

TOWARDS CASE-BASED PRODUCT AND NETWORK CONFIGURATION FOR COMPLEX CONSTRUCTION MACHINERY

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Abstract

Product configuration software tools are commonly available as stand-alone products or as part of standard enterprise software. The application of product configurators generally addresses three goals: Product configuration tools support sales activities, they support different tasks of process planning, e.g. automated generation of Bills Of Material and they preserve engineering knowledge by storing configuration rules or cases systematically.

The customer-driven product configuration of complex machinery usually affects several suppliers who consequently have to adjust their respective modules. The subsequently necessary coordination process between OEM and suppliers is both costly and time-consuming, accounting for a big fraction of the total time of delivery. Hence - depending on the dimension of adjustments - parts of the production network have to be incorporated into the configuration scope.

This paper presents a new and wider configuration approach by integrating the network design as well as a time and cost evaluation of a customer specific variant into a product configuration tool. It points out the methods applicable and critical success factors thus contributing to the design and implementation of product configuration systems and the customization of the logistic processes.

Keywords

Product Configuration, Network Configuration, Product Modularization

1 Introduction and research objectives

1.1 Introduction

Product configuration software tools are commonly available as stand-alone products or as part of standard enterprise software. The application of product configurators generally addresses three primary goals: Product configuration tools support sales activities through web-based user interfaces or as internal information and calculation assistance. They support different tasks of process planning, e.g. automated generation of Bills Of Material and they preserve engineering knowledge by storing configuration rules or cases systematically [Jensen 2002]. Along with the primary goals, the implementation of configuration tools provides secondary side effects such as the reduction of complexity in the course of necessary product modularization.

The manufacturers of mobile construction machinery in Germany face the challenge of heterogeneous and complex customer demands in the sense of product specification as well as delivery time. Innovative and customized products with a high rate of order-related engineering efforts, unsteady order receipt and order-related supply chain structures characterize the industry. In addition to the technical challenge, customers increasingly demand shorter delivery times in order to minimize their own risks. Just like many other industries the construction machinery industry faces increasing global competitive pressure with the need to improve efficiency, leading to the relocation of assembly-related-jobs into low-wage countries. In order to counteract the impending loss of approximately 25% of jobs in the German construction machinery industry [VBM 2004], a flexible delivery of the machinery is required. Vital premises for an efficient ability to deliver are information transparency throughout the supply chain, flexible capacity allocation and the simplification of coordination processes.

One solution to fulfill customer specific orders efficiently and in time is the application of product configurators. However, up to now product configurators are restricted to the product and do not take into account the effects on suppliers or the supply-network. Furthermore they are only able to generate evidence on material costs. Costs in overhead areas, such as compiling new routings or maintaining logistic data are not taken into account. However, in particular these costs cause a significant proportion of variant costs.

As the customer-driven product configuration of complex machinery usually affects several 1st-tier and 2nd-tier suppliers they consequently have to adjust their respective modules. The subsequently necessary coordination process between OEM and suppliers is both costly and time-consuming, accounting for a big fraction of the total time of delivery. Hence – depending on the dimension of adjustments – parts of the production network have to be incorporated into the configuration scope.

1.2 Research Objectives

The objective of the research described in this paper is to develop a concept of an integrated configuration of product and network. Focus is put on the aspects of network configuration and the evaluation of variants over costs and time. Applicable methods are being discussed, critical success factors are being identified and further requirements in research are pointed out.

The configuration concept will be transferred into a software prototype that demonstrates the core functionalities and validates the concept's applicability. Within the national research project

BAUMO2008 (funded by the German Federal Ministry of Education and Research), the prototype will then be deployed at partners in the German construction machinery industry in order to determine cost and lead-time of customer orders. The usage of the product and network configuration tool is prospected to fulfill two of the primary goals mentioned above: The systematic storing of engineering knowledge and the support of sales activities. Furthermore, the tool will contribute to the research project's overall objectives by side effects inherent by preparative product modularization and process engineering. The research project BAUMO2008 aims at enabling OEM to serve short-term customer orders in a flexible way by realizing a modular design of product, process and production network. Based on an efficient interface management – concerning in-house cross-functional-area-processes as well as cross-company processes – costs in overhead areas will be reduced. The application of the software-based product and network configurator facilitates the estimation of lead-times and variant costs, thus supporting the internal planning as well as the sales department's activities. In conclusion, the project contributes to preserve Germany as a location for production and assembly.

Following this introduction, Chapter 2 describes the development of the underlying model including the three levels product, process and network. In order to link these levels, different Order Categories are established. Chapter 3 describes the concept of an integrated software-based IT-tool, distinguishing the cases of configuration and reconfiguration. The development of the model and the prototypical realization of the IT-tool are carried out within the research project BAUMO2008, exemplified at a specific Truckmixer with an integrated concrete pump. Finally, Chapter 4 concludes the described work.

