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MULTI PRODUCT DEVELOPMENT: NEW MODELS AND CONCEPTS

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Abstract

Reduction of complexity of operations and applying a global view on company matters seems to be possible by thinking in platforms, architecture and modules, and by designing in a dialogue with product models. Therefore a new situation has appeared recently, namely a radical new way of developing new products, asking for new models, explanations, theories and a new vocabulary. This paper will try to identify the fundamentals of multi product development – the reasons and conditions for new performances – and propose new words and their meaning and relations.

1 Background

In the efforts to survive on international markets companies try to control and manage dynamics, flexibility, precision (Treffsicherheit) and quality. The main means hereto are those, which create agility and leanness in the way companies offers new products to the market place.

A substantial new situation in new product development emerges when we arrange multi product development, i.e. we plan and operate across product families and across time for aligning all operations along the realisation chain of activities. The high-level approach in multi product development seems to consist of:

- Rationalisation based upon re-use and pre-use controlled product variation and focused innovation
- Utilisation of knowledge management in new product development and product management
- Rationalisation of engineering work and operations related to the realisation of new products.

The part of a company's operation, which launches new products to the market, may be seen as complex machinery, which has until now operated in a stop-go manner related to each new development. We want now to operate in a continuous, lean and agile way but this demands for us to redesign the machinery. The redesign is today realised by platforms, architectures and complexity management, all together new concepts. What do they mean? Why do they make the machinery function in a new powerful way?

2 Problematic

The authors are active in the Design Society's special interest group *Product Structuring and Modularisation*, they are active researchers in the areas of platforms, product modelling, and modularisation, and they act as consultants for Nordic industry supporting the organisational and operational turn to multi product development. Based upon observations in industrial practice and review of the huge number of research contributions we see the following problems:

- The fundamental mechanisms behind the positive effects of platforms, architectural modular thinking are not well understood
- There are a high degree of terminology chaos and very few references to underlying theories in the research area
- Industrialists quickly adapt the consultant's buzzwords and jargon, which makes it difficult to really identify the industrial thinking patterns and reasoning.

Our approach
Our goal is to propose a set of concepts and models related to platforms, architecture and modularisation, which we believe, could explain and model central phenomena in the area. This seems to be an impossible or at least superfluous task when we for instance compare to a recent article from Gershenson et al [1] on Product Modularity: Definitions and benefits. The article presents 14 pages of viewpoints and definitions from 79 references, but there are no attempts to relate the different views or to identify the theoretical contributions. So our efforts here may end as reference number 80, trying to define the concepts, unless we find substantial links and theories.

We will show how model-based theories from design methodology, DFX, theory of dispositions, domain theory, and theories on product structuring all together can establish a structure of models, concepts and theories for platforms, architecture, and modularisation. This explanation of course only reflects the engineering design and design organisational aspects of the area.

The limitation of this paper does not allow us to make a closing argumentation, i.e. to confront the many views and definitions in literature and practice with our proposal. There for this paper shall be seen as our first step to be followed up by a more profound publication.

3 What is a platform?

Many references agree that a platform is a sum of assets of a company used for realising the launching of new products. One may say that platform thinking is a management view for making the machinery mentioned above designable and operational based upon company strategies and goals. This is not a new way of reasoning; in the eighties companies were 'spelled' as *core technologies*, in the nineties companies sought for identifying *core competences* or in reality *core integrating competencies*, and efforts were made to align these competencies and to outsource secondary operations.

A platform is an alignment of assets. How can we make a concretisation of this, model a platform, and manage the design and utilisation of platforms? Said in other words: What are the design concepts, characteristics and the mechanisms of the machinery? For answering this we need to define structure and architecture of functional areas of the company, define the alignment of these architectures and to define product architecture.

Life phase systems
Realisation and launching of a new product follows a sequence of activities related to different functional units of the company: Design/Purchasing/Fabrication/Assembly/Distribution/Sales. This sequence may be prolonged into a life cycle model: Installation/Use/Repair/Disposal/Recycling.

The activity in each step may be seen as a meeting, Olesen [2], between the product in different states, a life phase system, and operators (for instance assembly operators). The life phase system is a structure of means and action parameters (Handlungsparameter) chosen for the operation, see the example in Fig. 1.

