Proceedings of the 2000 Winter Simulation Conference
J. A. Joines, R. R. Barton, K. Kang, and P. A. Fishwick, eds.

THE ARGESIM-COMPARISONS ON DISCRETE SIMULATION RESULTS AND EVALUATION

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ABSTRACT

This paper describes how to set up courses in (advanced) simulation techniques based on ARGESIM/EUROSIM Comparisons. SNE has defined 13 Software Comparisons, of which 6 concern discrete models, and collected solutions over the last 8 years. These solutions have now been evaluated and made accessible via the world wide web. This evaluation may be used as basis for a course on modeling and simulation. Finally, there is a brief introduction of ETCA and it is shown how it uses the ARGESIM/EUROSIM Comparisons for giving advice which simulators to use in the field of environmental technologies.

1 MOTIVATION

In teaching simulation, it is preferable to use examples to demonstrate what we are talking about. This is best done through the use of executable examples. Since there are several different types of simulation software and modeling approaches, it is not always easy to find suitable examples.

ARGESIM/EUROSIM features a series on comparisons of simulation software. Based on easily comprehensible models, special features of modeling and experimentation within simulation languages, also with respect to an application area, are compared. Since 1990, thirteen comparisons have been defined and about 190 different solutions collected.

Each of the defined ARGESIM/EUROSIM Comparisons presents a central model and up to three additional tasks to be carried out. Each of these tasks focuses on a particular feature, for instance modeling technique, event handling, numerical integration, steady-state calculation, parameter sweep, output analysis, animation, sub models, macros, complex strategies, optimization of parameters, etc.

The ARGESIM/EUROSIM Comparison web pages offer definitions of the Comparisons as well as worked out solutions. The latter are evaluated - not only with respect to features of specific simulators but also with respect to modeling approach and methodology. Finally the solutions can be downloaded (executable code) along with detailed comments.

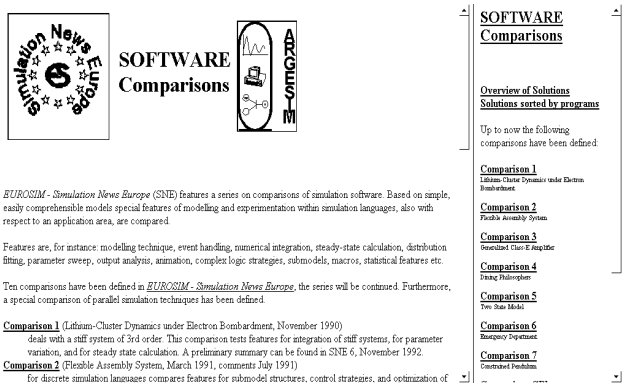

Figure 1: ARGESIM-homepage at <www.argesim.org>

This is an enormous pool of knowledge and experience and it has been made accessible via the world wide web! The collected information is not only appropriate for comparing features of simulators but also for comparing different approaches and methodologies. The idea is to use this knowledge - suitably documented at www - as a basis for (basic or advanced) courses on modeling and simulation. The courses can be traditional or web based.

This pool of knowledge is designed to be continually growing, as new comparisons are defined and published, and students and teachers are encouraged to make contributions of their own. Both solutions to existing comparisons as well as proposals for new ones are welcome.

2 EVALUATION AND CLASSIFICATION OF SOLUTIONS

The collected solutions of the ARGESIM/EUROSIM Comparisons are continually being evaluated and classified according to a set of criteria. There are general criteria (basically judging the methodology) and further criteria for the additional tasks (judging the individual performance needed for that task).

The criteria are individually chosen for each comparison but taken from a standardized set. This allows finding similarities in solutions of different comparisons! Given the great variety of models that is dealt with in the comparisons, it is interesting and instructive to see how the solutions for these comparisons sometimes use quite similar simulation techniques.

The ARGESIM/EUROSIM pages provide lists of the criteria for each comparison and a classification of the available solutions on a further page.

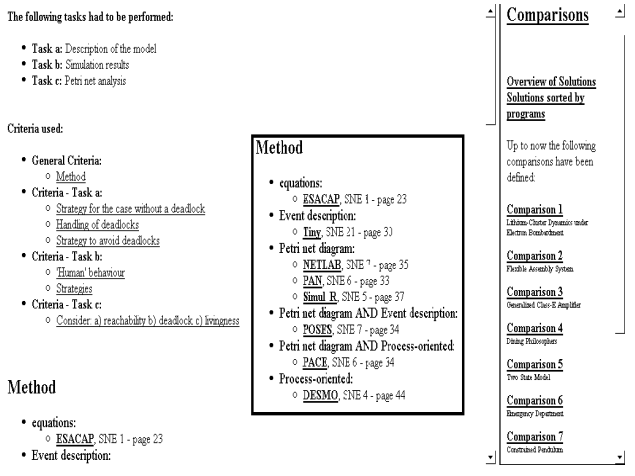

Figure 2: Evaluation of Comparison 4 (Dining Philosophers)

It is possible to view the used features for a single comparison and it is also possible to get a list of those comparisons which have a solution that uses a particular feature.

