Proceedings of the 1993 Winter Simulation Conference
G.W. Evans, M. Mollaghasemi, E.C. Russell, W.E. Biles (eds.)

HIERARCHICAL MODELING FOR DISCRETE EVENT SIMULATION (PANEL)

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ABSTRACT

This panel session is to discuss the issues and current research in hierarchical modeling for discrete event simulation. Three academic researchers are to briefly describe their research in hierarchical modeling and the issues and one industrial practitioner will present the issues from a user's perspective.

1 BACKGROUND

This write-up has been prepared by the session organizer and chair, Robert G. Sargent, and represents his views. The panelists may have different views.

It is interesting that (discrete event) modeling and simulation is the commonly used approach to study complex systems and yet none of the (major) discrete event simulation languages provide for hierarchical modeling. (There are a few specialized simulation languages such as RESQME (Gordon et al. 1990) that does provide some form of hierarchial modeling capability.) One would expect that hierarchical modeling would be a "standard" capability in simulation languages. There are several reasons that hierarchical modeling capability is desirable. These include modeling ease (e.g., reducing the time and effort required to develop models), allowing for model reuse (a topic of long standing interest, see, e.g., Sargent 1986), reducing the number of specific models required, allowing for the use of a data base of models (see, e.g., Zeigler 1984), and aiding in model validation (Sargent 1992b).

Why is hierarchical modeling not readily available? Hierarchical modeling usually requires "encapsulation". In modeling for simulation, we model such that, depending on the world view, an event an activity, or a process can interfere with another (such as in canceling) or use information from each other. (See Cota and Sargent (1992) for a discussion on this regarding the process-interaction world view.) Encapsulation requires a fundamental different way of modeling than is the "current practice" and how simulation languages are designed to be used.

Recently, the use of object-oriented programming languages which uses encapsulation of objects and message passing has lead to the idea of encapsulated modeling where "submodels" are encapsulated and messages pass between them using object-oriented programming languages. This approach of using object oriented programming languages is referred to by Cota and Sargent (1992) as the passive receiver approach as contrasted to the active receiver approach where messages queue at objects and are received by the objects when they want the messages (Cota and Sargent 1992).

2 APPROACHES TO HIERARCHICAL MODELING

Sargent (1992a) presents three basic approaches to hierarchical modeling for discrete event simulation. One approach is to use the "closure under coupling" approach of Zeigler (1984) where a "model" can be decomposed into a set of "connected submodels" or "submodels" can be connected into a "model" when the requirements of closure under coupling are satisfied. This approach is rather straight forward to use. A second approach, is to use metamodels (Kleijnen 1987), where a metamodel replaces one or more submodels. (This approach needs considerable development prior to becoming feasible to use; see, e.g., Sargent 1991.)

A third approach is to use a "specific software frame" that "plug compatible" submodels can plug into or communicate by passing messages. The specific software frame is often called a "backbone" in the Air Force and is called a "Base Model" (Duse et al. 1993) by the Advanced Modeling Project in the Center for Computer Integrated Manufacturing (CIM) at Oklahoma State University. In the latter case, "primitive objects" are developed for a library or data base that can be "plugged" together to obtain higher level objects (models). The software frame is what coordinates the simulation model and they are usually developed for a specific type of system or problem, e.g., a CIM system or a particular type of military system. An object oriented programming language is often used in this approach.

3 CHAIR AND PANELISTS

This panel session consists of three academic researchers and one industrial practitioner. Each of the academic researchers are pursuing a different paradigm in developing hierarchical modeling for discrete event simulation. They will each (briefly) describe their paradigm and present the issues as they see them. The industrial practitioner who is highly interested in model development will describe the issues in hierarchical modeling as he sees them. Following these presentations, a discussion - hopefully spirited - will take place among the panel and audience.

Bernard Zeigler has been involved with hierarchical modeling for a number of years and was probably the first such person - perhaps he is the father of hierarchical modeling for discrete event simulation. He developed the concept of "coupling under closure" for hierarchical modeling for discrete event simulation (Zeigler 1984). Furthermore, he and his students have developed a discrete event simulation system having hierarchical modeling capability called DEVS-SCHEME (Zeigler 1990) - based on DEVS (Zeigler 1976) and coupling under closure (Zeigler, 1984). This simulation system is for modeling and simulating any type of discrete event system (i.e., it is not oriented towards any specific application domain.)

