physical representation of the Volkswagen A-platform is not a platform. It is a rather simple visual representation of a number of architectures. Furthermore, we miss the most important issue: the associated supply chain architectures or at least their interfaces to the product architectures. These architectures and their interfaces are the explanation for the specific physical form, and most important, are the reason why Volkswagen can gain effects in both product development and their supply chains.

The theoretical problem of this paper is focused on establishing a first version of a so-called platform template. That is different aspects of a platform in the form of options that can be included in a company specific platform. The related theoretical problem is to associate this understanding of a platform to the architecture term and thereby making a sharp distinction between the two terms.

3 Research Set-up

We acknowledge that the theoretical and empirical research have to go in parallel. Due to the lack of theoretical clarification many firms are experimenting with their platform set-up. These experiments are often highly innovative and drive the parallel theoretical research. Our ambition has been to establish a closer relationship between these theoretical and practical activities.

In designing our research set-up we have been inspired by the Extreme Programming methods as applied in software development. Rather than spending a significant amount of resources to generate a fully and comprehensive specification we have identified a meta-structure, termed a platform template. This platform template captures the most important aspects of platforms and serves as a classification structure for the different contributions adding to the knowledge pool.

Our research set-up includes three main types of activities: literature review, case studies in industry, and action research in industry. Between the main types of activities there are a number of mixed types, e.g. conducting workshops in industry. All activities are continuing activities adding to our platform template, as illustrated in Figure 2.

Until now we have conducted more than 20 case studies and participated in 4 action research projects (one finished and three on-going). The later typically covers two to four years of close involvement with firms.

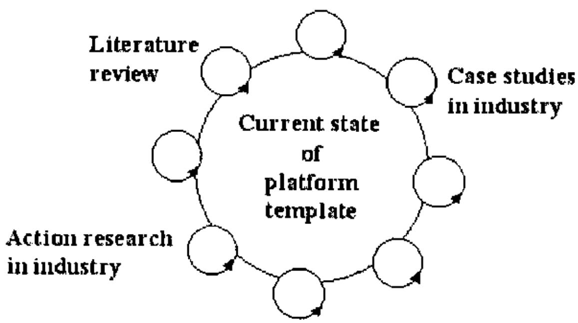

Figure 2 Research set-up

4 Platforms and Architectures

From a practical viewpoint, platforms reflect common sense of prior experience being rediscovered today by management in various industries. For instance, Cisco describes its platform as "… the internetworking operation system (IOS), which is based on open Internet communications and networking standards that Cisco did not define alone" [Cusumano & Gawer 2002, p. 55]. Philips company, on the other hand, uses the term 'standard design' to denote platform, as the term 'platform' has become overused and thereby lost its power. Furthermore is it also difficult to find descriptions of platform methods applied to non-assembled products [Meyer & Dalal 2002]. These examples support the notion of platforms and platform management being company specific.

Table 1 lists several generic definitions of platform.

Table 1. Definitions of Platform.

Terms	Definition	Author(s)
Platforms	• Platforms are components and systems assets shared across a family of products.	Krishnan & Gupta 2001
Product Platform	• A software product platform is both an architecture and an implementation architecture that comprises core subsystems that propel a family of software products or internal corporate applications	Meyer & Seliger 1998
	• Product platform is a collection of shared assets (such as components, processes, knowledge, and people and relationships) that are shared by a set of products.	Robertson & Ulrich 1998
	• Product platform is a set of subsystems and interfaces that form a common structure from which a stream of derivatives products can be efficiently developed and produced.	Meyer & Lehnerd 1997 Meyer & Dalal 2002
	• Product platform is a set of subsystems and interfaces intentionally planned and developed to form a common structure from which a stream of derivative products can be efficiently developed and produced.	Muffatto & Roveda 2000
	• Product platform encompasses the design and components shared by a set of products. A robust platform is the heart of a successful product family, serving as the foundation for a series of closely related products.	Meyer & Utterback 1993

Product platform provides the basis for the product architectures and related product families. Product architecture is the arrangement of functional elements of a product into several physical building blocks, including the mapping of the functional element to physical components (Ulrich & Eppinger 2004). A product family refers to [Farrell & Simpson: p. 541] "a group of related products that share common features, components, and subsystems, and yet satisfy a variety of market niches." The distinction between "platform" and "architecture" is important when deciding on the focus of analysis and design. In order to implement a platform strategy, product architecture strategies have to be devised (Mikkola 2003). According to Simon [1995], a complex system can be divided into hierarchies (consisting of few less complex stable components, each of these of a few even simpler components, and so on) that can be analysed into many independent components having relatively many relations among them, so that the behaviour of each component depends on the behaviour of others. A great number of closed-assembled systems (e.g., automobiles, airplanes, ships, elevators, etc.) are complex systems that can be decomposed into hierarchies (e.g., sub-systems, modules, sub-modules, etc.). All of this can efficiently be captured by architectural methods.

