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VARIANT CREATION USING CONFIGURATION OF A REFERENCE VARIANT

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ABSTRACT

The development of the market, demanding an individual product for each customer combined with the requirement to keep the internal variety of components and assemblies as low as possible, leads to the problem of enhancing the management of product data. This problem grows according to the product complexity and the number of engineering designers involved as well as the complexity in the organization, which induces department boundaries. An engineering designer is not able to find already existing data/information, which is relevant for the new order/requirement, in an adequate time. There are many standardization rules already defined and put down on paper. But due to time consuming searching processes, the engineering designer often doesn't consider this standardization. It is much easier for him to create a new component or new assemblies rather than to use any existing ones. The internal complexity will rise rapidly. This paper describes a development of a reference product structure, which consists of several reference variants and each is representing one particular product group. This reference variant can be used as a platform in a product data management system (PDMS) to keep the necessary standardization of components and assemblies within a certain product group. The engineering designer will be supported and encouraged more to configure rather than to design. The reference product structure can support the engineering designer to find the right data for fulfilling the new requirements and can also be used as a basis for collecting knowledge and building a knowledge pool.

Keywords: reference product structure, reference variant, product data model, product data management system (PDMS)

1 INTRODUCTION

Due to the need of less time to market, more rapid development and development at distributed locations as well as the progressing globalization, a company is challenged to work even more efficiently. In order to do so, it has to manage increasing complexity, regarding its products (external variants), parts/assemblies (internal variants) as well as a complexity in the organization or product creation process, since the management of complexity becomes a core management task [1].
The usage of existing parts/assemblies can induce the following advantages:

- Higher product quality through a higher usage rate of already approved parts/assemblies.
- Higher process quality through prevention of unnecessary operations and a concentration on innovative and value-creating activity
- Higher quality of data through prevention of redundancy.

The prerequisite to implement a variant management properly is the existence of a comprehensive product data model, meaningfully supporting the variant creation process. A product data model could be used to maintain the sustainability of variety in product data.
The approach of variant management in order to decrease the mentioned variety is often very difficult to realize. Despite the extensive preparation for a new product generation with its standard variants in the catalogue (see Figure 1 as an example), customers are always proposing new requirements, which differ from the standard products. The lack of communication between marketing and product development departments exacerbates the situation, so that the engineering designer does not experience the original wishes as listed by the customer, which experientially leads to the new requirements. The marketing department is not able to handle the existing variety in the standard catalogue, because the product data generated by the product development department is not

arranged/managed clearly in the system. Marketing development is not able to “translate” the customer needs into dedicated requirements, which are already fulfilled within existing product variants. As the customer requirements are not a subject to be questioned, the chance to fulfill the original requirements by using existing product variant will be missed.
The reason could also be induced by the company’s politics, which says that each request submitted by the customer should be fulfilled in any case, as long as the customer is willing to pay. But only direct costs are often considered in cost calculations. The overhead cost is not considered or at least not in an adequate way. This leads to the situation that the pricing of the standard product will be too high and the exotic, customized product will be calculated too low. Of course it has an enormous impact on the competitive ability of the company.
This paper does not suggest any other approach for decreasing or prevention of product variants (external variants) in a strategic level, but it primarily deals with the question, how the existing internal variants of parts and assemblies could meaningfully be managed in order to be able to govern the internal variety as efficient as possible. The product creation process will be supported adequately. It means that the usage rate of existing parts or assemblies should be as high as possible. It could be achieved by the meaningful arrangement of product data. Thus the engineering designer is able to generate a variant as a combination of existing parts/assemblies and the creation of new items can consequently be minimized. The aspect of process is not a main topic in this paper, but since the data is generated by processes and a process always needs and produces data, this aspect will be considered as well.