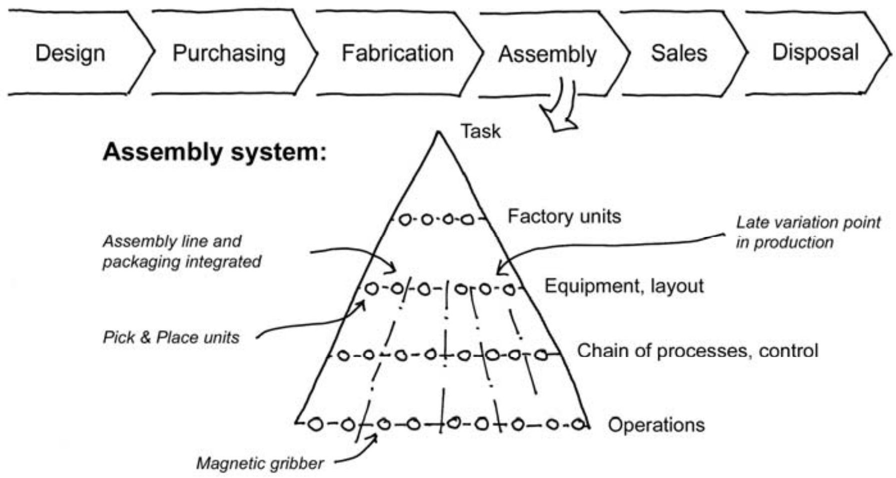

Figure 1: Structural elements and chosen action parameters (Handlungsparameter) for an assembly system, after Olesen [2]

Dispositions

Along the chain of life phase activities we find dispositions, it means decisions taken in one area which influence (dispose) the type and efficiency of the operation in another area. A theory of dispositions was first presented in one of the early symposiums by Olesen, who in his thesis [3] see dispositions as the mechanism behind all DFX areas and efforts. Fig. 2 shows the general model and the fitting of a product structure and an assembly system structure. When we have obtained this fitting an alignment is established for the actual life system architectures. Normally the word architecture is used as a synonym for structure, influenced by American literature, but the authors want to establish a more distinct meaning and difference to the word structure: An architecture is a purposefully aligned structure of a system. Observe that the alignment is mutually as we know from the DFX area: We have to both established DFA and AFD (Assembly for Design), Andreasen and Mortensen [4].

