FLEXIBLE CONFIGURATION MODELS IN INDUSTRY APPLICATIONS

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Different products and product variants require different plant structure and plant control software to fulfill all of the customer requirements. Despite the modular structure of advanced manufacturing systems and control software reconfiguration problems arise due to complexity of production environment and missing links among his partial models. As a result, each product and product variant has to be developed and prepared for production separately. There is still no methodical support by mapping the product demands into the plant configuration. This can be achieved only if plant structure and functionality and product specifications and demands are integrated simultaneously in the larger frame consisting of an integrated product and plant model. The main idea in our current research is to establish a link between the product and the corresponding plant definitions and in this way to meet the demand of plant and control software (re)configuration.

1. INTRODUCTION

Nowadays is not enough to model separately the product, the technological process and the plant on which this process will run. There is a need for formal models implementing all these three partial aspects of the production process, thus enabling fast changes (reconfiguration) of plant structure and control software due to product changes. The Reconfiguration Problem becomes central in advanced manufacturing systems. Product and Plant Lifecycle Management are strongly linked issues, becoming an important part of today's innovative production and business processes.

Making the plants free configurable is difficult due to problems caused by system complexity. The lack of common methodology and models on high abstract level results in the separate management of mechanic, electric and control documentation. The missing link between the concept definition of the manufacturing system and the developing of the control software makes the maintenance and tracking hardware and software changes difficult and time-consuming. Additionally, there is no integration of the product and the plant models. Last but not least, different business processes running in the company and related to current plant configuration have to be considered.

Useful ideas and successful implementations exist in two closely related domains – the **software design and implementation** and the **virtual engineering**.

The Unified Modeling Language (UML) [1, 2] provides the needed model-based design, implementation and code generation in a certain language framework. Existing Data Models can be reverse engineered to UML-models. Graphical notation and high level of abstraction helps to describe and manage complex structures, relations and components behavior. The models are executable and can be animated for validation and debugging. Further more, specialized dialects can be build-up on the top of standard UML implementations.

The Virtual Engineering (VM) [3] goes beyond the scope of traditional modeling and simulation in CAD/CIM environment and implements the following three main principles:

- **Model and Simulate**, which means to do manufacturing activities „virtually in the computer";
- **Predict and Evaluate**, which means to determine what would happen if the activities were actually carried out;
- **Make Improvements**, before the actual manufacturing is done.

In this sense the Virtual Product could be seen as an important engineering technique for internal rationalization and facilitation of the engineering process.

Significant number of research projects deal with closing the gap in the production chain beginning from the planning stage up to simulation of production processes within a common infrastructure framework of software tools with compatible interfaces. Formal methods, development environments and tools aiming the design and synthesis of mechatronic systems are researched and implemented [4].

The goal of our research is to formalize and automate at the first step the engineering design of the DriveSets and to create an informational design environment closely linked with the other program systems, supporting the business processes in the company. The results of this stage are important for the second, more ambitious goal – the straightforward implementation of the control software based on software templates, product requirements and actual plant configuration.

2. CASE STUDY

Significant work is already done in the direction of structural and functional decomposition, design and implementation of positioning and handling systems for automation purposes [5, 6, 7], produced from the company Systec, Germany (www.systec.de). The company implements the concept of "the virtual product" [4] and offers pre-engineered "custom-tailored" solutions (Drive Sets) according to the individual clients needs.

As a design object these modular positioning and handling systems (www.drivesets.de) expose the following features:

- they are complex modular technical systems;
- they are described with diverse sub-systems, structures and parameters;

- their development imposes observance of a large number of requirements and constraints.

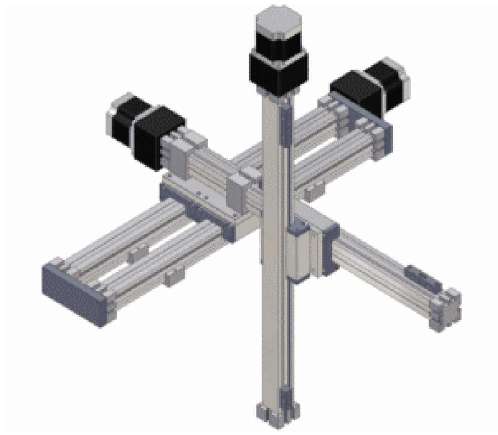

Fig. 1 The DriveSet as a modular technical system [www.drivesets.de]

Another important reason to choose this particular design object as example is the company's own controller, programming language and software development system for control code generation, realizing the needed functionality of the handling system.