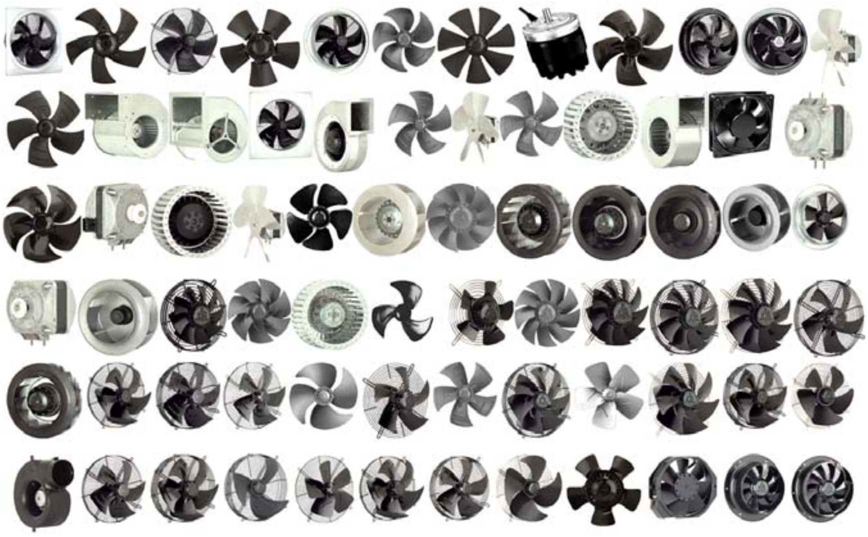

Figure 1. Product variants – example [2]

2 VARIANT MANAGEMENT

2.1 Definition

According to DIN 199 the term variant defines an object with similar form and/or function, normally with a high percentage of identical parts or assemblies [3].
Franke extends this definition by differing product variants and process variants: “a variant of a technical system is one another technical system with the same purpose, which differs at least in a relation or an element. An element differs from another element at least in one property” [4]. This definition can be applied for physical objects as well as for processes.
In order to gain control of product variety, an overall approach is necessary. Menge describes “variant management” as the control of all procedures, which serve for an optimization of the variety and the governing of a high variety product spectrum [5]. Thereby the identification of the differentiation characteristics represents an important precondition for the development of the market-driven product programs and involved the prevention of the creation of unnecessary product variants. Platform concepts, modularization and standardization are important approaches to reduce and to avoid the variety of parts and assemblies within the frame of a variant oriented product embodiment [6]. Further

information to the term definitions and also to the single approaches can be found at [7], [8], [9], [10], [11].
Complexity management according to Schuh et.al. covers the embodiment, control and development of the variety concerning the performance spectrum in a company (products, processes and resources) [1]. Compared to this, the main focus of variant management is not on the physical performance but on the complexity of the overall system (products, processes, resources) and its control [1].
Configuration management is a management discipline that will be applied through the whole life cycle of a product in order to ensure transparency and control of its functional and physical characteristics [12]. This paper considers configuration management as part of variant management to handle the variety occuring in a company, with the elements/aspects i.e. version management, release management and change management [14]. In practice an engineering designer performs variant management by creating a new variant using configuration/combination of existing parts/assemblies.
There are some approaches to knowledge management, for example the usage of ontologies. These approaches are only practicable in specific cases. Informally sitting-together during a coffee break often brings more advantages then a complex and cost intensive implementation of a knowledge management system, which actually does not manage knowledge but only data or information.

2.2 PLM-Strategy as a Solution of handling the Complexity

Nowadays companies have two challenges for being successful: the first challenge is to come through the today’s market situation. The companies have only small influence on this external situation. The reasons are [13]:

- A dynamical market behavior (change from a seller to a buyer market; the increase of variety and at the same time a decrease of batch size; the increase of product individualization due to customer wishes)
- An increasing competitive pressure (faster time to market; search after market niche; plagiarism problem)
- A growing globalization (different requirements due to political, local and cultural environments in which the product is used)

The second challenge lies in the direct internal impacts of the external situation on the whole company (including distributed locations [15]) through each department, which evokes a governable product variety:

- Dealing with an increasing company complexity, in combination with a lack of communication and cooperation between the company divisions.
- Involvement with numbers of suppliers
- Governing of product structure, process structure and organization structure, which mostly is due to historical background.

The described internal and external situation induces a company with a high complexity in the three levels as listed above (products, processes and organizations), see Figure 2, [1], [16]. In order to meet this complexity on the strategic level a lot of companies complement their existing overall strategy with PLM. PLM is to be generally understood as a knowledge based company strategy for all processes and its methods concerning the product development (from the product planning up to product control) [17],[18],[22]. Therefore PLM consists not only of the consideration of actual product, process and organization generation, but also of their future successor. This must be considered today, on the strategic level in order to be able to use existing company individual knowledge for future product generations.
Using PLM on the mentioned levels as efficiently as possible, associated product structures (based on the product generation planning, including “prepared” variants), associated development processes as well as a customized organization in the form of presentable models are required. These models will be implemented through a PDM-System and serve the PLM support on the operative layer [23].

