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WEB-BASED MODELING AND SIMULATION

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ABSTRACT

This paper introduces the emerging area of web-based simulations and presents an overview of the opportunities and challenges in this field. This introduction begins with an outline of the World Wide Web and aspects of simulation impacted by advances on the Internet. Next, various types of applications of web-based simulations are illustrated. This article concludes with an synopsis of research and development efforts on web-based simulations, including online simulation documentation, client-side simulation applets, server-side simulations, and distributed, interactive, web-based simulators.

1 INTRODUCTION

There is an increasing interest in applying the World Wide Web infrastructure to simulation modeling and analysis (Fishwick 1996). An excellent collection of web-based simulation resources is on the Internet (Page 1998). This Internet page has links to simulation support packages, on-line simulations, web-based environments, and information about web-based simulations in the literature.

Several researchers in the simulation field strongly believe that the web is likely to influence several areas of simulation including model building, execution, and sharing (Nance 1998). This tutorial presents a broad overview of web-based simulations oriented from the perspective of how students, faculty members, and practitioners interested in simulations can exploit the web technology.

2 WEB'S INFLUENCE ON SIMULATION

The Internet or the World Wide Web is a loose coupling of thousands of networks and millions of computers around the globe that together share information. This section examines in greater detail the impact of the web on different segments of simulationists, including students, teachers, and practitioners.

2.1 Students

Perhaps the biggest area of impact the web has made is in information access. Through the sharing of data between computers on the web, information is now more readily available than ever before. As a result, students have access to large number of resources in simulation.

Students in universities are exposed to simulation topics, typically, in courses in industrial engineering or in computer science departments. With the web, they have access to numerous publications, software, professional societies, and company information, all on their desktop. In teaching simulation classes, I have noticed that the quality of the student term papers has improved, as they are able to readily perform information searches and have more time to perform analysis and review in greater detail.

The Simulation Education homepage at <http://www.acs.ilstu.edu/faculty/wjyurci/nsfteachsim/indexnew.html> has exhaustive links to over 94 courses on simulations offered worldwide, has information about 140 books, numerous job postings, and links to over 40 simulation education organizations. This effort, funded by the National Science Foundation, seems to be a great resource for students to learn more on the topic of computer simulation and for accessing additional links.

In summary, with the web students can readily access large amounts of information from their desktops. At the click of the mouse button, they can access research papers, magazines, professional societies, and simulation companies. Since the coupling of web to simulations is a new field, they also have an opportunity to work on state-of-the-art research projects so they can influence the future of the field in terms of methods and products. The research aspects of graduate students are examined in greater detail in the overview of the state of the art in research and development.

2.2 Faculty Members

Faculty members in Universities are typically involved in three areas: teaching, research, and service. The impact of

the web on teaching and service are overviewed below. Research aspects of web-based simulation are outlined in a later section.

2.2.1 Teaching

Many faculty members have created home pages for their courses. At the minimum, they have information on the title of the course, topics covered in the course, and syllabus. Many courses also have links to class lectures, related research papers, etc. A few also have links to multimedia files with their face-to-face presentation so that students signed in the distance-learning mode can get a more personal touch to the class presentation. The course material is mounted on a computer server, typically hosted by the University.

A few years ago when the web was in its infancy, most web pages had to be created manually using hypertext markup language tags. Now, there are many free software packages that can be used to readily create web pages. It is very easy to create simple web pages with course syllabi, etc. and host it on a web server. In my experience, having course notes available on the web site before the lecture actually helps students pay more attention in classes. If there are concerns about copyright protection to class lectures, the web systems administrators can provide scripts that make the sites accessible only with passwords. Software to support instruction is becoming increasingly popular. Course support software provide the infrastructure to mount course material, administer quizzes and exams, and also manage student grade information, all on a web site.

In this tutorial, we will illustrate a few simulation courses on the web with varying levels of detail. We will also outline a step-by-step process of quickly creating and mounting a course web page.