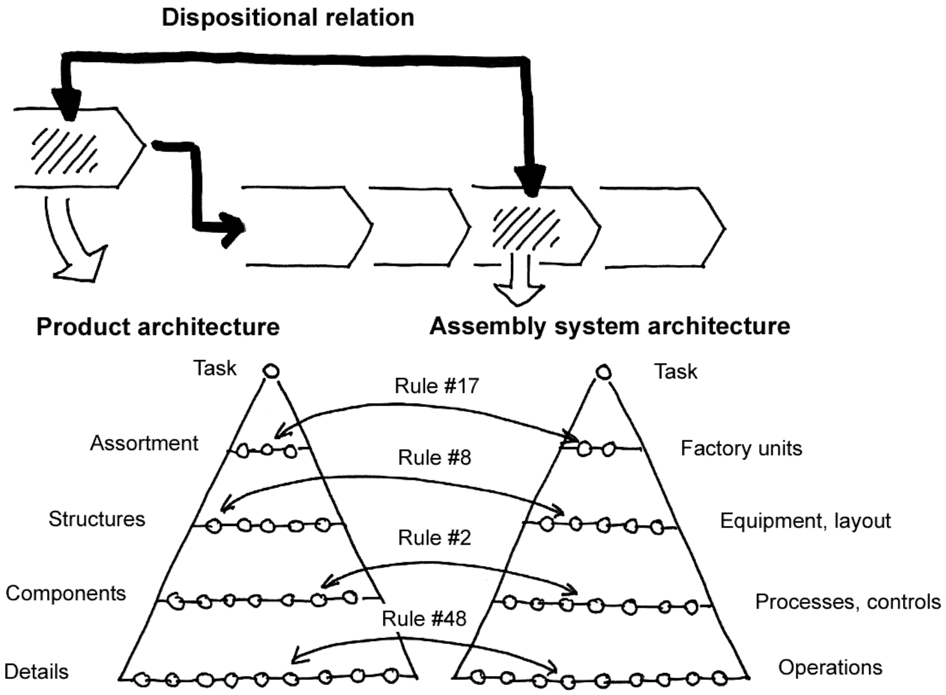

Figure 2: A dispositional relation leads to rule-based alignment

Platform as an alignment of architectures
A platform is an organisational design of the machinery, which creates and launches products. The dispositional alignment of architectures shall not only be seen as alignment of hardware but also as proposed by Nieuwland [5] an alignment of hardware, knowledge and activities. We therefore allow us to create a 3-dimensional model of the architectures and to define that a platform is based upon an alignment concerning hardware, knowledge and activities along the product realisation chain, see Fig. 3.

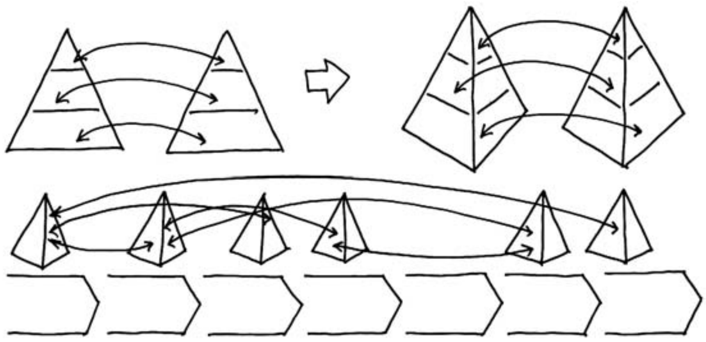

Figure 3: Alignment of product life system in three dimensions following the platform definition of Nieuwland [5]

But a platform is more than alignment
Enhancement of the machinery for new product development in the dimensions of agility and leanness is of course important but more important is the resulting portfolio of products and their competing edge. Seen from the customer's viewpoint are the criteria individualised products, many choices, and precision in functionality and delivery the criteria. The sales department aims at new markets, bigger market share, higher and differentiated prices, precise fit of the portfolio and variants to the market segments and customers, costless individualisation, and quick and safe delivery.

A broad portfolio with many variants put high demands on the organisation because of complexity effects. Therefore the product management and development manager look for re-use and pre-use, scale benefits, focused upgrading, and rational development and realisation.

The product family therefore has to be carefully structured, so that it, as shown in Fig. 4, lead to appropriate variety, show appropriate kinship (commonality), and lead to reduced complexity in operations. Again we may have a hardware view upon the family, or we may see the family as defined and created by hardware, knowledge and activity dimensions.

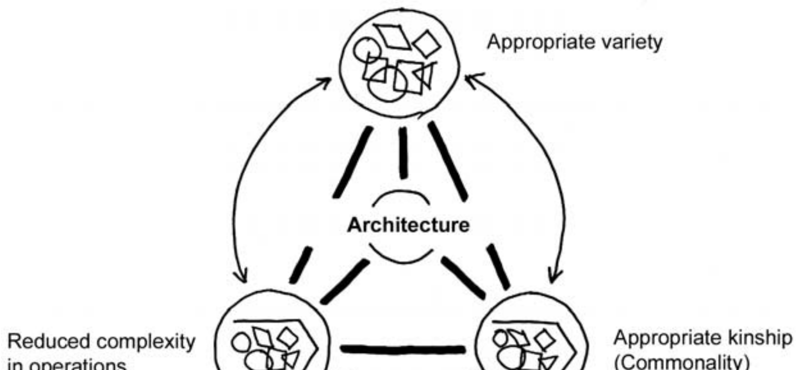

Figure 4: The architecture of a product family seen as these balanced aspects: variety, kinship and complexity effects, Andreasen [6]

Example: The Danish manufacturer of audiovisual products, Bang & Olufsen, does not see their product families as defined by hardware reuse, because of enhancement of the industrial design. So the elements or assets of the family, for instance, knowledge about fitting CD-units into the products or mastering the activity of purchasing CD-units from SONY or Philips.

So a platform is determined by the definition and strengths of the product family, covered by the platform, and the alignment of product life systems. We see this as a preliminary definition of a platform, which will be adjusted when we have taken a closer view upon the alignment and the product family architecture.