2 Design Model

Data for the modeling of a selection of cases is collected in cooperation with industrial partners and transferred into the IT-tool.

Within this, investigation is based on three core elements:

- A product model of the Truckmixer with an integrated concrete pump
- A model of order fulfillment activities
- A model of the logistics network

These three models will be combined, enabling an integrated configuration of products and networks as well as an estimation of lead-times and costs.

The first condition to build up a cross-company product and network configurator is to represent the product and its architecture. Variant-specific modules and components have to be identified and mapped in the product model. Using this model it is possible to determine the necessary engineering efforts to adapt existing or to design new modules. To differentiate the efforts to adapt components or redesign whole modules, the degree of modularity of the product is defined. If the degree of modularity is near to 100 per cent only minor efforts are necessary. Product variants can be made up of existing modules. The existing process and network structures can be used. If the degree of modularity is low, the resulting additional efforts to engineer and produce the variant in the production network are important.

In order to be able to estimate the cycle time and costs of a customized product, in the first step a process model has to be set up. Focus has to be put on the variant-sensitive, i.e. time consuming

and costly overhead departments, like engineering, purchasing and process planning as well as on the production itself. While in the direct departments cycle times and costs can be estimated accurately based on routings, in the overhead departments time and cost drivers must be identified for each activity dependent on the case variants. For process analysis, time-driven activity-based costing method was applied [Kaplan 2004].

This process model represents the firm-internal perspective of the OEM. In the second step, the logistics network has to be modeled. Focus is put on the important 1st tier suppliers. Existent supply chains as well as new alternative supply routes are mapped and provided with cycle times and costs. Important logistical scenarios such as amended suppliers and consignment stocks are included. By demanding input data from the suppliers transparency of the network's overall capacity is achieved. In combination with the internal capacities, estimations of cycle times and costs of customized products can be generated.

2.1 Product Modularization

The most important precondition for the configuration of complex products is the modularized product architecture enabling the combination of different product elements to obtain a great number of product variants. Various concepts of modular product architectures are known. They differ in some important criteria like the constancy of one or several modules (e.g. platform strategies), the limited or unlimited number of modules etc. [Pulm 2004] The different product architectures have in common that they are based on standardized product elements. Assets and drawbacks of modularized products are described in [Ehrlenspiel / Kiewert / Lindemann 2005]. The product elements have to be classified in several modules. Dependencies between modules have to be minimized. Modularization is therefore an important approach for organizing complex products and processes efficiently, by decomposing complex tasks into simpler portions so that they can be managed independently. Modularity permits components to be manufactured or assembled separately, or loosely coupled, and used interchangeably in different configurations without compromising system integrity [Mikkola 2001]. Modules form an entity of different components with high internal but poor external dependencies. Product characteristics have to be kept in mind, particularly the role of product functions: With wide-ranging overall functions, the partitioning of the product into function-oriented modules is important, while with a small number of overall function variants; a production-oriented solution is the paramount consideration [Huang / Kusiak 1998]. The degree of modularity depends strongly on the properties of its module interfaces [Koren et al 1999][Abele et al 2006]. The aim of modularization is to offer the customer a high number of product variants with only a limited number of modules. Time and effort for the production of variants should be minimized.

The existing product architecture and the modules can be used for mapping the product family using a variant parts list [Eversheim / Krause 1996]. Product elements, which have not been considered so far in the modular product structure, have to be added. The consideration of all possible developments of the product structure, the modules and the components is not feasible. Therefore it is important that the product architecture is easily expandable and alterable. This degree of accuracy is sufficient to realize the wider product and network configuration.

2.1.1 Determination of Product Modularity

An indicator is needed to measure the degree of modularity of an existing product family. Therefore a simple indicator is suggested. It is possible to compare the different degrees of

modularity to costs and lead times. The used degree of modularity (DoM) shows how many product elements are contained in the modular structure weighted by the production volume of the different product variants.

$$DoM = \frac{\sum_i \sum_n x_i q_{in}}{\sum_i \sum_n x_i q_{in} + \sum_i \sum_m x_i q_{im}}$$

DoM = degree of modularity
with

- x_i = production volume of product variant i
- q_i = number of product elements of product i ,
- n = Index of product elements, who are represented in modules
- m = Index of product element, who are not represented in modules

It has to be noted that the definition of the degree of modularity mentioned above can only be used for existing and well-defined product families at a particular time.

