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CREATING DISTRIBUTED SIMULATION USING DEVS M&S ENVIRONMENTS

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ABSTRACT

We briefly review the theory of modeling and simulation and its support for constructing distributed simulations. Formal representation of simulation models can contribute to a number of aspects in the modeling and simulation enterprise. Separation of models from simulation execution engines is a prerequisite transferring model among phases of a project as well as from project to project. The Discrete Event System Specification (DEVS) formalism, drawing on its system theoretic basis, provides a number of important properties such as hierarchical, modular composition, universality and uniqueness that can support development of simulation models and environments their development. An layered architecture for supporting comprehensive M&S environments is discussed that unifies the theoretical framework with implementation in distributed computational environments.

1 ELEMENTS OF THE THEORY OF MODELING AND SIMULATION

The theory of modeling and simulation presented in (Zeigler et al. 2000) provides a conceptual framework and an associated computational approach to methodological problems in M&S. The framework (Figure 1) provides a set of entities (real system, model, simulator, experimental frame) and relations among the entities (model validity, simulator correctness, among others) that, in effect, present a model of the M&S domain.

The computational approach is based on the mathematical theory of systems and works with object orientation and other computational paradigms. It is intended to provide a sound means to manipulate the framework elements and to derive logical relationships among them that are usefully applied to real world problems in simulation modeling. Interestingly, the framework and systems theory are intimately linked as suggested in Figure 2. The framework entities are formulated in terms of the system specifications provided by systems theory, and the framework relations are formulated in terms of the morphisms (preservation relations) among system specifications. Conversely, the abstractions provided by mathematical systems theory require interpretation, as provided by the framework, to be applicable to real world problems.

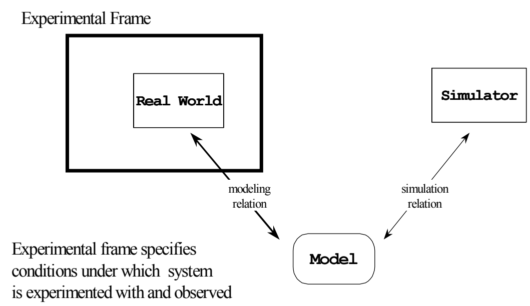

Figure 1: Entities and Relations of M&S in Framework

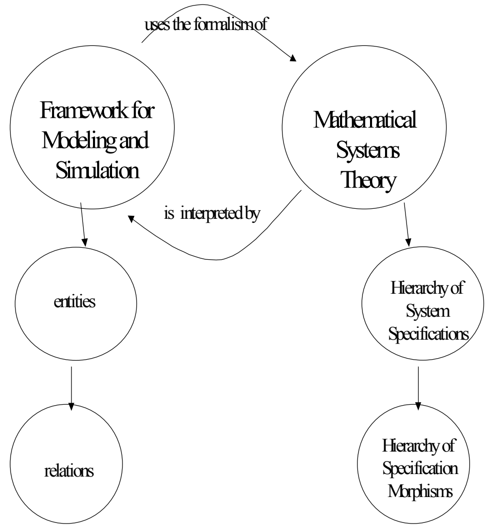

Figure 2: Interaction of Systems and M&S Concepts

2 AN ARCHITECTURE FOR M&S

Figure 3 shows a conceptual layered architecture that is intended to provide a framework for implementing comprehensive environments for M&S. We outline the layers:

- *Network Layer* contains the actual computers (including workstations and high performance systems) and the connecting networks (both LAN and WAN, their hardware and software) that do the work of supporting all aspects of the M&S lifecycle.
- *Simulation Layer* is the software that executes the models to generate their behavior (the essence of simulation). Included in this layer are the protocols that provide the basis for distributed simulation (which are standardized in the High Level Architecture (HLA)). Also included are database management systems, software systems to support control of simulation executions, visualization and animation of the generated behaviors.
- *Modeling Layer* supports the development of models in formalisms that are independent of any given simulation layer implementation. HLA just mentioned also provides an object-oriented templates for model description aimed at supporting confederations of globally dispersed models. However, beyond this, the formalisms for model dynamics, whether continuous, discrete or discrete event in nature are also included in this layer. Model construction and especially, the key processes of model abstraction and the DEVS-Bus representation are also included.
- *Search Layer* supports the investigation of large families of alternative models, whether in the form of spaces set up by parameters or more powerful means of specifying alternative model structures provided by the SES/MB methodology. Artificial intelligence and simulated natural intelligence (evolutionary programming) may be brought in to help deal with combinatorial explosions occasioned by powerful model synthesizing capabilities.
- *Decision Layer* applies the capability to search and simulate large model sets to real problem domains to support explorations, "what-if " investigations, and optimizations.
- *Collaboration Layer* enables people with partial knowledge about a system, whether based on discipline, location, task, or responsibility specialization, to bring to bear individual perspectives and contributions to achieve an overall M&S goal.

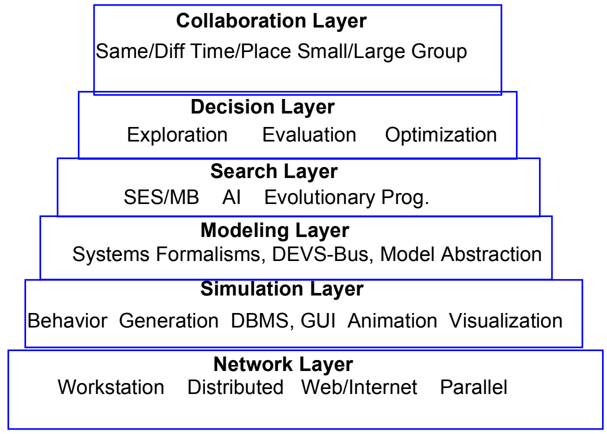

Figure 3: An Architecture for Modeling & Simulation

The DEVS/HLA M&S environment was developed to support HLA-compliant simulation based on the layered architecture (Kim, Chow, et al. 1999, Zeigler, 1999). The DEVS/CORBA M&S environment is being developed to provide a prototype of comprehensive environment which instantiates all of the features of the architecture (Kim, Buckley, and Zeigler 1999).

3 CONCLUSIONS

As computing infrastructure (computers and networks) becomes ever more powerful and the types of models that are simulated become more and more sophisticated, the software-based approach to simulation technology becomes less and less viable and the theory-based approach becomes more and more critically necessary. The DEVS formalism and its underlying system theory foundations provide a framework and a set of concepts to develop the infrastructure for supporting reusable and well-validated models executed within well-verified and fully-capable simulation middleware. DEVS has already been demonstrated to support industrial strength environments, such as Joint MEASURE^{TM}, and innovative modeling and simulation domain applications such as for distributed system design.

ACKNOWLEDGMENT

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