Reducing risk in innovation

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Keyword Index
Welcome to the 15th International DSM Conference in Melbourne, Australia. Complexity is perceived as an ever-present challenge in almost every business. The increasing complexity and the need for integration of systems and processes and their components in an increasingly complex, risky and globally distributed operating environment drives the search for simpler, leaner and low risk product, process and organizational architectures.

Especially the design of highly integrated systems, the management of process focused organizations and the adaptation of new products to different markets require robust approaches to the smooth and efficient modelling, analysis and synthesis of appropriate solutions to working with such complexity that work at the front end of innovation.

The understanding of dependencies in complex systems early in the innovation phase can lead to the generation of better, unique and copy-proof product architectures and intelligent management of innovation risk. This enables and drives innovations otherwise not possible. Therefore, if managed the right way, working with complex systems provides many opportunities to a business that cannot be realized otherwise.

Over the last couple of decades Dependency and Structure Modelling (DSM) methods have found their entry as mainstream applications in many corporations in many industries around the globe.

The formation and consolidation of the DSM industry Special Industry Group (DSMiSIG) as a supporting mechanism for DSM users in industry has proven itself over the last 12 months.

However, a strong scientific basis and continuing testing of new DSM methods and applications by scientists and industry practitioners alike is required to ensure that new systems and processes in industry are fulfilling the expectations of industry in improved system and process performance.

With an original strong homebase in the US and Europe the DSM community expanded its range significantly. After an outstanding event in Japan 2012, this year the community meets in Australia for the first time.

The two days of this annual conference are designed to act as a catalyst and forum for scientific discussion, interaction with industry and the members of the DSMiSIG and as a springboard for framing the scientific direction of DSM methods for the next few years.

Elke Scheuermann, Mike Stowe and Maik Maurer
Scientific Committee

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The International DSM Conference is an endorsed event of the Design Society.
Part I: Application of DSM and Matrix Methods

Three examples of how DSM enhances engineering design automation
Joel Johansson, Fredrik Elgh

Application of DSMs for Analyzing Product and Organizational Structures
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Evaluation of a non-conformity matrix complexity using components modularity metrics
Arsalan Farooq, António Araújo, S. M. O. Tavares, Henrique Nóvoa
Abstract: Since the automation of engineering design activities through increasingly complex computer systems is a big trend among manufacturing companies the need of supporting the maintenance of such systems now quickly emerges. In this short paper, we show how DSM has been used in three different automation projects, targeting the design of engineer-to-order-products, in order to ensure that the knowledge automated by the systems is consistent and easily accessible to engineers. The DSM was used to varying extent both during the development of the systems and in runtime of the resulting design automation systems. Three levels of usage of the DSM within the design automation systems were identified: “visualization only”, “static execution sequencing”, and “dynamic execution”.

Keywords: Automated Engineering Design, Inference Engine, Knowledge Object

1 Introduction

Knowledge based engineering (KBE) aims to automate engineering tasks by means of knowledge based systems (a branch of computer science). The fact that the concept of KBE has many definitions might be due to the wide area of knowledge-based systems and their many sub-categories. One widely used definition of KBE, that is adopted here, is the one stated by Stokes (Stokes 2001): “The use of advanced software techniques to capture and re-use product and process knowledge in an integrated way.”

A general structure of a knowledge based system is shown in Figure 1, adapted from (Hopgood 2001), and as seen in that figure, the two keystones in a knowledge based system are the knowledge-base and the inference engine. The knowledge base is comprised of facilities to store knowledge in the sense of information in context, here referred to as automated knowledge. This means that structuralized data is stored with its context in a way that makes it possible for the inference engine to make use of it. Hence, the knowledge is separated from the routines (the inference engine) that make use of the knowledge.

It is possible to define the knowledge base in different ways, using different knowledge representations. The knowledge base must of cause be machine-readable, which means that the knowledge base is designed to make the computer system able to automatically reason based on the automated knowledge. It would of course be highly beneficial if a machine-readable knowledge base was also human-readable, and much effort has been put to achieve this. One big problem with the KBE-systems is that the jungle of relations of different types grows very quickly over time and it becomes hard to navigate through it. The use of DSM to bring structure to the knowledge base at design time of the system and
Part I: Application of DSM and Matrix Methods

during run-time has proven to be successful in three design automation projects. The scope of these projects and how they were supported by DSM is outlined in this paper.

Figure 1. The main components in a knowledge-based system are the knowledge base and the inference engine.

1.1 Related work

The usage of DSM to manage engineering design knowledge has gained attention during the last few years. Sharif et al. studied how to use DSM to support the acquisition and management of knowledge for customer order driven engineering (Sharif and Berman 2007). Hung et al. studied how to make use of DSM to control product knowledge stored in a database (Hung et al. 2008). In that case, the focus was on how to integrate DSM and Quality function deployment (QFD) and how to plan the design process of developing new products. Tang et al. investigated how to structure captured knowledge through DSM in order to retrace design history, rational, decisions and assumptions (Tang et al. 2010). Bhaskara also showed how to use DSM for capture and reuse knowledge, but also how to use DSM to analyze the impact of design changes and for managing the requirements and design rules (Bhaskara 2010).

2 Case one: CoRPP – Knowledge processing with predefined static flow

The primary purpose of the CoRPP (Coordinated Realisation of Products and Processes) system was to support the company in its effort to gain design solutions with enhanced producibility through studies of variations in cost, weight and operation time, as described by Elgh and Cederfeldt (Elgh and Cederfeldt 2007).

The main element of the bulkhead is a circular plate with vertical structural members, which consist of cut, rolled and welded steel plating, as shown in Figure 2.
The system was developed together with an industrial partner and a research institute using a commercial off-the-shelf (COTS) approach (comprised of MS Access, MS Excel, MS Visual Basic, Mathsoft Mathcad, and PTC Pro/Engineer). The modules for process planning and cost estimation were developed by one of the authors. The system was considered to have many areas of use at the company: design calculations, design optimization, geometry modeling, automated CAD generation, knowledge repository, design manual, process planning, cost estimation, operation time estimation, and weight calculations.

The system architecture was modular, where the knowledge was “captured” in knowledge objects grouped in separated modules. Further, the system consists of a geometry modeller separated from commercial software for solid modeling. An extended product model was implemented in the geometry modeller supporting the process planning and cost estimation of the product.

The bulkhead was modeled in a software application as parametric solid models, using methods that permit dimensional and topological changes. The geometry modeller drives the parametric solid models. A nomenclature was defined and implemented. This enabled the mapping between the geometry modeller and in the standard process plans. Standard process plans, with the integration of a system for cost estimation, were created in a common spreadsheet software application. The operations in the process plans were activated in either of two ways: if there was a corresponding feature in the geometry model, or in accordance with rules where operations are interrelated. Geometrical and topological cost drivers were identified and corresponding parameters stated in the standard process plan. Production data and costs for production resources were gathered in tables.

DSM played an important role during the development of the CoRPP system. Design parameters and knowledge objects were retraced and developed through interviews and workshops together with the expert engineers. The relations between the knowledge objects were analyzed based on common parameters of knowledge objects, so that if knowledge object B has input parameters that come from knowledge object A, then B is depending on A. The DSM was filled in during the development of the system and