Different degrees of modularity cause dissimilar costs in direct (e.g. product development, manufacturing) and indirect processes (e.g. logistics, purchasing, controlling) of the enterprise. To calculate costs, cycle times have to be estimated in these processes and multiplied by the hourly wage. Investments and current costs have to be integrated. Using the product life cycle duration and expected production volumes, the investments can be added and compared to current costs.

To determine the optimal degree of modularity for a product family and the specific enterprise, the additional costs can be compared to the savings respectively the opportunity costs of modularization (see Fig. 1). The example of the product development process can be quoted to illustrate these findings.

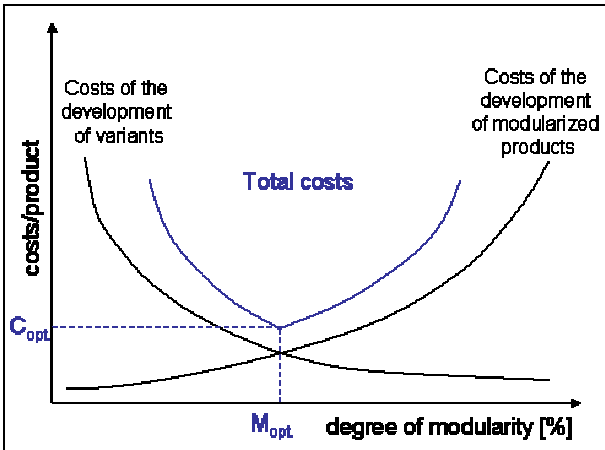


Figure 1: Qualitative relation between the different costs and the degree of modularity in the product development process

Other product specific processes of the enterprise behave akin. The addition of all product specific process curves lead to a cumulative curve. The optimal degree of modularization is achieved when the minimum of the cumulative curve is found. It must be emphasized that the additional costs caused by increasing the degree of modularity originate in other product related processes e.g. sales (or product documentation). The benefits and the costs of product

configuration itself also increase. It has to be noted that different processes of the enterprise contribute to the total costs in different measure. The most important and cost sensitive processes by varying the degree of modularity are product development, manufacturing, purchasing and logistics. The costs in supplier processes are also affected by the choice of the degree of modularity by the OEM.

2.1.2 Determination of a Satisfying Degree of Product Modularization

Obviously the curves mentioned above are idealized. At first the curves of real processes are not continuous. Furthermore big efforts have to be made to determine the different curves. Accordingly, the examination range has to be divided into different sub ranges. Building scenarios for different processes and degrees of modularization can determine the modularization degree. Primarily, different Order Categories have to be built, which represent different types of product variants. Applying these Order Categories, the efforts can be assigned to the different degrees of modularity. These degrees of modularity are determined with the experts of the enterprise who can estimate the technical feasibility. These steps lead to a matrix with the costs for each degree of modularity and for the Order Categories (see Fig. 2). Experts from the different departments of the enterprise estimate these costs.

degree of modularity	oder categories				sum
	1	2	...	l	
1	c_{11}	c_{12}	...	c_{1l}	$= g_1 * c_{11} + g_2 * c_{12} + \dots + g_l * c_{1l}$
2	c_{21}	c_{22}	...	c_{2l}	$= g_1 * c_{21} + g_2 * c_{22} + \dots + g_l * c_{2l}$
...	
k	c_{k1}	c_{k2}	...	c_{kl}	$= g_1 * c_{k1} + g_2 * c_{k2} + \dots + g_l * c_{kl}$
weighting factor	g_1	g_2	...	g_l	

Figure 2: Effects of different degrees of modularity on the costs for the several Order Categories

On the basis of this matrix a degree of modularization which meets the requirements of the company and the specific product family can be defined via a weighting of the Order Categories based on the allocation of the previous value (number of occurred cases and pieces). The degree of modularization that leads to the lowest total costs should be realized.

Due to the fact that the various customer requirements of special machinery are changing very fast, open product architecture has to be used. In the industry of construction machinery and especially in the construction of mobile construction machinery, a degree of modularization of 100 per cent cannot be reached. Depending on the requirements of the customer, the product, its technique and the business processes, a degree of modularization of 40 up to 70 per cent can be achieved. As the interfaces cannot be standardized to a greater extent within economically justifiable costs, the high variance in one single module has an effect on nearby modules. The product architecture for a construction machine contains modules on the one-hand and on the other hand product elements, which cannot be summarized in modules, without breaching the structure of modules frequently. As a result there are special designs in various amounts. This devotes an essential requirement to the method of product configuration. Not only completely modularized products have to be configured but also special designs of partly modularized products are to be realized. The reason of the relatively low degree of modularization in the sector of in the industry of construction machinery is the distinctive diversity of variants and the

extensive amount of costs, which emerge when continuous standardized interfaces are to be established. Besides, one has to make further endeavors to reduce the diversity of variants in advance (also within the module itself). With a manual for product design that is similar to Design for Assembly alternative solutions can be acquired.