A further step will be the development of a search engine. It will be possible to search for keywords (simulation features). The answer will be a list of categorized task evaluations of various solutions of different comparisons.

When setting up a course these evaluations and search results automatically provide causal case studies and results. This material may be used either in traditional courses, or incorporated directly (by a link) into a www based course.

3 USAGE OF ARGESIM COMPARISONS IN COURSES ON SIMULATION

It is suggested to use ARGESIM/EUROSIM Comparisons for advanced courses and it is also fruitful to include the central models in introductory courses. We suggest the following categories of courses:

- Introductory courses
  - on simulation software
  - on simulation techniques
- Advanced courses
  - on simulation software
  - on simulation techniques
  - on modeling methodology

The ARGESIM/EUROSIM Comparison web pages provide not only a list of the definitions and solutions but also allow searching for solutions that contain specific features. For example, one has access to a list of those solutions which use Petri-nets or as a second example those concentrating on state-events (comp. previous section).

For an introductory course on a particular simulation software, for example, one would search for solutions which use that software. These solutions can then be discussed in class and even downloaded and executed (if the simulator is installed locally).

3.1 What Does Such a Course Look Like?

The main objective of the ARGESIM/EUROSIM pages is to provide well documented examples for any kind of courses on simulation. Experience shows that it is a good idea to first present a method, a simulator and a problem, then let the students try and work out solutions. Advanced students may choose or even develop the method they use themselves.

This sequence of steps has its advantages:

- The course is more than a simple programming course and students dig deeper into the problems of modeling and simulation than they would do if presented with a sample solution at the beginning and just redoing it.
- Sometimes new, not yet published approaches are chosen for a particular comparison, thereby widening the view of the problem.
- Students who have made their own models before and experienced the difficulties will draw more and more useful information out of the ARGESIM/EUROSIM pages.

An important feature of a course should also be a discussion about the advantages and disadvantages of the different approaches, which is made possible by the large amount of published, classified and commented solutions.

4 EXAMPLES

4.1 Introductory Course on Petri-Nets

When planning a course on Petri-nets, one can visit the ARGESIM/EUROSIM Comparison web pages and search for examples that are suitable for demonstrating them. Today he or she would find comparison 4 and comparison 10 (Dining Philosophers).

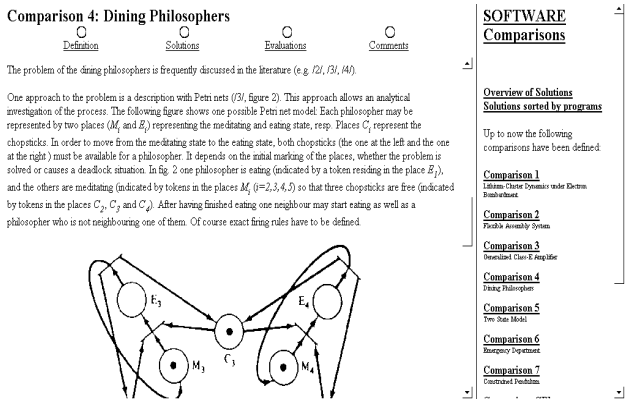

Figure 3: Definition of Comparison 4

Comparison 4, initially at least partly intended as entertaining riddle for stressed simulationists, turned out to bring in a huge variety of different approaches and to be very interesting for computer science (allocation of resources in distributed systems, probability, prevention and handling of deadlock/system crash). This is the reason why it was redefined in a more technical way as Comparison 10.

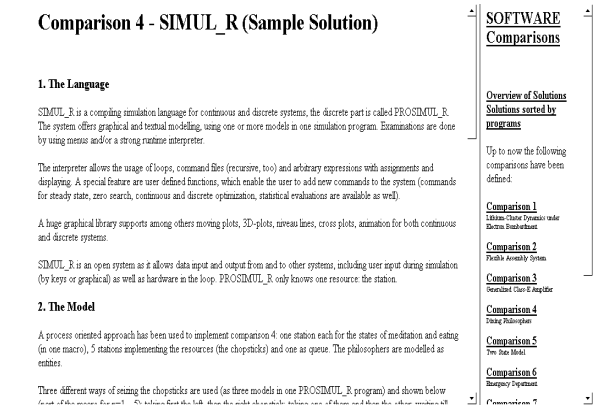

Figure 4: Sample Solution of Comparison 4

There are four sections for each of the comparisons: Definition, Solution, Evaluation and comments.