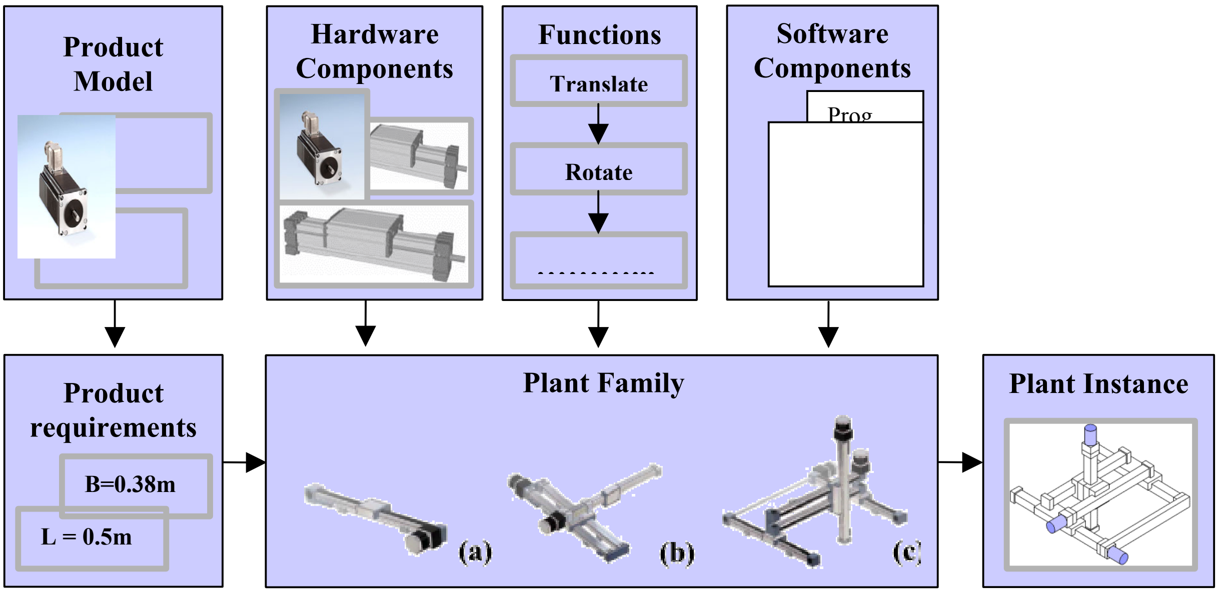

Fig. 2 Configuration and Instancing

As shown above, the plant description based on structural and functional decomposition can be derived from:

- The set of configurable components and their structural relationships,
- The description of devices and functions as operations and states and
- The control code, responsible for the action and interaction of the components.

These design and configuration process has to be driven generally from the product model description, in particular from a set of plant relevant product characteristics.

For the plant description can be used a multi-level object-oriented approach. Each level uses the objects and methods defined by the inner level. The highest-level objects use as input the parameters describing the characteristic of the individualized products. The functions of the lowest levels use directly the possibilities that are offered by the control devices of the plant components. The straightforward implementation of this idea deserves appropriate methodology and tools.