The level above the product variant lies the product family category, defined as "a set of individual products that share common technology and address a related set of market applications [Meyer & Lehnerd 1997, p. 35]. One way of describing the basic relationship between product platform, product family and respective variations of end products is illustrated in Figure 2, adapted from [Mikkola 2003]. For a given product platform, a number of product families [e.g., $f_1, f_2, \ldots, f_k$] can be generated, each with its own unique architecture [e.g., a_1, a_2, ..., a_k]. Based on one product family architecture, many different products are created. For example, family f_1 with product architecture a_1 can produce n products, and family f_2, m products, and so on. For example, the platform for *Audi A4* is the basis for *VW Golf*, the new *Beetle*, and *Bora* product families (or sometimes labelled as brands) [Lung et al. 1999].

This level can be captured by our architectural methods as well. A particular crucial issue on this level is the internal interfaces of the product family architecture [Sanchez 1999].

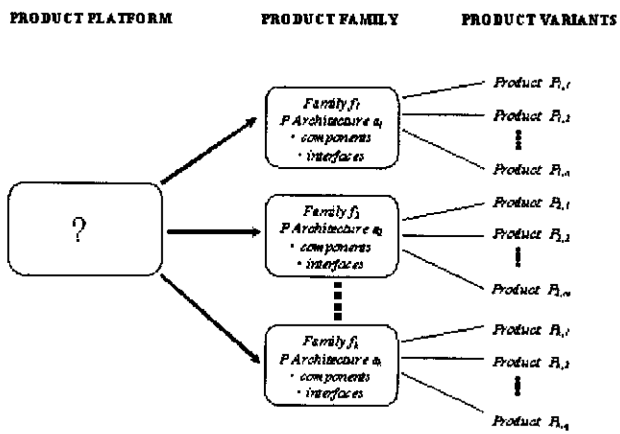

Figure 2. Product platform and product family architectures.

At the highest level of analysis of complex systems, is the product platform. As indicated in figure 2 we anticipate that the platform includes more than an architecture. Based on the literature reviews, the various platform definitions (cf. table 1), and not least our empirical research we propose that it makes sense to view a platform as including a number of interfaced architectures (see Figure 3). The architectures might be product (both structure and technology) or process related – and they might be internal or supplier related.

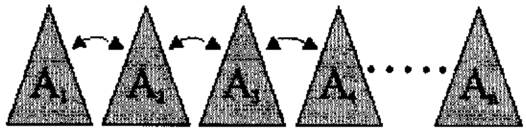

Figure 3. Platform constitutes of a number of architectures

The architectures can be treated as "owned" individually by separate organizational units. This feature ensures that the architectures can be developed and updated separately, and provided the interfaces are kept or updated, the platform will keep its purpose.

Some architectures are owned by the individual company and the company has the full control of the development of the architecture. In other cases the architectures are owned by external suppliers and the company has to adapt to the interface requirements determined by the supplier. This is the case with most specialized process machinery.

To illustrate this distinction between platform, product family, and product we have included a simple example of a LEGO minifigure.

4.1 Illustrative case: LEGO mini figure

The LEGO Mini Figure celebrated its 25th anniversary in 2003. Since its launch in 1978, 3.7 billion Mini Figures have been produced. The Mini Figure is consisted of 9 elements: 2 arms, 2 hands, 2 legs, a head, a torso, and a hip joint (see Figure 4). It can bend the hip, turn the arms, and grasp tools. Originally the figures were only decorated with a happy smiley-like face and the elements were one color.

