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Towards a Classification of Architecture Initiatives: Outlining the External Factors

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Abstract
This paper introduced a set of external factors capturing the contextual differences that set the stage for architecture initiatives. These are derived from a systems theoretical approach recognizing the fact that architecture initiatives should respond the challenges posed by the external environment in which the company and the future product program is operating. The outlining of the factors are based on the conviction that no one-fits-all exists, when it comes to architecture initiatives, and the notion that it is impossible to truly evaluate whether an architecture initiative is good or bad, without including the contextual differences. The purpose of the external factors is to improve scoping and goal setting of architecture initiatives, and improve comparability between- and transferability of knowledge from architecture initiatives. The external factors are a first step towards an actual classification of architecture initiatives.

Keywords: Product architecture; product platform; systems theory; contingency factors

Introduction

Challenges

A vast array of new methods and techniques for successful implementation of product architecture initiatives are presented every year in various conferences. The contributions are based on experiences from many different companies and research work. However, due to the fact that product architectures are a complex phenomenon in itself, the findings and discoveries reported from research originating from specific architecture initiatives, can be difficult to transfer from one context to another. And while researchers often neglect to include the contextual differences that set the boundaries and conditions for the architecture initiative, it is difficult for practitioners to adapt towards and benefit from the latest ideas and concepts.

In close relation to these challenges is that the lack of inclusion of contextual differences makes it difficult to evaluate whether an architecture initiative is good or bad. There is no one-fits-all when it comes to the tailoring of architecture initiatives to a specific situation of a company. The lack of inclusion of contextual characteristics simply poses a risk for unsuccessful scoping and goal setting of architecture initiatives eventually leading to underperforming product programs.

This paper addresses this challenge by outlining a set of external factors that capture the most significant contextual differences, as a first step towards an actual classification of architecture initiatives. This is based on the basic hypothesis that proper classification is a prerequisite for improving the maturity of research within product architecture initiatives. Here, the aim is to improve the scoping and goal setting of architecture initiatives, and improve generalizability of research in architecture initiatives as a prerequisite of comparability and transferability.

The external factors are proposed based on the experiences collected from various action-based research studies, which leads towards a later publication of an overall classification.

A systems theory view

In order to address the challenges described above systems theory is applied.

Definition of the system and its boundaries

When developing a new product architecture, is has previously been presented how it is necessary to define the product architecture in close coordination with the market aspects and the production setup. This approach is captured in the DTU framework for architecture initiatives (see Figure 1) [1], [2].

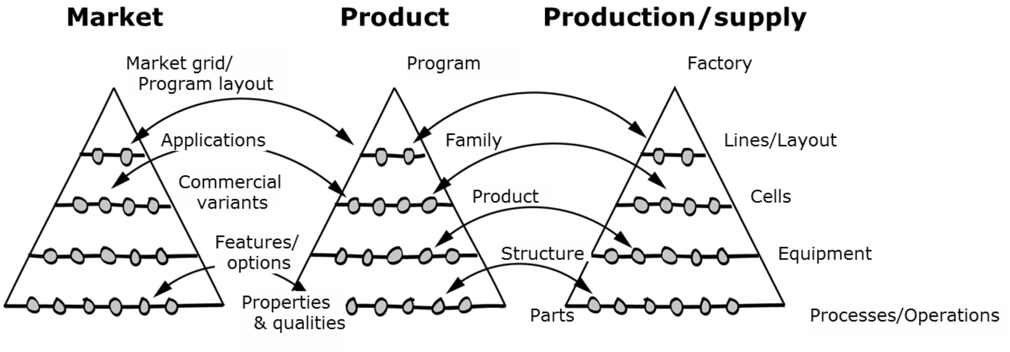

Figure 1 – DTU framework for architecture initiatives

The framework builds upon the classical partitioning of the market, product and production/supply domains [3]. This is most recently presented and described as the market architecture, product architecture and production/supply architecture. The elements described in each pyramid, can be seen as the behavioral and constitutional elements of an architecture that an architecture initiative can change and affect.

In order to separate the architecture initiative from its surroundings, it is necessary to consider the architecture under development as a system. The architecture initiative can change elements *within* the system (the architecture) as a response to the external factors.