4 Platform effects

The platform is carried by several actors, who has to bring each their contribution to the alignment, but also to "harvest the effects" of the platform, i.e. create such operational and financial benefits that the platform becomes liable. This multi-actor aspect and cross-organisational role of the platform makes it a demanding management task to create and utilise platform thinking.

Fig. 5 illustrates once again the alignment, this time along two time axes, the one seen along the development of a product family based upon a platform definition, the other time axis seen as the past and future of each stakeholder's responsibility, namely the enhancement of the product life systems performance, and the harvesting of platform effects.

We may, as mentioned, see each area as a system, and each area has its own strategy, roadmaps for future technology, plans, staffing etc. Each area has an articulated alignment, which we will call *platform preparation,* (the terminology is parallel to the well known production preparation). This preparation follows the disposition roles and the goal in each area is maximising the platform effects.

Example: In some of the products from the Danish toy company, LEGO, the product contains different standardised features for connecting the blocks and figure elements. These standard features lead to tool features, which are repeated in high member. Therefore the features are established as standard form elements, produced for effective production of forms and low establishing and maintaining costs. So the tool department has its platform preparation agenda.

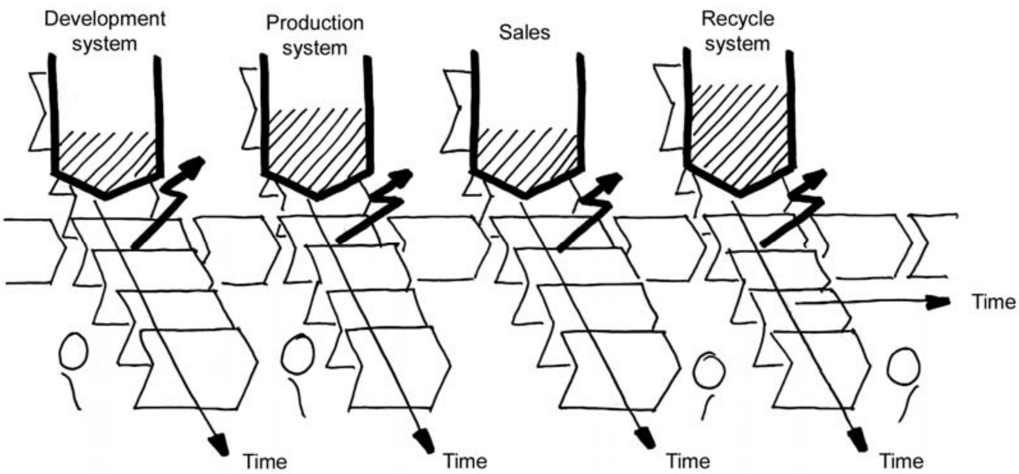

Figure 5: The alignment of product life systems based upon preparation in each life system area, see the text

There exist many types of platforms (hardware, knowledge or activity enhanced) and, depending upon the nature of the business, the products and the services provided, there are many types of alignments and harvesting areas, which may be established. This area needs a closer investigation and mapping.

5 Product architecture

In the German design methodology approach products are seen as systems, and having structure, i.e. the set of elements and their relations. Different system based views may be applied, like elements seen as parts (parts structure, Baustruktur) or as functions (Funktionsstruktur). Andreasen [7] points in his Domain Theory at three important views: *Transformation System*, where the elements are product related activities such as use, *Organ System*, where the elements are organs (Funktionsträger) and their relations are functional (organ logic), and *Parts System* where the elements are machine parts and their relations are assembly relations (interfaces).

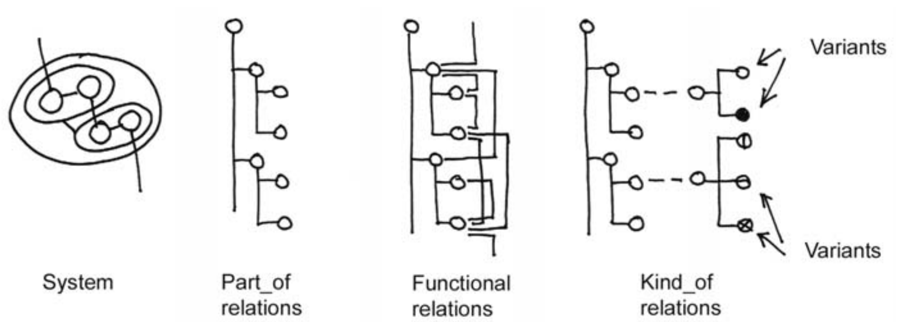

Figure 6: Modelling of a products organ structure

The organ structure may be modelled as shown in Fig. 6 by part of relations, functional relations and kind of relations, where some of the organs have alternative or variant embodiments.