With an optimized product design customer needs and process requirements can be taken into consideration so that the cost curves in Fig. 1 can be influenced. Restrictions of reducing the diversity of variants and therefore limits for the standardization of interfaces can be identified. Thereby technical limits for the raise of the degree of modularization are ascertained.

2.2 Process Level

2.2.1 Process Modeling

The model's second level comprises the process level. The evaluation of single customer orders with costs and cycle times requires the modeling of the relevant activities and processes in a coherent process landscape. Variant costs are in large parts caused by internal activities. In practice, these costs are regarded as overhead costs and are consequently accepted as fix costs. Thus, products and orders with substantial material costs or high volumes are allocated with high overhead costs. Variants and orders of low quantities are allocated only with a fraction of the effectively caused costs. As a result, special orders and customized products are assigned too high contribution margins [Horváth 2006]. Against this background, the project aims at developing an evaluation concept, underlying the approach of activity based costing, which allocates overhead expenses on the variants, according to the actual input involved.

With the target to calculate variant-driven costs, the Time-driven Activity-based Costing (TD ABC) approach offers a useful methodology for modeling the process landscape. The concept of TD ABC represents an enhancement of process orientated costing systems [Kaplan 1999]. One essential advantage of TD ABC is the introduction of individual projected handling times for sub-processes. In this context, time equations are modeled for each sub-process, assigning each sub-process an individual target time depending on identified influencing factors [Kaplan 2004][Coners 2004]. Consequently, from the intensity point of view the process becomes adjusted to the degree of the handled object's complexity, e.g. the usage of special packaging for oversea dispatches instead of the regular packaging (see Fig. 3).

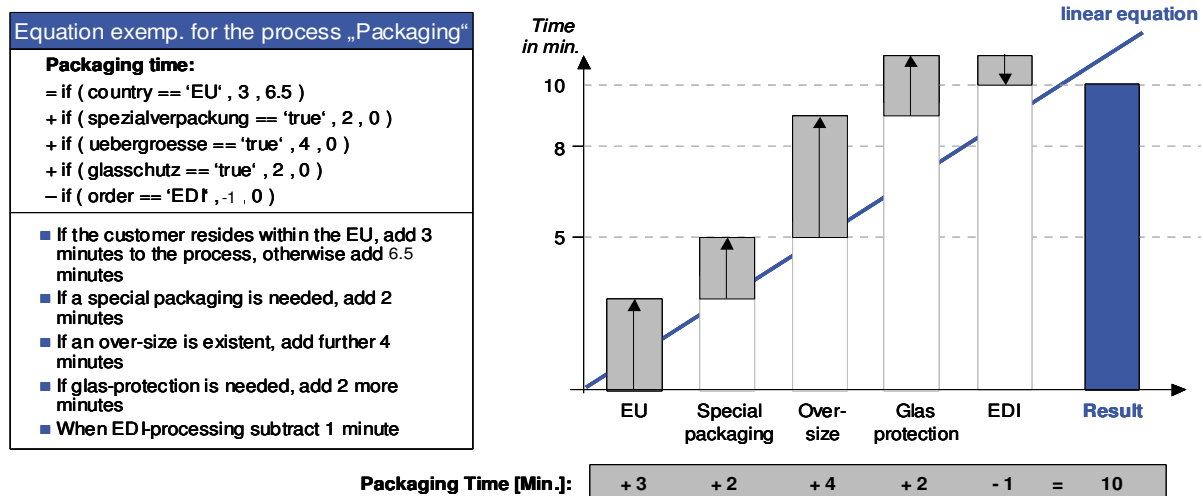


Figure 3: Time equation at the example of a packaging process

On the basis of certain characteristics of business activities the per-time unit producible quantities (q/t) become determinable. For this reason TD ABC allows the evaluation of business activities considering costs and time.

2.2.2 Process Model Components

Products with multiple versions have a cost-driving impact with influences on the entire order-fulfillment-process [Wulfsbert 2005]. Hence, mapping the process landscape requires identifying and modeling the relevant, i.e. input and cost-intensive, departments and processes. The production of different versions leads to additional time and effort, particularly in the departments engineering (such as mechanical drawings for new modules and components), operations-scheduling (setting up new routings), purchasing (e.g. coordination of suppliers) as well as in logistics (e.g. re-planning supply). In the configuration model these departments are mapped on the level of sub-processes assigning every sub-process a projected handling time as well as considering time buffers between sub-process and parallel processes.