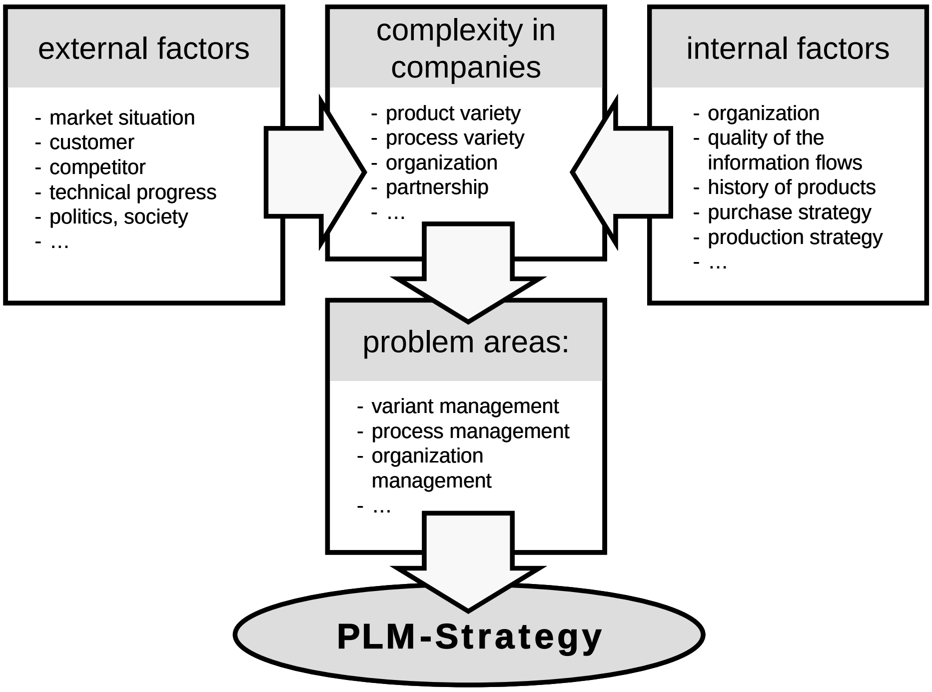

Figure 2. External and internal influencing factors of the variety in the company [6]

2.3 Variant Creation Process

There are several approaches to describe a design methodology, e.g. according to Pahl et.al [6], Koller [19] and VDI 2221 [20]. These methodologies describe a general design process from an idea over a physical solution to finished manufacturing documentations. A comparative overview on these methodologies can be found in [21]. The methodologies have the intention to support engineering designers by providing a general procedure for developing an engineering solution. The whole process is mostly deployed for a new design projects.

In practice the engineering designer uses a pragmatic way to create new variants. After collecting and analyzing the requirements, any existing product data serves as a template to create an additional variant (see Figure 3). There are no clearly references between the existing product variants. Some companies even copy the whole product data first and modify the copied data afterwards. This leads to a huge amount of data with a high degree of redundancy.

In some cases several sub-departments in a company develop similar products concurrently. The experience and the access of data are kept within a certain sub-department. There is no significant data exchange between these divisions. In fact, there are a lot of differences within the development process in each sub-department. Corporate data storage actually exists, but every sub-department has its own way, how the data will be stored and handled. Furthermore each employee has his own folder structure. A standardize data structure is already determined by the management, but it serves only as a guidance. Since the employees have the ability to create their own data structure, they don’t pay attention to the default standard.