Product modularisation
If we want to understand a products mode of operation we have to read its organ structure. The part structure only explain the assembly relations, but of course these relations and the nature of the parts respect the behind laying organ structure.

All products have a structure, basically in one layer (Fig. 7A), unless we decide to arrange the product as building blocks (humps, chunks, sub assemblies), see Fig 7B.

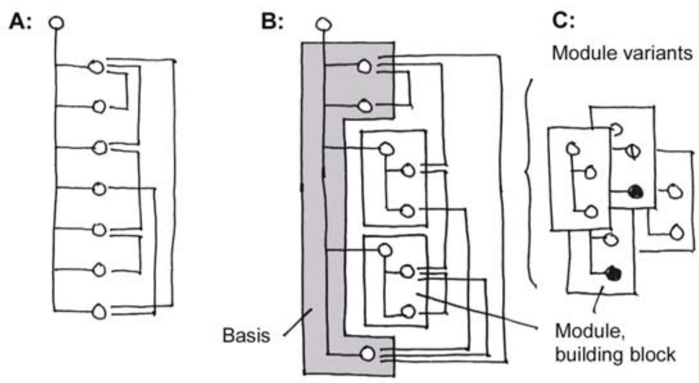

Figure 7: A product’s structure may be transformed into building blocks, having alternatives or variants. What makes this structure a modular one? See the text.

By this operation we may isolate a product basis, and we register the distribution of functional relations between the building blocks and between building blocks and the basis. Each block may have variants, i.e. we may substitute a block with an alternative one, which gives the product the same or different functionality, new features and/or new properties (yield, efficiency etc.), see Fig 7C.

There is a dialectic relation between giving a product a modular structure and making the elements into modules. We cannot define modularity and module independent from each other.

If we want to make the product modular (giving it a modular structure) and create modules (varying building blocks of modular nature) we have to:

* Give the blocks a *specific meaning* or role, which is related to the customer (sales features, individualisation) and/or related to the way we realise the product (production sections or modules, Baukasten System, combinatoric structure etc.). The specific aspects may be:

  - function(s) of the block
  - features or property enhancement
  - building elements in production
  - the block's role as a basis or special supporting, helping, attaching elements

* Make the blocks *relatively independent*, i.e. reduce the types and number of relations between blocks and between blocks and basis. The relations in focus are:

  - functional relations, organ logic
  - flow relations: material, energy, information
  - space relations (arrangement)
  - disturbing relations (emissions, safety, …).

  Of course certain relations are necessary because of the mode of action, but the distributions of these relations may be rearranged, so that simple, easy standardable relations and interfaces are established.

* Utilise that *interchangeable* blocks may be arranged. The interchanging should:

  - maintain the products meaning/role, i.e. other operations than the exchange should not be necessary for the functionality
  - deliver a specific, different enhancement (variety) like a new functionality, new features or new properties.

There are many methods and a rich literature telling how this modularisation shall be arranged for creating appropriate variety, appropriate kinship, and reduced complexity in operation, see [1].

Seen in a time perspective, each block may be the carrier of higher or lower degree of feature enhancement or innovation or be seen as a stable, unenhanced element over time. In certain branches the modules are delivered by suppliers, which have their own interest in creating modules with a wide applicability, utilising the suppliers knowledge and specialisation, and leading to a sound business.

Modularisation is a relative concept
Even if many authors claim, that modules shall have such a delimitation and such interface, that it contains only one independent function, and the interface shall be simple and articulated in strict rules, which the variants shall follow, we see many, many other types of modularisation applied in practice. We see the role of modules vary across the product, from production oriented via feature-oriented to functional modules. And we see complete functional, testable and assembly-ready modules together with modules, which need programming, fitting, adjustment etc. before they can join the product.

For underlining the relativity of the modular concept, we present Fig. 8 showing the space of modularity, where the specific meaning or roles of the modules may vary from none to ideal enhanced functionality, the ideal relations may vary from multirelational, situation dependent relations to relations following articulated rules, and modularisation with variation (module enhancement) which vary from unsharp to sharp, business and customer oriented variation.