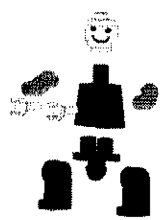

Figure 4 The elements of a LEGO minifigure

Two month after the launch of the first Mini Figure Man in 1978, its first variant appeared as a Mini Figure Woman. Originally the figures were only decorated with a happy smiley-like face and the elements were one color. It was, however, obvious that the figure could be customized; hence the early customizations appeared by means of stickers. The stickers were followed by lasting decoration techniques. Due to the addition of different headgears, possibilities for customization became, in principle, endless. During the 1980s the figures got facial expression and in the late 1990s the figures appeared in licensed products like Star Wars and Harry Potter. Most recently in 2003, the two LEGO Mini Figures, Biff Starling and Sandy Moondust, became the first "man" and "woman" on Mars. The product variant and the product family can easily be described by existing architectural methods.

The LEGO Mini Figure platform does potentially include architectures related to materials, moulding tools, moulding machines, moulding processes, assembly systems, decoration systems, packing, packaging systems, packing, building system, design, marketing, and finally the product family architecture of the mini figure itself. Most of these architectures will potentially be a part of other platforms as well.

5 Platform Management

As explained by Meyer and Dalal [2002: p. 278], platform management is "the integration of the building blocks (the core technologies and processes) with common architectures (the shared subsystems and interfaces), with user requirements aggregated into target market segments towards the end of producing value rich products and systems. Product platform has tremendous implications for a firm's product portfolio management, in which set of technologies and products are evaluated in relation to each other [Mikkola 2001]. How platform is planned and configured, in terms of technology composition contained in the sub-systems and respective interfaces linking these sub-systems, has significant impact on trade-offs between the degree of standardization and customisation of product families and respective end products. The result of that integration should be product families that serve a spectrum of price and performance for one or more market segments." Furthermore, having platform leadership [Cusumano & Gawer 2002] allows a company to drive innovation around a particular platform technology at the broad industry level. Platform leaders, however, face three problems (p. 53):

(1) How to maintain the integrity of the platform (the compatibility with complementary products) in the face of future technological innovation and the independent product strategies of other companies
(2) How to let platforms evolve technologically while maintaining compatibility with past complements; and
(3) How to maintain platform leadership.

In order to implement a platform strategy, product architecture strategies (which can range from modular to integral) have to be devised. The purpose of devising modular product architecture designs is to create flexibility and changeability [Erens & Verhulst 1997]. Product architecture can be defined as the arrangement of the functional elements of a product into several building blocks, including the mapping from functional elements to physical components, and the specification of the interfaces among interacting physical components [Ulrich & Eppinger 2004]. According to Robertson and Ulrich [1998], good product development means good platform development, and in order to do so, a firm must carefully align its differentiation plan and its commonality plan through an iterative planning process. This planning process leverages the trade-offs between distinctiveness and commonality in product architectures. At the heart of platform is the organization of components and interfaces making up the product architecture, and the degree of modularity embedded in the product architectures is dependent on the composition of the components, how these components are linked with one another, and substitutability of unique components [Mikkola & Gassmann 2003].

Some of the main benefits gained from a platform strategy include reduced development and manufacturing costs, reduced development time, reduced systemic complexity, better learning across projects, and improved ability to upgrade products [Muffatto 1999]. Some of the main decision making problems with platforms are related to:

- The ratio of number of models per platform – the trend is to increase the number of models while reducing the number of platforms
- Integration of existing platforms – there is a tendency to integrate home and foreign developed platforms
- Development of new platforms – setting up joint ventures based on developing common platforms is a good indication to the increase in the exchange of know-how between firms
- Cross transfer of platforms between models – platform strategy has an important effect on the international product development and operations management policy of companies.

The different views and definitions of platforms can be collected into a comprehensive structure, which we have decided to name a platform template, described in the next section.

6 Implications and Further Research

Based on the literature review and our on-going research, the following factors are identified as potential elements of a platform template:

- The platform is based on one or more architectures
- It forms a meaningful part of a product or a process
- It includes relevant knowledge at the architectural level
- It serves as a basis for long-term development work
- It serves as a basis for short- and medium-term continuous improvement
- It is based on a partly modular structure (by adopting modular architectures)
- It specifies internal and external interfaces
- It is specific about where to gain effects

These aspects can be seen as a meta-stage for more comprehensive platform architecture. A specific company can make its own definition, and most importantly, define the process by which it defines implements, develops, maintains, and justifies the resulting platforms. Relevance and strategy determine which aspects and to what extent the specific company would include them in their platform approach.