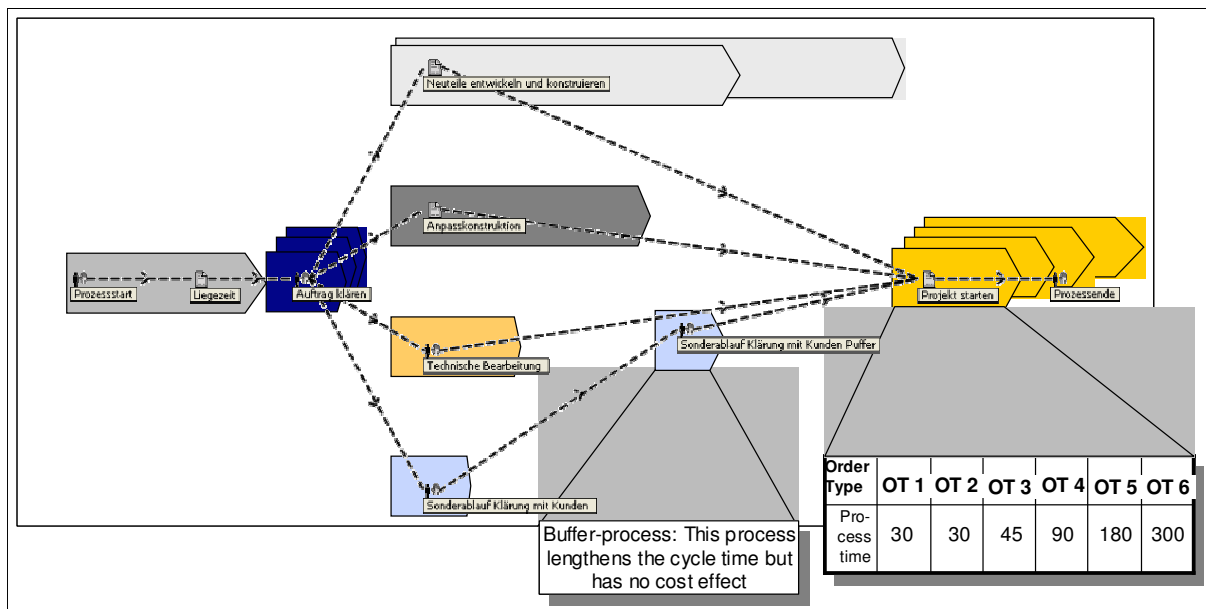


Figure 4: The configurator's underlying process model

In order to be able to estimate version-driven costs and times, influencing factors determining the sub-processes' time consumption and thus the resulting costs have to be defined for all sub-processes. By applying if-then-functions, time-consumption functions are derived. The order categories that have been defined on the product level vary in subject to the intensity of influencing factors. In dependence of a customer configured product, this categorization allows to determine the consummated times in indirect departments thus calculating the variant's costs.

2.3 Network Level

2.3.1 Network Planning and Supply Chain Design

Inter-enterprise logistics play a major role within the goal of an integrated product and network configuration concept as described in this paper. The range, within which costs and delivery time can be adjusted in short-term is significantly wider in physical transportation processes than in product design or in business process design. The configuration of the supply network, however,

requires a set of alternative network layouts to choose from. Besides the as-is state of the respective supply network, different standard supply relations are to be identified that match the requirements of the network. The standard supply relations differ in terms of costs and delivery time, e.g. by the use of different means of transportation or by combining demands of several locations. Thus the results of Supply Chain Design activities are transferred into the network layout.

The Network Level within the model contains the components of inter-enterprise logistics. It is possible to set up miscellaneous supply concepts, e.g. Just-in-Time delivery and Milk runs, as well as alternative transportation routes and even transportation modes in order to display different means of transportation. Based on these modeled network components, the inter-enterprise logistics network can be configured for a customer order as described in Chapter 3.

2.3.2 Network Model Components

The third level of the model contains not only the inbound logistics network of the OEM and several partners in the as-is state but also alternative supply relations. The model consists of the network partner's geographic locations, referred to as knots, and the transportation relations between the knots, referred to as edges. Both of the components bear attributes that represent cost and cycle time per unit. This generic pattern of knots and edges suffices to calculate network-specific costs and lead-time for a product variant and customer order respectively. The operator can define the network's boundary deliberately during the modeling process. Thus, the number of network stages is not limited on system level.

The network entity, which is a partial solution of the configuration task, can be illustrated as an incomplete, non-planar graph [Diestel 2000]. It contains the entire route from the raw material's supplier to the point of sale or the point of assembly for each product module that is relevant according to the customer's order.

3 Case-based Product and Network Configuration

3.1 Scientific Configuration Approaches

Based upon recent scientific work, the different approaches in configuration logic have been surveyed in order to find the most appropriate one. The typically complex interdependences of product modules in the construction machinery industry as described in Chapter 2.1 commend a configuration approach that does not require a complete data model of the product's modules and variants and their specific conjunction.

