Model and Dependency Management in Mechatronic Design

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Abstract

Managing consistency is a major concern in the design of complex engineering systems. At times, inconsistencies may lead to wrong decisions, resulting in design flaws which can compromise safety and cause failures. One cannot forget the 1999 NASA unmanned MARS Climate Orbiter, which was destroyed due to use of inconsistent units by design teams. Sadly, the history of inconsistency causing failures does not end there. In 2006 Airbus suffered a massive 6.1 billion dollar loss due to use of inconsistent specifications in different versions of design tools. So what causes inconsistency, and how best to avoid it? These are some of the critical questions behind the research reported in this thesis.

Today's engineering systems cannot be designed by a single individual, but require the efforts of design teams each managing a portion of the overall problem. Naturally, information exchange between teams is necessary for effective decision making. However such communication is often error-prone and inadequate to manage dependencies between tasks, operations, components or properties. As a consequence, inconsistencies and design errors arise, which may cause catastrophic failures.

This thesis investigates the nature of dependencies, typically in the design process of mechatronic products, and proposes an approach for model and dependency management. The proposed solution is based on an expressive Domain Specific Language which enables capturing dependencies (between disparate models) formally and explicitly. This language is called the Dependency Modeling Language (DML), and the supporting tool is named the Dependency Modeler. The overall approach is exemplified through a robot design example, where the DML is used to capture dependencies between mechanical design and control design models. In support of the DML, dependency patterns gather known dependency relationships between different types of properties - such as a pattern between system hierarchy and mechanical CAD assembly. Model transformations are essential to support execution of such patterns and to support the necessary information exchange between disparate models to enable dependency modeling. Transformations supporting the dependency pattern between system hierarchy and mechanical CAD assembly are illustrated for the robot example. Initial reflections on the Dependency Modeler show a strong potential to support change management, workflow management and consistency management.

Future work targets further development and testing of DML in order to achieve a sound platform for dependency management. A development environment supported by an integration framework - encompassing different model-based design tools - is envisioned as an infrastructure for model management in mechatronic design. It is hoped that such an infrastructure will
equip designers with the best possible tools to make better decisions and to spot design errors that might otherwise be fatal.

**Key Words**
Dependency Modeling, Model-Based Systems Engineering (MBSE), Mechatronic Design, Model Integration, Tool Integration, Common Language, Mechatronic Challenges, Domain Specific Language.