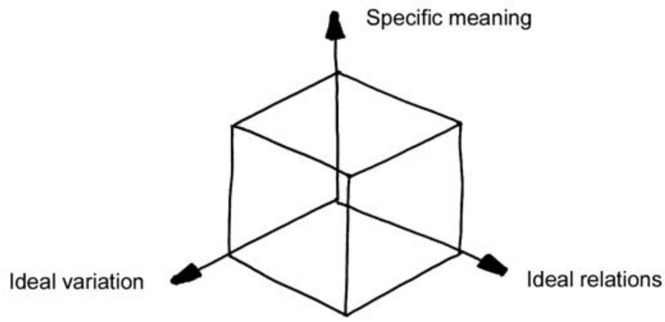

Figure 8: Practical modularisation shows a range of idealisation in this space of meaning, relations and variation.

6 Platforms and modularity

Above we have seen how modularisation can be utilised for giving a family of products the wanted variety and controlled commonality, which leads to market strength and internal rationalisation. But what is the role on modularisation in the platform alignment? Or articulating the question in another way: Where in the modular structure do we find the alignment?

The building blocks of the modular structure are the modules, which may be seen as *encapsulations*, Andreasen [8], i.e. entities that has an importance or significance in the products, but encapsulate the components on lower level, which do not play a role. By this trick we have lowered the complexity, and especially lowered the complexity of the operations related to the product life activity.

Because of this encapsulation it becomes easier to articulate the rules of the architecture and the alignment. Fig. 9 shows an ideal *product family master plan*, Mortensen [9] i.e. a model of a product family showing the structure, relations, modules and variants. In this plan we may articulate the following:

- The rules, which tell about feasible, functional *configurations* of the product. These rules both relates to the relations between modules and the nature of a module master.

- The rules, which tells how to create *commonality* and *variety*. These rules also relates to the module masters.

- The rules for *dispositions* in relation to other architectures, leading to *alignment*.

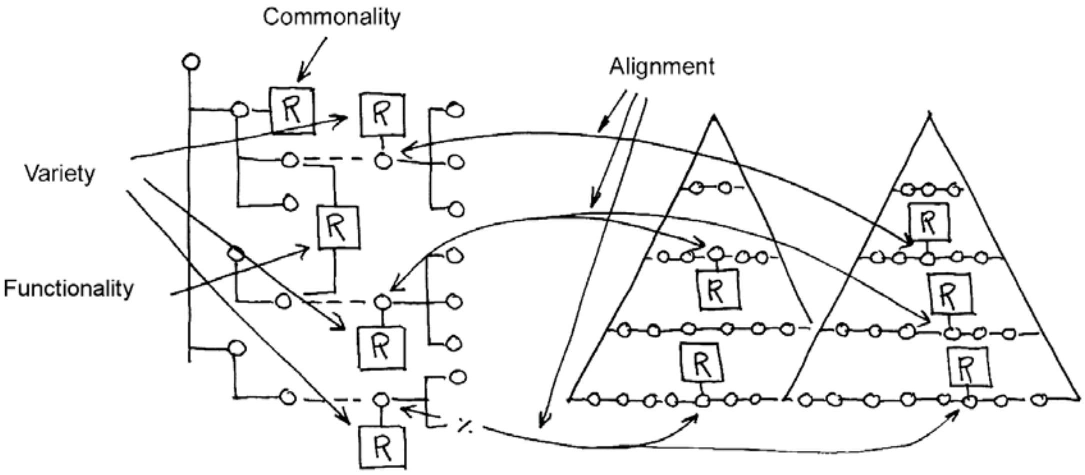

Figure 9: The architecture of a product family, called a product family master plan, Mortensen [9], carrying rules for configuration, commonality, variety, and the aligning dispositions.

It seems a paradox, that modules at the same time may carry variety and commonality. The explanation is, that we see the variety between module A and B when we compare them to each other, while the question about commonality depends upon viewpoint: A and B may be identical (show commonality) seen from the purchasing system because the routines are the same, or seen from the assembly machines, because the variation only rely upon colour and text, see Fig. 10.