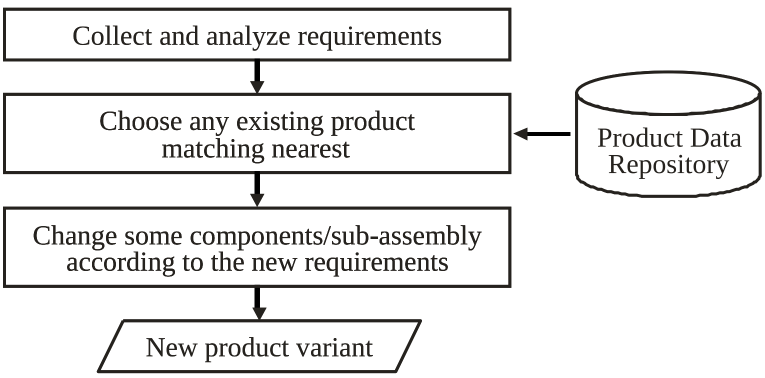

Figure 3. variant creation process nowadays

2.4 Product Data Management System (PDMS)

The problem of data management has actually been realized in a lot of companies (especially SMEs). To sort out this problem an implementation of PDMS often comes into question. A certain number of companies have already done this; but a lot of them are still in the preparative phase. They already recognized that the complexity of data is always increasing. This situation gets even worse due to the unavoidable implementation of 3D CAD applications. In a lot of cases the product data is stored in a shared file server without reference to each other. Some companies manage the data using self programmed software, which is developed internally by IT-departments. This program grows historically according to the requirements coming from other divisions (product development, process engineering, marketing etc.) without any clear common or holistic concept.

This leads to the situation, that a lot of engineering designers spend an enormous amount of time for managing the data. The orientation to find the relevant data becomes more and more difficult as most systems in the company are not referenced to each other. Search activity is then a time-intensive activity and the uncertainty (regarding which one is the right data or whether the data is actual or not) is very high. The coordination effort in a product development project gets immense and often bursts the existing resources. As result the quality of working process is deficient resulting from the inadequate quality of data. The engineering designer has to spend a lot of time complying with the standardization of the company. In a lot of cases this standardization will be bypassed, the engineering designer simply creates new parts/assemblies without considering the existing ones, as it is currently faster and easier for him.

In order to have well organized data and processes, companies need the utilization modern PDMS. The problems described above can be solved by deploying PDMS. They provide numerous functionalities, which might help a company to manage its complexity, e.g.:

- Lock data to avoid parallel work (check out, check in).
- Management of CAD-Data with their references.
- Management of all product documentation including BOM and their references to CAD-Data.
- Interfaces to other systems, like ERP.
- Workflow management (e.g. approval process, review process etc.).
- Role-dependent data access management (who has which kind of access in which condition to which object in which life cycle status).
- Notification due to a certain event.

In a company there is also data from the product development department, which is not supposed to be used any further. This data is, for instance, resulting out of the prototype creation process. Usually it is not documented, although this data could be useful to future projects. The same experience (e.g. the same mistakes) in another department will be done. Only the engineering designer involved knows about the existence of the data. Since the data is not published in the system, because there are no associated customer orders, the data can not be used by other departments. Without PDMS, the data will be saved in the file server without any reference or meta data and can only be found by the engineering designer, who created it. Even this person could probably have difficulties to find the data again.

2.5 Requirements to Data Management

To achieve clearness in the management of product data, a product data model must be developed, not depending on the fact whether the company uses PDMS or not. A Product data model describes the existing product data with its variants. The relation of each product data will be described clearly. Using a product data model as a basis, it can help to support the company introducing PDMS anyway. Although the data is distributed in several databanks, the reference between the data can be presented in a single product data model. By the implementation of this product data model a product variant can be generated then trough configuration of existing data. The creation of unnecessary redundant data can be avoided. This allows to decrease or freeze complexity level.

The data maintenance should be kept as simple as possible and data documentation should be done parallel to the project progression.

Therefore a directive or template, how the product data should be formed, is necessary. It concerns not only the arrangement of product structure and its content in form of 3D CAD models, but also all product relevant data should be considered. It involves the references between the data. A meaningful implementation of development processes on the system level in form of workflows could be very helpful. Besides that an optimal concept for the employee's rights to access certain data can minimize the human error. However caution is required. A free access for all employees could lead to the situation that everybody does whatever he want, producing data which is not useful for the others. On the other side, a very restrictive access could lead to the situation that the employees often consult the system administrator, as they do not have appropriate access to the desired data. The administrator will usually, due to time pressure, give an access which is considered as a temporary exception. As time passes by, there are a lot of exceptions, so that the former concept of access rights is broken up.

