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APPLICATIONS OF DISCRETE AND COMBINED MODELING TO GLOBAL SIMULATION

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ABSTRACT

This paper calls the attention of discrete event modelers to some potentially important applications of their skills in the field of global simulation. It also informs them about Mission Earth.

A limited investigation of the use of discrete event simulation in world simulations is reported. It is found, surprisingly to the author, that very little use has been made of discrete event models in world simulation.

Therefore, there appears to be a good opportunity for discrete event and combined (discrete event plus continuous) modelers to make contributions to world simulation. Specific aspects of world simulation are identified as targets.

In the Society for Computer Simulation International there is an Activity which provides a home and forum for such work. The activity is called Mission Earth. Its purpose is to explore and promote the uses of simulation as the prime tool for global planning to sustain all life on earth.

1 MISSION EARTH AND GLOBAL SIMULATION

Mission Earth consists at present of 9 committees serving the foregoing purpose and providing mutual support. The committees are the organizational units in which the Mission Earth efforts are performed. The ones that are most relevant to the present discussion are the Modeling Management Committee, Alfred Jones, of Florida Atlantic University, Chair, and the Standards Committee, James Daly, of Electronic Associates, Inc., Chair.

In addition the Activity. organizes and manages a Mission Earth Symposium as a part of at least four SCSI conferences per year. A typical symposium consists of one track for about three days.

Mission Earth does not itself do modeling; it offers services to support global modelers and simulationists. Examples of these services are: development of suggestions and standards for world modeling and simulation, data management, literature searching, provision of a quar- terly forum for papers and discussions about world simulation, a newsletter, a part of a column (Simulation in the Service of Society) in Simulation, and distributiuon of model management information.

2 GLOBAL PROBLEMS FOR DISCRETE EVENT SIMULATION

As a first step toward identifying some problems of global or nearly global scope for
simulation by discrete event methodology, the overall global problem will be broken down into the following intercoupled subproblem areas:

1. Physical Environment (land, fresh water, atmosphere, and ocean physics and chemistry, including pollutants and thermal effects)
2. Economics (resources, trade, production, energy, investment, foreign aid, and agriculture)
3. Population Dynamics (including health, famine, food aid and consumption, migration, level of living, birth rates as functions of economic level, etc.)
4. Ecosystems (including their exploiters and managers, land uses, and fisheries, in terms of interacting populations of species or broader biological taxa)
5. Military Conflicts (international, intranational)
6. Infrastructure (cities, roads, transportation systems, etc.)
7. Government (politics, fiscal systems, taxation, special interest groups, nonprofits, problem awareness lag, public thinking and decisions, etc.)
8. Some of the dependent variables in the foregoing models contribute to a world "value function" (to be maximized over time in some

fashion by plan parameter variation); compare the "quality of life" measure used by the Meadows, et al.

Technological advance projections would be included in each category. However, overall technical advance is not modeled as such.

Of the foregoing problem areas some are more suitable for discrete event modeling than others. Thus the physical environment is normally not suitable, being much more of the nature of a set of continuous systems. Economic transactions, on the other hand, are suitable for discrete event methods. Ecosystems have often been simulated by discrete event approaches (Fehr, Nuckols, et al., 1977; Miles, et al., 1974; Peart and Barrett, 1976; Talavage and Triplett, 1974). Military conflicts could be represented by discrete engagements. Infrastructure could, in principle, be dealt with as progressive incre-ments added and incorporated when needed and when funded. Govern- ment problems might lend themselves to discrete simulation by treating questions individually in terms of successive decisions and actionsw in response to pressures.

There are a few general guidelines. For example, a discrete event model is most natural when changes in objects' states are discontinuous and large, such as the conversion of a forest plot to agricultural land by a set fire. Likewise, an event approach can be used to advantage in any problem having complex logic, switching, resource selection, etc. Also it is common for stochastic effects to be rendered within a discrete event simulation, although stochastic effects can be dealt with also in continuous systems. Clearly it would be inadvisable to either omit or confine oneself to discrete event models in world simulation. They have potential roles which must be established.

3 PAST METHODOLOGIES FOR GLOBAL SIMULATION

Jay Forrester, who did the first significant world model, used his own methodology of system dynamics, which is of continuous type. Dynamo software was soon developed, and it was used by most world simulationists for a decade thereafter. Then Stella, an improvement over Dynamo, was developed for use on Apple computers.

Development of world simula- tions of systems dynamics continuous type reached a peak in the 1970's (McLeod 1992). However, extensions of the technique continue, featuring breakdowns into interconnected subglobal models, use of other languages such as Fortran (but the same mathematical models), and software improvements to make world simulations more accessible and easier to use by researchers and students.

An inquiry by the author among a few simulationists who should know could not come up with any examples of a world simulation rendered entirely or in large part in discrete event models. It might then be said that the discrete event methodology apparently is not being used to the extent that might be desirable.

A search of the author's files brought to light an idea by Paul Medow (1979): he suggested discrete event simulation as a methodology for economic simulations. Also there was a usage of qualitative and logic-type relationships "wherever appropriate" in the work of Pestel and Mesarovic (1974), but the majority of their models were expressed in differential equations.

Several methodologies for global modeling were mentioned by Strauch (1984): systems dynamics, systems engineering, input-output, and econometric. Discrete event per se is absent from the listing.

A related search that might be performed would be in institu- tional modeling (companies, nonprofit organizations, government bodies, etc.), to see whether discrete event models have been used. The carryover to world simulation is apparent, if one thinks of the world in institutional terms.

4 DISCRETE EVENT WORLD MODELING

In view of the situation described here, it would follow that there is a good opportunity for discrete event modelers in the field of world simulation. They are needed on world simulation teams, on Mission Earth committees, and in other key positions.

One of the reasons that this approach has not been popular thus far is that most simulationists have tended to think of a world simulation as a single thin model that attempts to deal with everything important all by itself. However, if one broadens one's thinking to include a model that is hierarchically structured and deep, or a hierarchical set of separate models that are not linked on-line, one could consider discrete event modeling for at least some of the models or submodels.

The discrete event languages and software required are available. Even techniques of animated multiple displays are available, such as in the computer games in which one can run a city or the planet.

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