International Council on Systems Engineering
New England Chapter Meeting

Advances in Computational System Architecting: Architecture Decision Graph (ADG)

Speaker: Dr. Willard L. Simmons, VP of Technology at DataXU

Date: **Wednesday, January 14th, 2009**

Time: **6:00-6:20pm Social / Refreshments**
6:20-6:40pm Chapter Meeting / Networking
6:40-8:00pm Featured Presentation

Location: **Avidyne Corporation, Constellation Conference Room**
55 Old Bedford Road, Lincoln, MA. 01773

Reservations:

For planning purposes, please RSVP at info@incose-ne.org

For further information about the International Council on Systems Engineering, please see the INCOSE Chapter website at http://www.incose-ne.org/

Cost: $10 for members, Free for students and first time attendees

About the Presenter

Dr. Willard Simmons completed his PhD in Aeronautics and Astronautics at MIT in January 2008, specializing in the nascent field of Computational Systems Architecting. Specifically, Dr. Simmons' research created a decision-based computational approach that is applicable in the systems architecting phase of the systems engineering lifecycle. Though the use of this technique, systems architects can represent and automatically generate larger spaces of possible designs than previously possible. His research has been applied to current NASA Mars Exploration systems as well as BP Arctic Oil Exploration systems.

Dr. Simmons is currently employed as the VP of Technology at DataXu, a Cambridge-based startup that is developing new technologies to disrupt the way advertising is bought and sold on the Internet. Dr. Simmons previously designed extra-solar planet finding

telescope systems at Princeton, worked as a Controls and Propulsion Engineer for the Chandra X-ray space telescope at TRW (now Northrop Grumman), worked as a Rocket Guidance, Navigation and Controls Engineer at Lockheed Martin, completed an MS degree in Aerospace Engineering at University of Colorado and a BS degree in Mechanical Engineering at University of New Hampshire.

Abstract

Systems Architecting is the early stage of the Systems Engineering lifecycle. The job of a systems architect is to take a fuzzy set of needs and goals and transform it into an *architecture*: a high-level, but stable mapping of system functions to system forms. Traditionally, Systems Engineering is done by a group of wise engineers who brainstorm many ideas, then use their experience and judgment to cull it down to a smaller set of alternatives. It is often stated in systems engineering literature that it is impossible to automate these tasks. However, recent research at MIT is developing new techniques and computational tools that combine the power of computational theory with systems engineering methodologies. The overall goal of the research group is to produce game-changing techniques that will disrupt the way people think about systems design. The general approach is the develop techniques that allow a human engineer to focus on what he or she is good at: creative thinking and describing relationships between small numbers of parts of the system, then allow a computer to do what it is good at: tedious calculation for generating alternatives, evaluating constraints, and simulating entire systems. Today's topic focuses on one technique that has come out of this research, the *Architecture Decision Graph* (ADG).

Architecture Decision Graph is a computational framework that supports human decision-making by providing a methodology for generating and analyzing architectures as the result of a set of interrelated decisions. ADG's explicit representation of an interconnected decision problem is a bipartite graph of decision variables, property variables, logical constraints, and property functions. The Architecture Decision Graph's framework provide tools for reasoning about the structure of a decision problem, generating the set of feasible combinations of decisions, and simulating their outcome. The underlying computational engine used by ADG is the Object-Process Network (OPN) kernel.

The contribution of this research to the field of systems architecting falls into three areas: First, the research contributes the ADG representation of an architectural candidate space as a set of interrelated decision variables. Second, the research contributes the ADG framework, which leverages the ADG representation of architecture to transform an architecting problem into a computational problem. Third, this research contributes decision space viewing tools, which present the potential impact of changes in the assignments of the decision variables to an architect.

The ADG representation, analysis methodology, and tools are demonstrated with two applications. The first application is a retrospective study of the architectural decisions related to the development of the Apollo moon project of the 1960's. The second application is a study of decisions in support of NASA's lunar outpost architecting effort. The applications include discussions of the practical considerations related to the use of ADG as a decision representation method, the efficiency of the simulation algorithm, and a discussion of the architecting insights that can be drawn from the results.