3 REFERENCE VARIANT AS PART OF PRODUCT DATA MODEL

3.1 General Product Data Model

The product data in a company is usually stored at many different data bases. Due to various required software applications for each sub departments (design, prototype test, FEM calculation, engineering process, software development, electronics etc.) some "product data islands" arise. It is a huge effort to find the relevant data and to find out which data belongs to which product because of missing digital references. As an example: in a BOM (bill of material) system the product data can be found by the product ID number, but another product data (e.g. calculation report, requirement list) is stored project oriented in a project management system. There are no references between both systems. The engineering designer must permanently switch from one system to another in order to find the relevant product data.

To have an overview of the existing product data and the references, companies need to describe all relevant data of the product including its references. This description is called product data model. Figure 4 shows the structure of a general product data model.

Product, assembly and part (the product can also be considered as an assembly) serve as a core object in this model and are described by two elements: documents and attributes. A document can also be considered as an object with either a (original) content or an associative. This document object can have several attributes as well, which could serve as a reference to the attributes of the product object.

According to their purpose, attributes can be:

- classification attributes, to describe the parameters of a part/assembly within a classification.
- rule attributes, e.g. design rules to describe a constraint for the combination of parts and assemblies (combination forbiddance or combination enforcement).
- reference attributes, to describe the relation of the object to another object. The connection to the process model (e.g. life cycle status, activity etc.) and role model (e.g. created by, actualized by etc.) will be also described by this attributes.

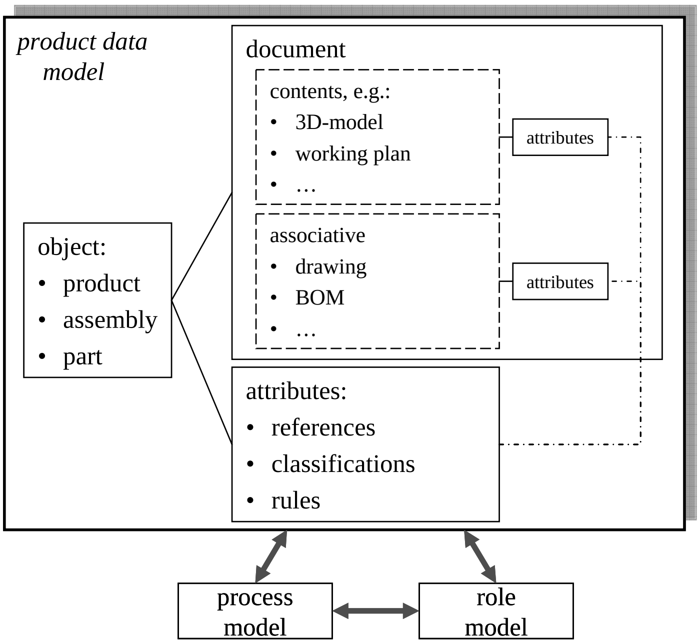

Figure 4. General product data model

3.2 Reference Product Structure

The Reference product structure is an important part of the product data model and describes a valid structure of (almost) all existing product variants. Ideally there is only one reference product structure for the whole company. In practice it is useful to define one reference product structure for a certain product family, in which a lot of common/similar parts or assemblies are used. Feldhusen describes a method to derive a reference product structure out of existing product variants [24].
Figure 5 shows an example of a reference product structure derived from the general product data model described in the previous section.