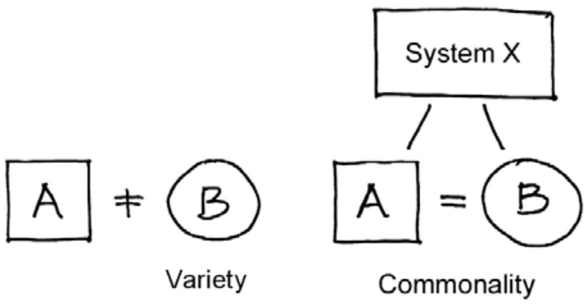

Figure 10: The paradox of variety and commonality at the same time, see the text

7 Explaining platforms, architecture and modularisation

In Fig. 11 we try to summe up the product platform mechanisms, models and concepts, linked together by the following statements. A product platform may be seen as

- An architectural definition of a product family, in form of a product family master plan.

- An alignment of the product architecture and the architecture of the product life systems.

- This alignment and the variety and commonality is controlled by rules, explicit articulated in the reference architecture belonging to the platform.

- The platform's position effects both related to agility and leanness, and to external strengths like dynamics, flexibility, precision (Treffsicherheit) and quality, are created and harvested in the preparation areas.

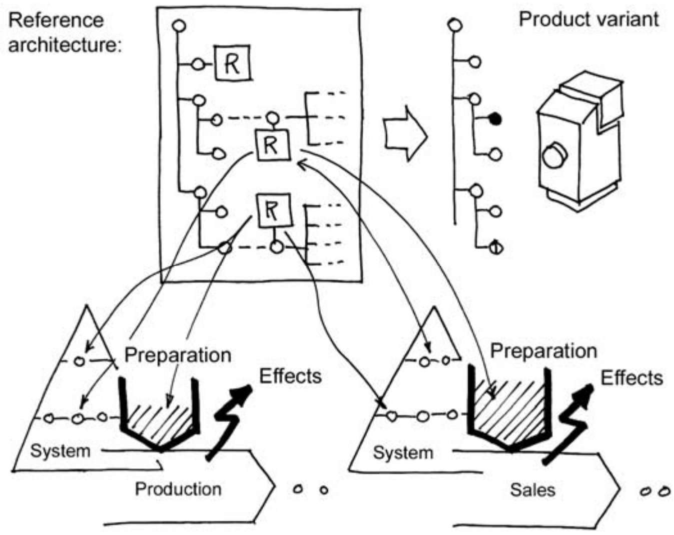

Figure 11: A product platform showing, variety, commonality and alignment

he reader may argue, that this is a very complex and articulated view upon platforms. This is correct, there are many types of platforms (we only explain a product platform) and many ways of utilising platforms. The approach here has been to explore platforms related to articulated product architectures and to show how we have to design the machinery for bringing the organisation into position for utilising the platform and harvesting the positive effects.

8 Balancing the article

The authors see multi product development utilising platforms and modularisation, and supporting this by digital product modelling (outside the scope of this article) as a shift of paradigm in design. The new paradigm has many contrasts to earlier approaches:

- product develop becomes a central part of the business management of the company

- the time aspect of design becomes quite new: lead time is substituted by reaction time.

- the new way of designing has company wide alignment as a prerequisite for operating and for harvesting effects.

- the new paradigm do not allow local handling of new product development: platforms and modularisations has to do with integral aspects. Good modularisation cannot be measured or judged by looking upon the products, it is a relational property.

- platforms and modularisation is not a new method, but today it means a reorganisation, design approach, and new IT-tools.

- engineering is not sufficient, we need business, organisational and strategic thinking, and long term planning.

It is outside the scope of this article to take a closer look upon the designing of a platform and architecture. The influencing factors are many and at high level, Kristjansson and Hildre [10], and the design process is strategic, roadmap- and business oriented and therefore take place in a cross-organisational team partly outside the scope of the product development department, Mortensen [11].

9 Conclusion

Our aim of this article was to propose models, theories and vocabulary for platforms and modularisation. The strength of the paper is the comprehensive linking of these concepts and the pointing out of mechanisms and theory foundation. The weakness of our approach is, that we have not related our proposals to the state-of-the-art proposals for terminology found in literature [1]. This needs more space than allocated here and a serious discussion, which is not yet worked out.

10 References

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