Definition provides a detailed definition of the comparison that does not only give the tasks to be performed, but also highlights the role Petri-nets play.

Solution gives a list of all received solutions, stating the used software and the date of publishing; *Evaluation* gives a classification of the solutions according to certain criteria. This is the point to visit when looking for solutions with certain properties.

The available solutions are compared with each other and commented in detail at *Comments*.

Finally the source-code of the solution can even be downloaded and executed on a local computer.

4.2 Advanced Course on State Events

For a course on State-Events, it is suggested to use Comparison 7 (Constrained Pendulum). Again, there is a detailed definition and a collection of solutions.

This Comparison tests features of simulation languages regarding state events, comparison of models, and parameter variation. In an advanced course the different possible methodological approaches might be of main interest! So the *Evaluation* section gives a list of the solutions sorted by methodological aspects, i.e., the way in witch the change of states is handled. One can now study the different approaches by comparing the listed solutions.

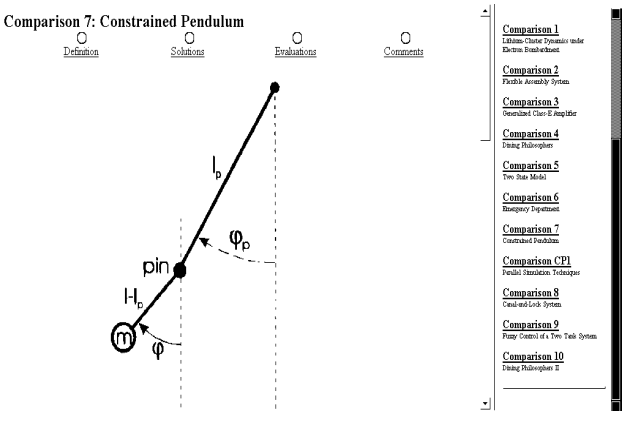

Figure 5: Definition of Comparison 7

The most important feature tested by this comparison clearly are state events. This concept is ubiquitous in today's large models, but has been adapted relatively late by programmers of simulation tools, due to the numerical problems that arise out of them.

The approaches used for this comparison include hybrid modeling, implicitly segmented modeling, law-oriented modeling, non-segmented modeling, segmented modeling, ranging from traditional methods (imitating analog computers) to very high level model descriptions.

Using the ARGESIM/EUROSIM Comparisons does help designing excellent lectures on simulation.

5 ARGESIM COMPARISONS IN ETCA

ETCA (Environmental Technology Concerted Action) is an informational infrastructure for research, industry and authorities.

ETCA provides

- an organizational background for projects in the European Commission workshops of the environmental program, and for the relations with national programs
- a communication network in the field of environmental technologies
- a scientific secretariat for research in the field of environmental technologies.

ETCA is aimed at

- promoting research and bringing Research, User/Producers and Authorities together
- reducing costs of research and promoting inter co-operation of national and EU programs
- allowing the application of the results of research
- improving competitiveness of European industry and SME

To meet these aims ETCA will act as a clearing house (information concerning experiences with methods, equipment, facilities, etc.) and a discussion forum (technical aspects, regulations) considering their implications on e.g. measurement techniques, social climate. It has also established several work groups that will concentrate on isolated aspects of environmental technologies. The topics of work group one and two are

- Available tools for the development and the assessment of benefit of environmental technologies.
- Design of a practical toolbox on the basis of existing methodologies, measuring techniques and integration procedures.

Clearly simulation is a powerful tool for development!

ETCA will use ARGESIM's knowledge of simulation languages and its collection of solutions to the comparisons. Whenever ETCA suggests to use simulation for the developing of environmental technologies it will also indicate which simulators are appropriate for the given problem. For that ETCA will use the ARGESIM/EUROSIM Comparison pages which do indeed give this information.

The typical modeling approach in environmental applications of simulation will be *compartments* or *system dynamics*. So ETCA will look up the ARGESIM/EUROSIM Comparison web pages and search for solution based on the desired features. Since complex problems need an individual solution, the set of desired features will always be different. There is no standard answer so the AGESIM/EUROSIM Comparison pages will be helpful in providing suitable advice.

The web-address of ETCA is <http://etca.arcs.ac.at>.

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