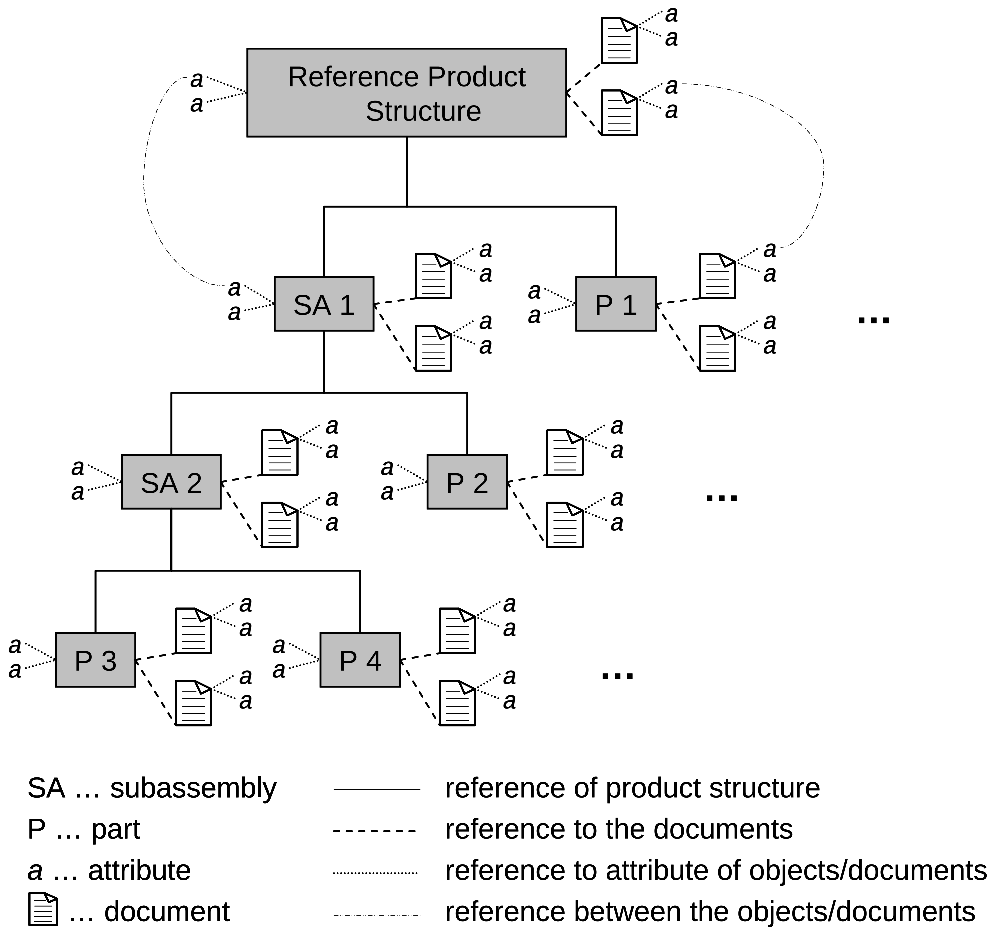

Figure 5. Product data model in a product structure

3.3 Application of Reference variant

Within a reference product structure some reference variants can be defined. It is strongly depending on the product characteristics, how the reference variant should look like. Existing parts and assemblies from all similar product variants can be included in a reference variant. Parts and assemblies, which are also used in another reference variant, can be considered as a standard part within the related product family.
Figure 6 shows an example of a reference variant. Existing parts and assemblies are considered as options of the related part/assembly object.
A product variant can be then derived from this reference variant (see Figure 7).