Configuration concepts can be classified according to the underlying knowledge base that consists of the database and the configuration logic. *Blecker et al.* describe according to this classification case-based, rule-based and model-based configuration concepts [Blecker et al 2004]. However, others distinguish additionally constraint-based configuration and genetic algorithms [John 2002], structure-based and resource-based concepts [Hotz/Krebs 2003] and graph-based configuration [Sinz 2003], respectively. This ambiguity in concept classification illustrates the dynamic of scientific work in recent years.

According to the complex interdependences of product modules, a case-based configuration approaches as described by *Blecker et al.*, *John* and *Hotz/Krebs* has been selected [Blecker et al 2004][Hotz/Krebs 2003]. In short, the case-based configuration is about matching customer

requirements with an adapted variant of predefined product configurations (cases). In case-based configuration solutions can be found despite the database may be incomplete or rather abstract and although the solution is based on already existing, possibly minor solutions by nature, the case-based configuration provides significant results within reasonable operation time. Thus, by the description of selected cases it is possible to avoid the exhaustive modeling of the entire product structure in detail.

When applying configuration systems a distinction is made between the configuration process, i.e. to find a solution for a configuration task, and the reconfiguration process (also referred to as modeling), i.e. maintenance and extension of the database [Jensen 2001][John 2002]. The former will be described in chapter 3.4, the latter in chapter 3.5.

3.2 Dependencies between the Degree of Modularization and Product Configuration

If the product is not entirely modularized a case-based product configuration is recommended. In the run-up to a new product construction or adaptation, when it is obvious that the product cannot be established by configuring the existing modules, product configurations are not able to indicate and represent the product development process as well as the production and logistic network. For this reason different Order Categories are developed. These categories represent the most important processes within a company and they are in accordance to the processes mentioned in Chapter 2.2. The Order Categories themselves are modular. There are different modules for each process, so further specialized Order Categories can be created. Therefore the different relevant situations within the network can be displayed. The Order Categories represent a various number of different single orders.

Every product variant is analyzed due to the effects it will approximately cause in the different processes. Based on these effects, categories are created. Every category represents therefore a number of product variants that are akin concerning the efforts in different processes of the enterprise. Using these Order Categories the product configuration and the configuration of the network could be performed. In order to optimally represent the user's order structure, the details of Order Categories can be set appropriately. A guideline with generic descriptions of the different Order Categories is offered to the user.

In case of a low degree of modularity the most important asset of the Order Categories and the case-based product configurator is the consideration of change efforts for product variants in the product development processes as well as in manufacturing and assembly and further processes. Experienced employees can easily estimate the efforts that are caused by product variants, and thus allocate the underlying customer order to the adequate order category. Therefore the planning of the processes in early stages of negotiations with the customer or product development becomes possible and the sales employee can calculate delivery dates realistically. This categorization scheme also helps the user to determine which orders he should accept following the company's strategy.

3.3 Integration of Product, Process and Network Model

The realization of a case-based configuration tool that includes the three elements product, process and network in order to display both costs and lead time of the solution requires a common mapping of the three model components (see Fig. 5). The software prototype that is being developed will be based on the existing standard software for logistics planning 4flow

vista®. Besides the structure for product data, business processes within the supply chain and logistic networks, 4flow vista® provides a variety of analysis tools, which calculate Key Performance Indices, e.g. costs, for the configured solution. Furthermore, the modeling environment of the software eases maintenance and extension of the database as it allows to set up (re)configuration cases by a graphical interface.

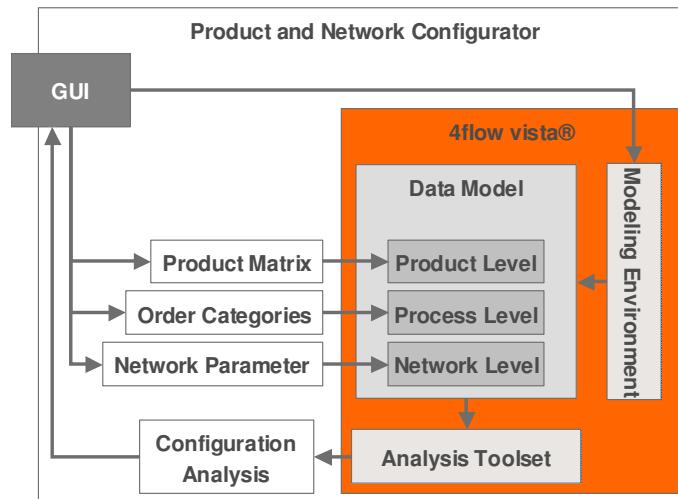


Figure 5: Product and Network Configurator Scheme

In order to adapt the configuration tool onto existing corporate software systems, data interfaces to common ERP-software are implemented.