2.2.2 Service

Faculty members typically serve on committees at the department, college, and university levels at their institution. They may also serve on conference organizing committees, review technical papers for peer-reviewed publications, and write grant proposals. The web has influenced all these processes. The focus of this overview is on the organization of simulation conferences and the technical paper reviewing process for simulation-related journals.

The *Winter Simulation Conference* organizers exploited the web technology in the dissemination of information, collection of the technical papers, and accomplished associated activities. *The Society for Computer Simulation* also used the web extensively for their recent Summer Simulation Conference.

Several journals that publish simulation-related articles are slowly moving towards utilizing web infrastructure to expedite the process and reduce the costs. For these journals, the authors can submit papers electronically and the reviewers can view the papers on the journal web site. An increasing number of journals are making the articles available online.

2.3 Practitioners

Practitioners interested in simulations have been exploiting the web in several ways. Consultants and simulation product development companies can advertise their capabilities, services, and products online. The basic steps are to register a domain name, generate their web homepage, and mount their site on a web server. They can either perform these steps themselves or use the services of companies that specialize in these steps. The web presence can also be used for sales, recruitment, and customer support. This tutorial will illustrate how some simulation companies have exploited the web in a variety of ways.

Perhaps the area where simulation companies can truly make an impact is the development of simulation products that exploit the web technology. This is an area where developments are occurring currently and is likely to be exciting in the next few years. To understand this area better, we will provide an overview some of the state-of-the-art research and development efforts.

3 WEB-BASED SIMULATION RESEARCH

Several research efforts are focusing on exploiting the web infrastructure to build models and execute simulation components remotely on the web. Many of these results have been published in the annual conferences on web-based simulations in SCS and Winter Simulation, and in a special issue of the *Simulation* journal devoted to web-based simulations (Fishwick and Hill 1999).

Broadly, these efforts can be classified into four interrelated categories. The first type addresses efforts that use the web to provide online documentation to existing simulations. The documentation can be about the modeling components, or the results of output analysis for a set of inputs, or even animations that display the simulation modeling results. In order to provide access to information about simulation model and results on the web, means to create hypertext documentation is what is primarily needed. This tutorial will illustrate examples of online documentation to simulations, including methods to do it efficiently using computer tools.

The second type of effort enables modelers run the simulation model on their desktop, where they provide input parameters through a web (Buss and Stork 1996). The simulation model and user interfaces run on the client as applets. Applets are programs written using Java that are embedded on web home pages. Basically, the simulation model components and user interfaces are downloaded seamlessly on the browser and are executed at the user's

desktop. In order to develop applets for simulations, basic knowledge of Java is useful. The fundamental steps are writing the Java applet subclass, creating the associated home page, and mounting the home page on a server. This tutorial will go through a step-by-step process for creating a simple simulation applet.

The third category represents efforts where analysts can access the simulation program remotely from a web browser and execute it on a server platform. The results can then be viewed on the browser (Fishwick et al. 1997). The advantage with this approach is that larger simulations can run on powerful, high-end computers and the analysts can get access to the results from any low-end computer with a browser. The disadvantage is that it requires knowledge of common gateway interface (CGI) scripts, Java servelets, or middleware technologies such as CORBA (Harkey and Orfali 1997). The different means of enabling server-side connectivity have an impact on the execution speed of the simulation program (Narayanan et al. 1998). This tutorial will illustrate one mechanism of providing modelers access to a server-side simulation program through a web browser.

The fourth category represents efforts on distributed, interactive simulations on the web, where potentially multiple users can interconnect with the same underlying simulation model through web browsers from different locations (Narayanan et al. 1997, 1998, and 1999). The simulation model executes on the server side, but the user interfaces could be tailored to different users depending on their level of abstraction. The graphical interfaces typically display the system state and also enable human operators to make changes to the system model while the model is executing. These simulators are similar to visual interactive simulations that can be used for training and decision aiding (Bell and O'Keefe 1987). This tutorial will present an outline of an architecture we developed for modeling uninhabited aerial vehicles and describe the core research and development challenges in its development and implementation.

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