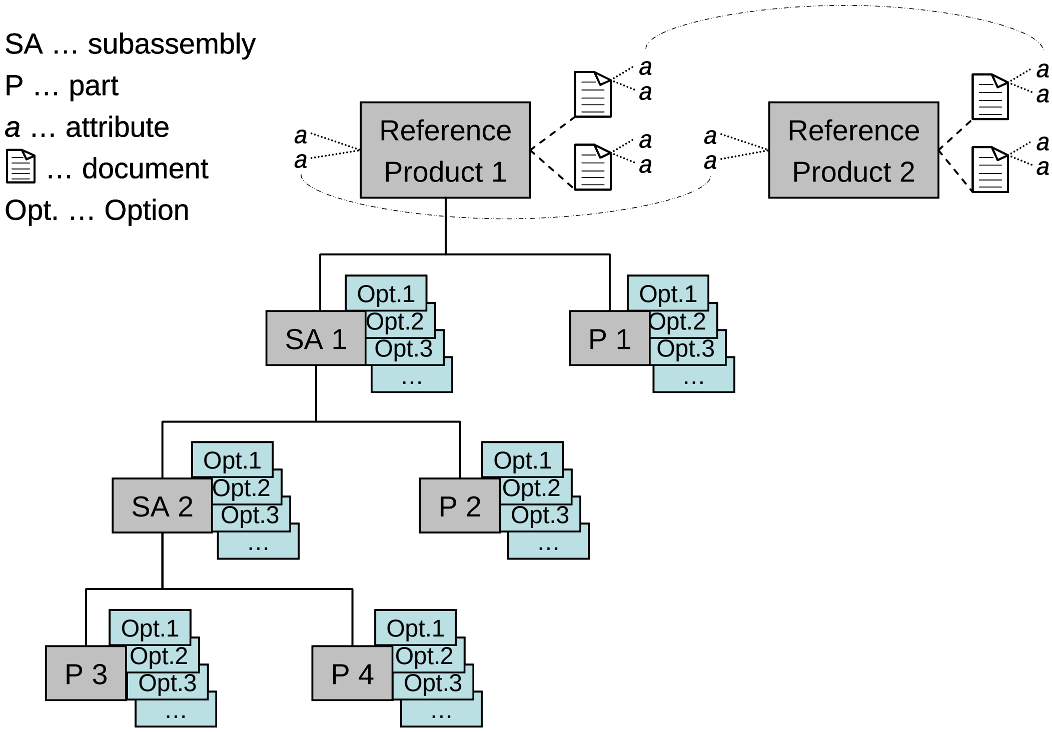

Figure 6. Reference variant serves as a storage of existing parts and assembly within a product family

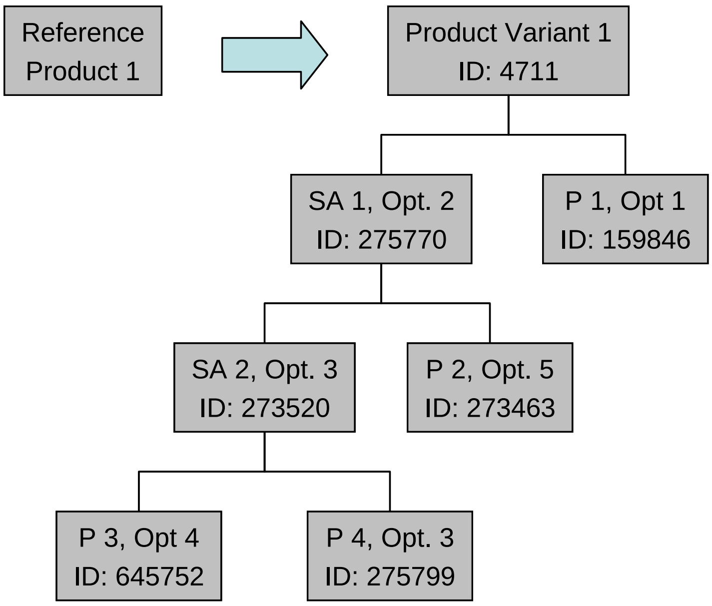

Figure 7. product variant as a derivation of a reference variant

3.4 Implementation of the Approach in PDMS

The definition of reference variant and its configuration into a product variant could be managed in PDMS. A proper prerequisite regarding product data model, process model and role model is necessary [23]. Some functions of PDMS to support this configuration are listed as follows:

- “Iteration”, serves as object actualization (after every check-in) within a version
- “Versions”, serves as a derived object from previous version. The different options of parts/assemblies can be implemented as an object with different versions.
- “Latest configuration”, serves as a configuration of product variants consisting of the last version in the last iteration of each objects in the product variant.

- “Product configuration”, serves as a derived product variant consisting of the determined version in the last iteration of each objects in the product.
- “Baseline configuration”, serves as a configuration of product for a certain point of time (snapshot).
- “Effectivity configuration”, serves as a configuration with its validity will be effective from a certain point of time.

The implementation of a reference variant in a PDMS should imply the following steps:

- Similar parts or assemblies can be implemented as an object in different versions.
- A new product variant is a derivate of a reference variant produced by product configuration. Every part or assembly – except the customer specific solutions, which have to be kept minimal – is coming from the related parts and assemblies of the reference variant.
- Every product variant can be implemented in a separate context.

4 SUMMARY

This paper describes an approach to derive a product variant out of reference variant through configuration of existing product data. It could help the engineering designer to work more efficient creating a product variant with small differences. The arrangement of product data will be stored in a product data model, which describes all existing product data and their references.

This approach does not want actually to discourage an engineering designer to stop the innovation activity. But less effort in the unnecessary coordination works releases time for more important design activities. In fact, the experience by the development of product data model for the variant creation process can be applied as a template during the development of the next product generation.

The use of PDMS in combination with this reference variant enables a company-wide, consistent basis for the development process. Thus complexity is not an impedimental problem but if handled with this proceeding it helps to strengthen the market position and generates vantage points in the global competition.

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