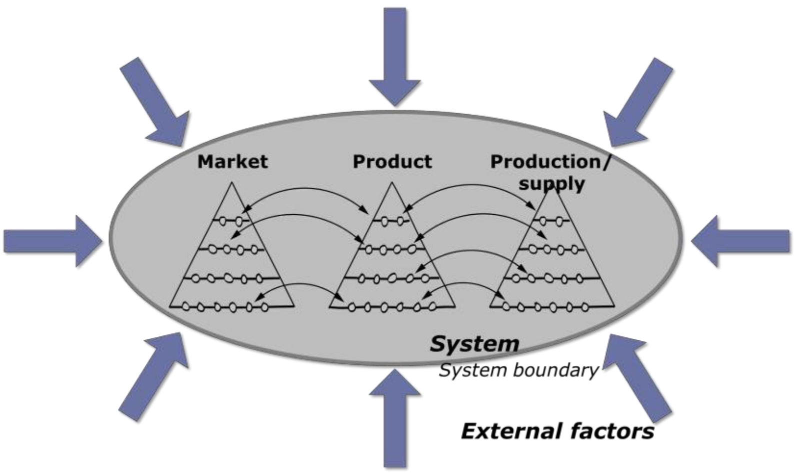

Figure 2 – System, boundary and external factors

Figure 2 shows the architecture as a system. The task of the architecture initiative is to provide a response to the external factors, in order to improve competitiveness of the company where the architecture is developed. The important aspect here is that the external factors provide the conditions for the environment in which the system is performing. Therefore, there are no such "absolute truths" when it comes to architecture initiatives. From contingency theory Galbraith (1973) described this phenomenon years ago [4], stating such design of complex systems, not one single design can be the best in all cases and that the best design depends on the character of the environment, which the system is going to interact with.

This paper will address the challenges above by taking an important first step towards a classification of architecture initiatives. Firstly, the motivation for the classification is described in headlines including small examples; secondly, the external factors are outlined to describe the contextual differences setting the boundary conditions for an architecture initiative; and lastly, a few examples are shown including a short reflection and a conclusion.

Why do we need to classify architecture initiatives?

Motivation

Scoping and goal setting of architecture initiatives
The primary motivation for classifying architecture initiatives, is to improve the scoping *and goal setting* of architecture related initiatives in general. The authors repeatedly experience a mismatch between the definition of the initiative and the situation the initiative should respond to. In other words, often, the concepts and ideas of the architecture initiatives do not match the challenges companies are facing. Therefore, many companies end up in classic pitfalls [1], due to the lack of proper scoping *and goal setting of the architecture initiative eventually leading to architectures that are not appropriately tailored to the situation.*

Improve comparability of initiatives
A secondary motivation for classifying architecture initiatives is the difficulty experienced when comparing different architecture initiatives with each other. Often, attempts to generalize experiences end up in rough simplifications (when the abstraction level gets too high) or alternatively too much "contextual noise" (when the abstraction level is too low). A classification of architecture initiatives should serve to overcome these challenges by providing a common "language" for either making comparison possible, or support and clarify why comparison is not possible.

Improve transferability of experiences
The comparability of initiatives should also serve to improve transferability of experiences between researchers and between the academic societies and industrial practitioners. Many concepts and ideas from academia are more or less randomly dispersed across different industries, often not optimally scoped or tailored to suit the needs of individual companies being in different situations.

State of the art

Adjacent fields of research

External complexity drivers
Bliss (2000) defined three external complexity drivers determining the "market complexity", namely demand-, competitive- and technological complexity [5], and argues that companies must adapt their internal complexity to match these external complexity drivers.

Contingency theory
Zeithaml et al. (1988) formulated a number of principle solutions or responses that can be used to satisfy the requirements of a given competitive environment [6].

Strategy definition
One of the most significant contributions within this area is still Porter's (1980) generic strategies [7]: Market segmentation/focus, cost leadership or product differentiation. However, an appropriately scoped and successful architecture initiative can serve to *combine* these strategies, e.g. enabling differentiation and cost leadership at the same time.

The production task
Skinner (1974) argued decades ago, a blind-spot for most production managers is the attempt to design a production setup that has to compete with an impossible mix of demands [8]. Many additional contributions from Skinner emphasized the strategic definition of the production task as a central aspect of the corporate strategy, and a powerful response to external competition. As the requirements for a production system are dynamic, the production task is not stabile and changes over time

The specification task
Hansen (2003) contributed similarly by describing the need for analyzing and defining the task of the variant specification system [9].

Business structures vs. competitive conditions
Sant (1988) linked typical business structures, competitive conditions and product offerings in relation to the market life-cycle phase of a product program [10]. This was a continuation of Skinner's definition of the production task to include the domain of product development and place this into a business perspective.