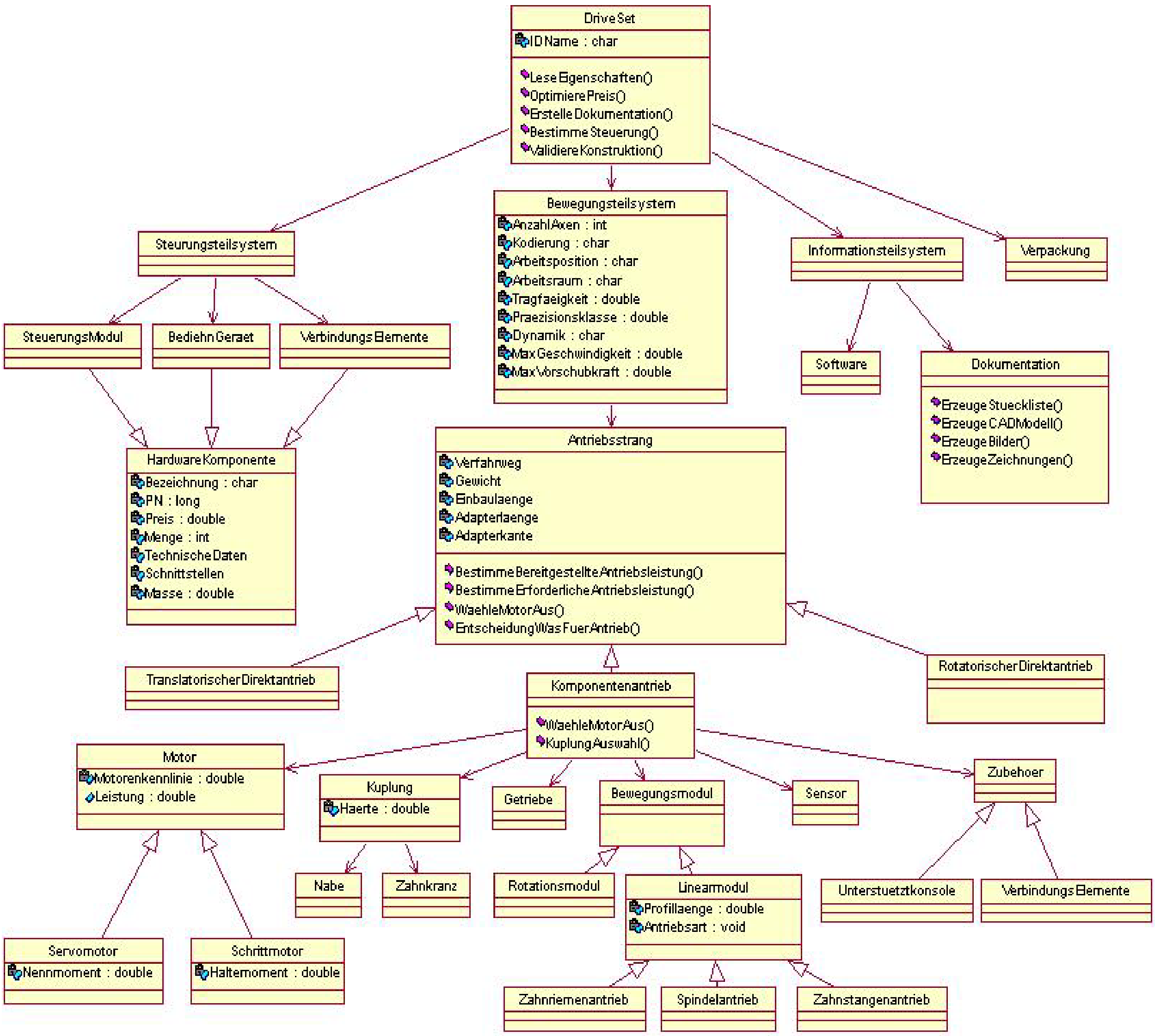

Fig. 3 Class Diagram: Logical View of the DriveSets

The above mentioned considerations defined the use of UML in the attempt to describe on both structural and functional level a plant model of configurable system that can be used for transportation, testing or assembly purposes.

In the frame of a common research project following results was obtained:

- An UML model with relationships between the structural components was defined (Fig. 3),
- A data base model was derived from the UML model (Fig. 4),