There are strong and proven tools to map the architecture of a given product, process or supply chain. However, platform is not identical to architecture and the tools are not identical. A platform includes one or more architectures; it adds relations and a view of the purpose. Whereas the methods for mapping the architecture are widely described in theory and tested in practical settings, the parallel methods for defining the platforms and specifying the benefits are only emerging. The existence of such methods and theories is a requirement in order to bring the platform thinking from being an interesting philosophy towards becoming a strong managerial tool.

7 Conclusions

This paper discussed the various perspectives of platform management and its implications for product architecture management. Both theoretical and managerial perspectives are discussed. Platform can be analysed at different levels of complexity, depending on the prior experience that is being rediscovered by management in various industries. Furthermore, platform management is firm-specific, so imitation of a platform leader's strategy by a follower firm does not work. The way in which platforms are planned and configured has significant impact on trade-offs between the degree of standardization and customization of product families and respective end product. In order to implement platform strategy, product architecture strategies have to be devised.

References

Cusumano, M.A. & Gawer, A., "The Elements of Platform Leadership", MIT Sloan Management Review, (Spring), pp 51-58, 2002.

Erens F. & Verhulst K., "Architectures for Product Families", Computers in Industry, No. 33, 1997, pp 165-178.

Farrell, R.S. & Simpson, T.W., "Product platform design to improve commonality in custom product,", Journal of Intelligent Manufacturing, Vol. 14, pp 541-556, 2003.

Fine, C.,"Clockspeed – Winning Industry Control in the Age of Temporary Advantage", Little, Brown and Company, 1998

Krishan, V. & Gupta, S., "Appropriateness and Impact of Platform-Based Product Development", Management Science,Vol. 47, No.1, pp 52-68, 2001.

Lung, Y., Salerno, M.S., Zilbovicius, M. & Dias, A.V.C., "Flexibility through modularity: Experimentations with fractal production in Brazil and in Europe," in Y. Lung, J.J. Chararon, T. Fujimoto and D. Raff (Eds.), Coping With Variety – Flexible Productive Systems for Product Variety in the Auto Industry. Ashgate Publishing, pp 224-257, 1999.

Meyer, M.H. & Dalal, D., "Managing platform architectures and manufacturing processes for nonassembled product,", Journal of Product Innovation Management, pp 277-293, 2002.

Meyer, M.H. and Lehnerd, The Power of Product Platforms, The Free Press, New York, 1997.

Meyer, M.H. & Seliger, R., "Product Platforms in Software Development", Sloan Mnagement Review, Fall 1998, pp 61-74

Meyer, M.H. and Utterback, J.M., "The Product Family and the Dynamics of Core Capability", Sloan Management Review, (Spring), pp 29-47, 1993.

Mikkola, J.H., "Portfolio Management of R&D Projects: Implications for Innovation Management", Technovation, Vol. 21, pp 423-435, 2001.

Mikkola, J.H., Modularization in New Product Development: Implications for Product Architectures, Supply Chain Management, and Industry Structure, Copenhagen Business School, Ph.D.-Series 3.2003, 2003.

Muffatto, M., "Introducing a Platform Strategy in Product Development", International Journal of Production Economics, Vol.60-61, pp 145-153, 1999.

Muffatto, M. & Roveda, M., "Developing Product Platforms: Analysis of the Development Process", Technovation, Vol.20, pp 617-630, 2000

Mikkola, J.H. & Gassamann,O., "Managing Modularity of Product Architectures: Toward an Integrated Theory", IEEE Transactions on Engineering Management, Vol.50, No.2, pp 204-218, 2003.

Robertson, D. & Ulrich, K.T., "Planning for Product Platforms", Sloan Management Review, Vol.39, (Summer), pp 19-31, 1998.

Sanchez, R.., "Modular Architectures in the Marketing Process", Journal of Marketing, Vol. 63,1999, pp 92-111

Simon, H., "Near Decomposability and Complexity: How a Mind Resides in a Brain," in Morowitz, H. and Singer, J. (Eds.), The Mind , the Brain, and CAS, SFI Studies in the Science of Complexity, XXII, Addison-Wesley, 1995.

Ulrich, K.T. & Eppinger, S.D., Product Design and Development, McGraw-Hill, New York, 2004.