3.4 Configuration Interface

In the following the concept of the software-based configuration application will be described in detail. According to Chapter 2 the three levels of the data model, i.e. product, process and network, have to be configured each. Hence the user has to define the solution space for the configuration task, i.e. the customer order, and the configuration tool has to assign the appropriate entity out of the general data model for each of the three model components.

3.4.1 Product Definition

In the first step (see Fig. 6) the product's modules have to be defined according to the customer's needs and priorities. For this purpose the significant properties of the product modules covered by the data model are linked to their impact on the product's behavior via a Product Matrix. This matrix is loosely based on the methodology of the K-&V-Matrix as described by *Bongulielmi et al.* which has been developed as a tool for the structuring and mapping of informal configuration knowledge [Bongulielmi 2003][Puls et al.2002].

In the context of the introduced product and network configurator, the Product Matrix serves the following objectives: Firstly it acts as a filter as well as linkage for the selection of product modules that match the customer needs. Secondly it records order-specific information with relevance for the supply network, such as customer-driven default components that require certain suppliers (e.g. default chassis manufacturer). Furthermore, the Product Matrix defines the

correlation between product behaviors, e.g. working range of the Truckmixer, and module specification, e.g. type and pressure of the concrete pump, and thereby serves as decisive component for the modeling of new configuration cases (see chapter 3.5).

Unlike standard product configurators the introduced Product Matrix does not map every single part of the product and thus does not create a Bill of Material. The Product Matrix comprises just the major modules of the product.

Thus, in the first step the product entity has been created out of the data model by means of the Product Matrix.

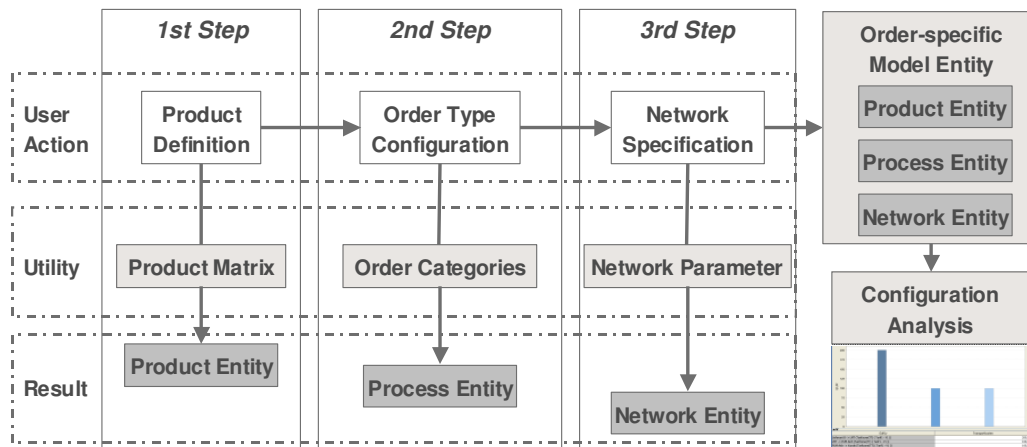


Figure 6: Configuration Workflow

3.4.2 Order Category Configuration

In the second step (see Fig. 6) of the configuration cycle the user has to define the Order Categories for the network partners that match the customer order. According to chapter 3.2 these categories describe to which extent the customer order causes specific efforts and in which departments the effort occurs. As the order category system is generic regarding mobile construction machinery industries, it allows for various possible customer orders without requiring an instant re-modeling of the data model in case the product specifications have not been realized before. The selected Order Categories of the respective network partners, i.e. OEM and selected suppliers, each determine the initiated processes, which are combined and consolidated to a single continuous process entity. As described in chapter 2 the process entity determines order-specific costs and lead-time.

Thus, in the second step the process entity has been created out of the data model by means of the Order Categories.

3.4.3 Network Specification

In the third step (see Fig. 6) of the configuration cycle the supply network for the customer order is being specified. As exposed in chapter 2.3.2 the data model contains several alternative supply routes for each network partner and several alternative suppliers for certain modules. The Network Parameters allow the user to express his priority concerning time of delivery and logistic costs in the entire network. Depending on the customer's urge to get the product as quick as possible, different supply structures, e.g. express delivery vs. railway transportation, are

assigned to the configured product and process entity. In this process the previously recorded order-specific information concerning network structure, e.g. default suppliers, are incorporated into the network specification.

Thus, in the third step the network entity has been created out of the data model by means of the Network Parameters.

