Grace

inteGration of pRocess and quAlity Control using multi-agEnt technology

Grace project

The EU FP7 Grace project aims at **integrating process and quality control within a production line**. This goal is fully in line with the trend to develop modular, intelligent and distributed manufacturing control systems.
The system is based on a collaborative Multi-Agent System (MAS) which operates at all stages of a production line and it is complemented by self-adaptive control schemes developed at the level of process resources and quality control stations as well as at line or factory level. The MAS aims to individually tune parameters of each product taking into account information collected during the whole production process, so to compensate production process variance.
The innovation is the **new vision of the production process which leads to a deep integration of process control with quality control and finally product value**.

Engineering Methodology

How to apply decentralized manufacturing to your production systems?

The main objective of the engineering methodology is to identify the impact of Grace control concepts on manufacturing engineering activities, to create suitable and effective engineering concepts for decentralized automation and to render them applicable for industrial applications. The following objectives will be reached:

- An **activity model-based engineering process** supporting the combination of manufacturing entities for rapid creation of case dependent Grace MAS platform adaptations using standardized interfaces;
- A **possibility to easy extend Grace MAS platform** capability for providing changed/additional functionalities with a minimum effort in order to enhance and adapt MAS to changing requirements from products, types of production and quality assurance, or manufacturing technology;
- A **support for the management of production models, data and further relevant information** on Grace MAS platform and its engineering including behavior modeling for control application and overall behavior analysis.

The big picture

For the complete understanding of the engineering methodology it is crucial to realize that it is not just one monolithic piece. Instead the methodology is a big picture that accrues by putting a lot of puzzle pieces together (Figure 1). Some basic models on which the engineering methodology is based on are the MAS approach and the according Grace MAS architecture, the mechatronic unit approach, an engineering process reference model and engineering process meta-model, some basic engineering

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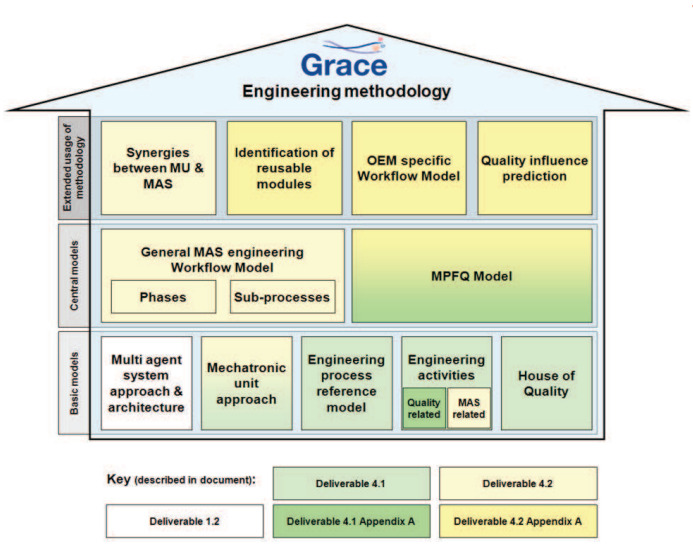

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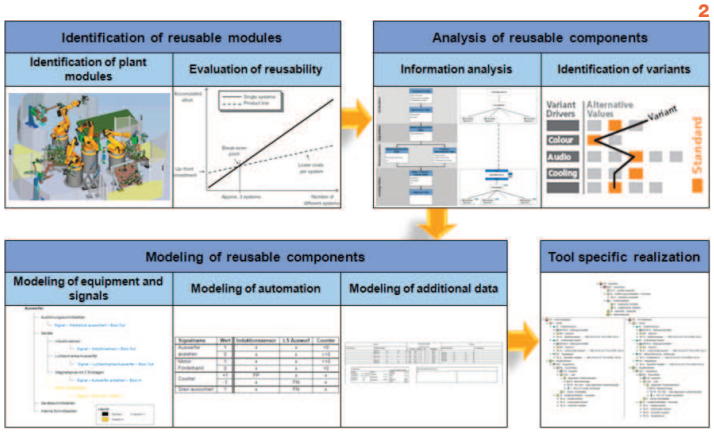

2

1 Grace engineering methodology

2 Development process for reusable modules

activities, and the House of Quality.
The subsumption of these approaches and findings builds the foundation for the whole engineering methodology. Utilizing these basic input models comes the next level within the engineering methodology. These are the central methodology models, namely the general MAS engineering workflow and the Material-Process-Function-Quality Model (MPFQ model).
On top of these central models there is some extended usages of the methodology. Thus, synergies between the mechatronic unit approach and the MAS approach can be achieved, and approaches for the identification of reusable modules, the prediction of quality influences within the engineering and also an OEM specific workflow can be given.

Activity model based engineering process (workflow)

The engineering process workflow as one central part of the engineering methodology was developed based on the general engineering process reference model. It can be divided into two sub-processes: the “development of reusable modules”, where modules are modeled and realized for reusability within a specific engineering project, and the “engineering project” itself, containing all activities and documents needed for the engineering of a production line/factory.

Development of reusable modules

The development process for reusable modules starts with the identification of reusable modules. Here different projects are taken as an input to first identify which are the modules of a plant and subsequently elaborate their reusability potential. A methodology to perform this identification process is also developed within Grace. An overview is given in Figure 2. The outcome of these activities is a list of reusable modules.
All modules of this list are then analyzed regarding to their information. Based on this analysis also different variants can be identified (e.g. using the METUS® approach). To ensure a maximal reusability also across different engineering tools the reusable modules and its variants are modeled tool independently. This includes all mechanical, electrical, automation, and other data. Only then the modules are realized within a specific engineering tool.

Engineering project

The sub-process “engineering project” starts with process planning phase. Herein requirements are specified and then used as a basis for the plant modularization. Within the second phase -“basic engineering”- these outputs are used to select modules out of the library of reusable modules built up in the development of reusable modules phase and a system concept is derived. This concept is continuously detailed, e.g. by instantiating the reusable modules.
The next phase -“detailed design”- starts with the domain specific implementation of the modules. Here the instantiated modules are refined and modules which are project specific and thus not reusable are created, resulting in a detailed module/component specification. These specification drawings are then evaluated, leading to a first acceptance of the module drawings. Afterwards the modules and components are integrated into the overall plant which is then undergoing an integration test. The final result of the detailed design is a tested detailed system specification of the plant taking into account the information of every involved discipline.
This is the starting point for the last project phase -“realization & commissioning”-, where the real modules are tested and integrated. The final step of the engineering process is the final integration test (also called FAT) of the plant.

The MPFQ model

The second central model of the engineering methodology is the Material-Process-Function-Quality Model (MPFQ model). It is currently still under development but a first version of this model was already used by Siemens AG within the common workshop with Whirlpool S.r.l. to identify crucial engineering activities from a quality point of view and to work out the dependencies between the final product quality (e.g. of a washing machine) and the engineering of the manufacturing line. Here over 100 influences of the engineering on the final quality produced on the production line could be identified. The final model will be presented in the near future.

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