REINISCH SYSTEM THEORY IN COMPLEX SYSTEM DESIGN AND VERIFICATION

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Karl Reinisch was one of the first scholars who saw the generality of system and control theory, that can not only be used for designing control and signal processing problem but can contribute to understanding of all areas of science and philosophy. It is a basic principle underlying human thought and understanding. With this understanding he tackled complex problems in engineering and biology. He excited scientists, philosophers and people of other disciplines around the world about the power system theory.

One of the most challenging problems today is the design of complex systems. Less than 4% of designs have no critical problems. The current design methodologies do not work. Problems are not only in engineering methodologies but also in organizational processes that coordinate scientists and engineers, and communications between people of different disciplines who are cooperating on design and development. A solution of this problem must encompass the Reinisch system theory and find a coordinated solution between philosophies and methodologies of different disciplines.

Complex systems are always designed and developed by groups of people, departments and/or companies. The system is partitioned into subsystems and subsystems are assigned to different groups. Each group typically has unique knowledge in a particular field and will use their own methodology, models and software system for the design of their assigned component.

For design, validation and verification design groups will consider a range of possible parameters and use approximate models for analysis. Different designers/developers will exchange information about their components to other designers according to design or process graphs, Figure 1. The exchanged information typically will not include all assumptions and ranges of uncertainty considered in the design of components. The reason is that some of the uncertainties are very specific to the field of knowledge used for a component and other designers will not understand this information nor will they be able to properly evaluate potential interactions between components in different subsystems.

For ten designers doing a conceptual design and each is passing on a minimum and a maximum of one component specific parameter to the integration team, the integration team would require to integrate 2^{10} different system designs for analysis and verification. This would be too time consuming when done manually. It is therefore not done. For system integration, each team will pass on their "best" design to the integration team.

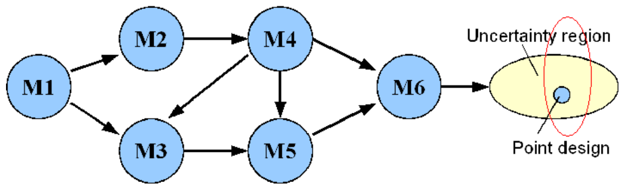

Figure 1: Design process graph

The integrated system is therefore not verified for variability due to uncertainties in subsystems and interactions between components located in different subsystems. Hence nearly 0% probability of having no critical errors in a complex system design.

The design must be automated, in order to overcome this problem. 2^{10} iterations of a simulation are not very unusual, dependent on the complexity of the simulation. Figure 2 depicts such an automated design process simulation. Each designer has to develop an executable model of her/his design methodology. Process engineers design the process design graph that connect the executable design methodologies.

The simulation generates a set of feasible designs and maps component uncertainties into system uncertainties of coupled designs and can determine which designs meet system requirements for all uncertainties in parameters, architecture, missions/use cases, and environment. If the system performance falls within the permissible performances of the design specifications, the design is verified.

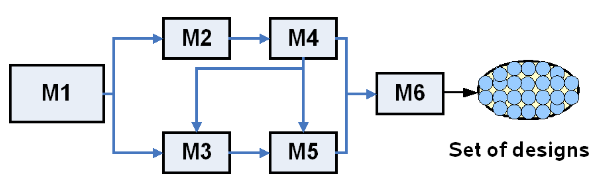

Figure 2: Executable design methodologies, connected by a design process graph

The technology for executing simulation sets connected by a design graph is currently being developed. First results on using this technology for the example of architectural exploration of avionics systems showed orders of magnitude improvements in reliability.