Industry life-cycle and game rules
Johnson and Scholes (2008) proposed life-cycle model of an industry and merged this with various business structures to derive a set of basic game rules [11]. The game rules highlight the most important competitive parameters of the different industry life-cycle phases.

Product architecture
Mortensen et al. (2005) argued the need for modeling of *opportunity roadmaps* to capture the need for future changes of features, technologies, standard designs and products [12].

Open innovation
Riitahuhta et al. (2011) defines a Company Strategic Landscape, within which the product structure must be aligned with the value chain structuring, strategy structuring, process and service structuring, and organizational structuring [13].

A life-cycle view
The Design-for-X life-cycle perspective also entails a line of contributions centered on integrating life-cycle knowledge in product development by recognizing the need for e.g. time-to-market focus by corresponding Design for time-to-market methods [14].

Variant management
The German school of variant management provides a vast number of methods and techniques to optimize the design of variance in product families as a response to the external factors from a competitive environment.

Gap
Very few contributions have dealt with the definition of external factors that act as boundary conditions of an architecture initiative. The clear focus on the task definition and the

influencing factors of this seems to be rather isolated to the production domain, and there is a need to implement this thinking in architecture development in order to enable the improvement of scoping, comparability and transferability of architecture initiatives. For example, a large number of contributions focus on modularity as a goal in itself, even though modularity will always remain *a means* to achieve desirable effects in response to the challenges imposed by external factors.

Towards a classification: The external factors

In order to present a classification of architecture initiatives, this paper will propose a set of external factors that the classification has to take into account. The actual classification will be presented in a later publication.

Framework of reference

To be able to capture the complex aspects of architecture initiatives, it is proposed to refer to an architecture framework recently proposed by the authors (see Figure 1). This is in compliance with many of the contributions presented in the previous section thus creating a solid foundation for deriving the set of external factors.

The external market factors

Market launch clock speed

The frequency of market launches has a large impact on the planning of new product introductions. Certain companies are situated in industries with e.g. yearly trade exhibitions that make it necessary to target new product introductions to these. Other companies are operating in industries where continuous product launches and upgrades are expected to keep the attention of the main markets. The market launch clock speed can be determined strictly by external parameters in certain companies, whereas it can be the sole decision of a strong marketing department in other companies. Again, the market launch clock speed has a huge impact on the stability it is possible to implement in the architecture development, as the need for an *evolving and transforming* architecture arises when the clock speed increases.

Marketing channel/supply chain position

The channel of which the products are delivered to the market place is another influencing factor of which architecture initiative to work with. In situations where products are delivered directly to end-users, the architecture should be prepared for a clear differentiation of offerings through *features with positioning properties*.

In other situations sales are carried out through sales subsidiaries to wholesalers, where *range completeness* and a leveled distribution of variants throughout the offerings spectrum can be achieved with *balanced performance steps*. The architecture has to be prepared for that, as this has an impact on e.g. basic technological scaling principle.

Thirdly, other companies sell their products to contractors or technical advisors that focus solely on sales price and minimum required performance. In these cases the *optimal distribution of cost- and price points* and the use of *proven technology* are of fundamental importance.

Lastly, other companies sell their products through public procurement agencies (e.g. medical products) that need a strong *formal justification of incrementally added value*, compared to previous product generations, as formal documentation – often accompanied by passing formal test procedures. In these cases, the product and production architecture is strongly assigned to accomplishing these obligatory properties in order to be part of public tenders etc.

Market positioning
The market share and bargaining power are important factors closely related to the factor of product customization.

If customers are in possession of the bargaining power, the architecture can either only be prepared to a certain level (CTO/ETO), or a strong cost focus must be applied throughout the architecture development. On the other hand, if the company has the bargaining power, the architecture initiative can be focused to maximize feature multiplicity and launch clock speed.

The market share can be equally decisive for the focus of the architecture initiative, as factors as range completeness can be important to maintain a large market share, and as unique differentiation can be important to maintain a niche market share.

The external product and production factors

Primary driver for product positioning
The primary positioning driver of products to be derived from the architecture is of course specific from company to company. However, in general there is often a focus on *sheer performance* or *feature multiplicity* in order to position the products ahead of those of competitors.

A focus on sheer performance sets a number of physical constraints on the architecture, as mechanical compromises can be difficult to match with functional encapsulation and modularization. In most cases, the challenge is here for the architecture to enable the functional and physical encapsulation around the performance critical parts or modules, or isolate the modularization efforts to the production domain. In other cases, the architecture initiative could be centered on defining an integrated but scalable structure of the products, in order to reduce lead time of the development task and production ramp-up.