Joe Mize and his group has been studying the use of modeling and simulation of CIM systems. Apparently, their initial interest was in model reuse but has now involved into also developing a new model paradigm for discrete event simulation which includes hierarchical modeling and modeling environments. This work is summarized in Advanced Model Project: Program Description and Accomplishments (1993). (Also see Bhuskute et al. 1992, Duse et al. 1993, Mize et al. 1992, Pratt et al. 1992 and 1993.) They are using the object oriented approach where they have plug compatible primitive objects and model from "bottom up." They use a base model (a software frame) and their system is for modeling and simulation of CIM systems. This system uses the object oriented programming language Smalltalk-80.

Robert Sargent and his group have been developing a simulation system that will allow hierarchical modeling and will allow the simulation models to run on different computer architectures (i.e., sequential, parallel, or distributed computers) without any involvement of the modeller (i.e., the modeller does not need to model differently for different computers architectures or add additional information.) The paradigm they are using is based upon Control Flow Graphs (Cota and Sargent, 1990c) which is a directed graph model representation that allows analysis to be performed on it to provide the information needed for algorithms that have been developed for different computers architecture (Cota and Sargent, 1990a and 1990b). Control Flow Graphs are based upon a modification of the process world view as described in Cota and Sargent (1992) and uses the active receiver approach. Hierarchical modeling (Fritz and Sargent 1993) capability is provided by a hierarchical modeling language which uses "coupling under closure" and converts a hierarchical model into a control flow graph representation. This system uses the process-interaction world view and is to model and simulate any type of system. Furthermore, this paradigm satisfies the requirement specified in Sargent (1992c) for a new model paradigm.

David Withers has had considerable experience with using modeling and simulation in industry. He is interested in model development and in improving the productivity of developing models. Furthermore, he has experienced the lack of model reuse and the need to have a large number of simulation models using "current approaches". One approach that his group is exploring to help address these issues is Data Driven Simulations (see, e.g., Pidd 1992).

4 SUMMARY

This panel session presented the issues in hierarchical modeling for discrete event simulation, described three different paradigms being researched for hierarchical modeling, and discussed the issues and current research. It is hoped that this panel session will stimulate additional research into hierarchical modeling and practitioners to demand such capability in simulation languages.

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BIOGRAPHIES

JOE H. MIZE is Regents Professor of Industrial Engineering and Director of the Center for Computer Integrated Manufacturing at Oklahoma State University. His research interests are in advanced modeling/simulation environments and manufacturing systems integration. He has authored six engineering texts and has edited 90 others. He is a Fellow and Past President of the Institute of Industrial Engineers and is a Member of the National Academy of Engineering.

ROBERT G. SARGENT is a Professor at Syracuse University. He received his education at The University of Michigan. Dr. Sargent has been awarded the TIMS College on Simulation Distinguished Service Award for long-standing exceptional service to the Simulation Community. His research interests include the methodology areas of modelling and discrete event simulation, model validation, and system performance evaluation. Professor Sargent has published widely, is a member of Alpha Pi Mu, New York Academy of Sciences, Sigma Xi, ACM, IIE, ORSA, SCS, and TIMS, and is listed in *Who's Who in America.*

DAVID WITHERS is Director of Re-Use Engineering and Modeling at Mead Data Central. He received a BS in Engineering from the U.S. Coast Guard Academy, and MS degrees in mathematics and computer science from Rensselaer Polytechnic Institute. He has held a variety of management and technical positions with the U.S. Coast Guard and IBM. His research interest is in improving the productivity of model development. He was on the committees for the 1991 and 1992 Winter Simulation Conferences and is a member of ACM, ORSA, TIMS, and the TIMS/CS.

BERNARD P. ZEIGLER is a professor in the Department of Electrical and Computer Engineering at The University of Arizona. His research interests includes artificial intelligence, distributed simulation, and expert systems for simulation methodology. He is a senior member of IEEE.