3.4.4 Configuration Analysis

The three levels of the model, i.e. product, process and network, constitute a continuous entity that represents the customer order in terms of product specification, order-specific processes and supply network. The overall time of delivery and the order-specific costs can then easily be analyzed with the integrated toolset. The data model and the configuration logic is embedded in a standard software that provides detailed analysis of the three levels of the model entity. The analysis not only displays total costs and time of delivery at a glance in order to evaluate the customer order's characteristics but also allows the in-depth examination of the production network and its components. Thereby shortcomings in specific configuration cases, i.e. customer orders, can be identified and resolved.

3.5 Reconfiguration Interface

The integrated configuration of product and network as described above is a meaningful tool for the mobile construction machinery industry that improves the handling of customer-specific orders. However, any configuration system requires maintenance and enlargement of the database at regular intervals in order to keep up-to-date. Especially case-based configuration logic is in need of new or adjusted cases because case-based configuration is not designed to create solutions out of a vast database deliberately but is bound to existing preliminary modeled cases.

In the here-described approach the database consists of three levels, i.e. product, process and network level. Thus the user support in editing the database and the configuration logic is vital. The described Product and Network Configurator provides a modeling environment that has been proved in daily business, as it is part of a standard planning software (see Fig. 5). A graphical user interface (GUI) supports the set up of product modules and the definition of their specification and the design of processes and network structures. The redesign of the database in this environment is prospected to account for the major part of redesign effort compared to the redesign of the configuration logic, because the database will be subject to both, the adjustment of existing components, e.g. altered transport tariffs, as well as the definition of new items. The configuration logic however, has only to be adapted along with the definition of completely new items, i.e. new product modules, business processes or supply relations.

In this case, the modeling in the sense of database update (reconfiguration) has to be accompanied obviously by the update of the configuration logic, precisely the configuration utilities Product Matrix, Order Categories and Network Parameters. Any new product module that has been modeled in the database automatically updates the Product Matrix by exactly this module. The operator then has to define the linkage between the new module and existing database components in order to create new configuration cases that concern the product level. The Order Categories, which correlate with the model's process entity, need to be updated whenever a new category occurs that cannot be covered by the initially defined categories. Then,

the relevant processes have to be defined in the modeling environment (database) and the linkages of the new Order Category have to be created manually by the operator. The third configuration utility, the Network Parameters, do not require specific adjustment in case the supply network is subject to changes. Network Parameters, i.e. costs and overall lead-time, are generically defined in the configuration logic. Thus the solution to the stated problem, i.e. the configuration according to the customer order, is retrieved by the embedded logic that analyses valid supply chains through the network and selects the most appropriate according to the Network Parameters.

4 Conclusion

4.1 Discussion

Modularization provides the opportunity to effectively balance the trade-off between product-related standardization and required market and customer orientation. Fulfilling individual customer orders can be achieved by the combination of standardized modules. A well-defined and systematic product structure is the basis for the realization of closed process chains from the sales department to the operations scheduling – resulting in significant time and cost-savings within all affected departments. The instrument enabling the organization to realize these closed process chains is the software-based configuration tool. It allows an integrated information-flow from the sales department to the production. Further efficiency potentials can be realized by the integration of suppliers' processes. Delivery bottlenecks and speed-up-paths can be identified and managed actively. In consequence costs and delivery time are reduced whereas the delivery reliability will be increased, both to the advantage of the customer. The integrated use of time and cost-evaluations enables statements about cycle times and costs of specific customer orders, giving the OEM information about cost-driving customers respectively variants. Due to the reduction of internal complexity customer individuality can be maintained. In summary, both OEM and customers benefit from such an optimized order fulfillment process.

However, two aspects mainly determine the limits of this model. Firstly, the complexity of the underlying product influences the realization of the modularization and therewith the creation of a systematic product structure. The realization of a complete modularization is therefore carried out in two steps: the first is the creation of different order types, which get further detailed afterwards. Secondly, an up-to-date and complete database is required for the integrated configuration. That applies to the same degree for the data used for the intern product-model, as well as for data used for the extern supplier-net-model. Integrating the supplier probably poses the hardest challenge. Due to the pre-competitive nature of the BMBF-funded BAUMO2008 project, in the present case the most important partners of the supply-net are integrated. In this context it must be stated, that the position and negotiating power of the OEM plays a decisive role for supplier-integration.

4.2 Outlook

Summing up, it can be stated that the presented model is an innovative approach, exceeding the hitherto existing functions of product-configuration-tools. The integration of a process and a network model allows the application of product configuration tools in new contexts. The prototype enables OEM to perform an active supply-chain-design and a calculation of variant costs.

At the moment, the concept is in the development and elaboration stage. A prototypic IT-solution will be realized within the runtime of the research project BAUMO until midyear 2008. This prototype will indicate further necessities of development and more fields of activities, on the basis of which a specific further development will be carried out.

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