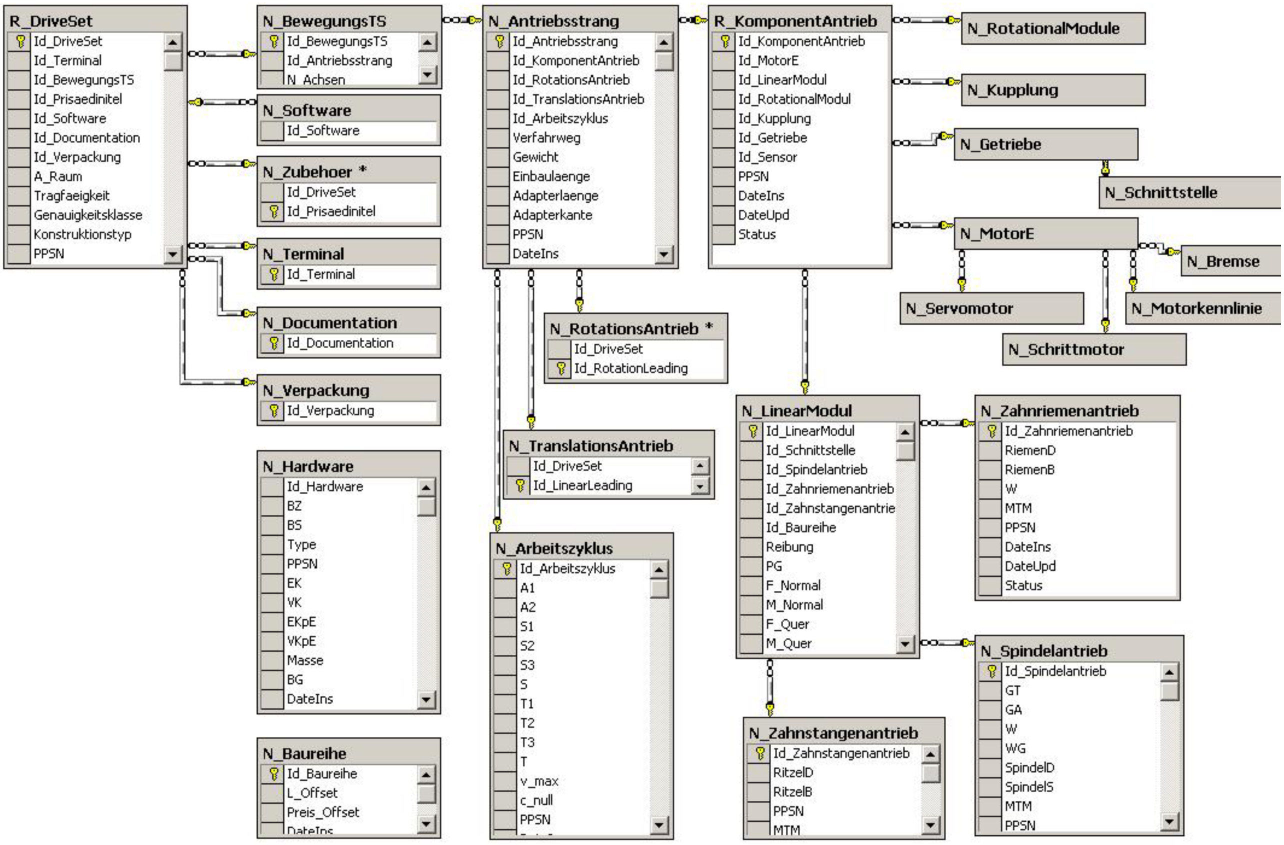

Fig. 4 Relational Data Model of the DriveSets

- Catalogs data for the different OEM components was used to fill-in the Database and
- Instances of complete systems was created in accordance with predefined criteria, rules and restrictions, based on needed static and dynamic characteristics of the system, spatial and operational structure, etc. [3].

The static and dynamic characteristics of the system instance with the optimal spatial and operational configuration of the components and their control code generation will be derived at the next step from the product model (e.g. weight, physical dimensions of transported parts, trajectories, etc.)

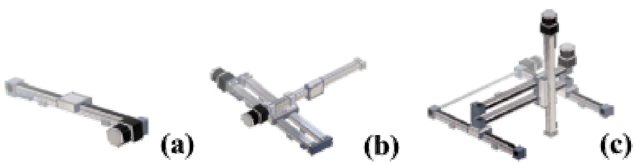

Fig. 5 3D-models of the *DriveSets*-family instances (a), (b), (c)

3. CONCLUSIONS

Current research results address the object-oriented plant description with UML tools and the development of common informational environment for design and lifecycle management of plant configurations.

The arising plant reconfiguration problems by the production of product variants demand deeper inside in the design and configuration of plants and control software in a common informational environment and their formal description on a higher abstract level.

As soon as the Configuration problem for these given class of mechatronic systems is solved, the Reconfiguration problems can be deeply addressed.

The integration between the code generation templates and the model components will enable in the future a self-acting configuration of the whole plant driven by the specific product parameters.

4. REFERENCES

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