A focus on feature multiplicity can be ideal as a driver for modularization as part of the architecture initiative, and the focus will be the balancing of feature variety and payment willingness towards incremental production investments and development lead time.

Product customization
The type of product customization is included as an influencing factor. Here, a distinction between whether the market can be served with a *definite solution space* or an *open solution space* is made.

In companies having a definite solution space, pre-defined product variants are developed in discrete instances. These companies are also nominated product-based companies, and the focus of the architecture initiative should be the preparation of multiple planned product launches while minimizing the internal resource consumption.

In companies having an open solution space, configurable product variants are customized. The architecture developed here is focusing on isolating the reusable standard designs from the customer-specific design units, while focusing on preparing the architecture for short development lead times. Here, the challenge of the architecture is to enable a controlled specification of customized products (e.g. with configurators) to guide customers towards similar solutions in order to reduce internal complexity. The solution space can be more or less defined often differentiating between Configure-to-order (CTO) or Engineer-to-order approaches.

Product and production technology clock speed
The frequency of technology renewal has a large impact on the *stability* it is possible to implement in the architecture development. High technology clock speeds often rule out

physical reuse, thus focusing the architectural potential at a higher structural level. For instance are elements on parts and process level not standardized, but product structures and product equipment might be reused across product generations and families. Or, physical reuse can only be obtained by thorough encapsulation (e.g. by isolating functionality completely).

High technology clock speeds can result in very short market life cycles of products or short life cycles of production equipment leaving a small room for architecture initiatives focused on traditional reuse. Also, technology clock speed is a high determinant for the dependency towards technology development centers and external suppliers of key components.

Volume per variant
In continuation of the influencing parameter of product customization, the volume per variant is another parameter differentiating architecture initiatives.

Companies following an ETO approach are developing *one-off* products in some cases. In these situations the architecture initiatives focuses of interface management, decoupling of the development task and a close integration of requirements from the installation and commissioning phase.

Other companies following a CTO approach are often manufacturing a relatively low volume of each variant. In these cases, the architecture initiative cannot pursue benefits from economies of scale between the low volume variants, but the development of a robust production architecture can be another good way of ensuring competitiveness as long as preferred solutions are implemented in configuration systems to control the specification of new variants within the boundaries of the production capabilities.

In high volume production, the architecture initiatives should strive to accomplish the virtues of a traditional mass customization paradigm.

Macro-economic environment
It is necessary to mention the macro-economic environment as well. The interest rate, currency exchange rate, customs duties, logistics costs, market accessibility and legislation, raw material prices all play a huge role for the placement of production sites, sourcing of parts, supply chain design and choice of materials etc. Globalization has made the importance of macro-economic factors even more evident, and most factors remain relatively unstable.

Experiences from application

It is the experience of the authors, that it is immensely important to take the external factors into account while scoping architecture initiatives. The central point here is that different contexts require different solutions. There are no one-fits-all when it comes to the scoping and definition of powerful architecture initiatives, and many parallels can be drawn to the research conducted within the production domain on the definition of the production task. However, these aspects become even more important concerning architecture initiatives, as the product and production architectures share a number of relations. Therefore, it is of fundamental importance to include the external factors and provide a clear definition of the task that the architecture initiative should solve:

- Map the external factors of importance
- Prioritize which factors to take into account
- Concretize and quantify how to address the factors
- Design the architecture initiative to respond to the external factors

The experiences are gained through numerous action-based research studies within primarily Scandinavian industrial companies.

Reflection and further work

This paper is just a beginning. A structured and systematic ongoing work with the factors lies ahead of the authors. In addition to this, the next step of this research is to develop the actual classification of the initiatives. It is the ambition to develop not only a framework, but also a “guide” for researchers and industrial practitioners. A central aspect here is to map the external factors towards a set of generic types of initiatives and outline a set of practical and action-oriented solution recommendations. The understanding of the external factors presented here is seen as a prerequisite of this next step.

Conclusion

The paper has introduced a set of external factors capturing the contextual differences that set the stage for architecture initiatives. These are derived from a systems theoretical approach recognizing the fact that architecture initiatives should respond the challenges posed by the external environment in which the company and the future product program is operating. The purpose of the external factors is to improve scoping and goal setting of architecture initiatives, and improve comparability between- and transferability of knowledge from architecture initiatives. The external factors are a first step towards an actual classification of architecture initiatives.

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