Proceedings of the 2002 Winter Simulation Conference
E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes, eds.

WEB BASED SIMULATION CENTER: PROFESSIONAL SUPPORT FOR SIMULATION PROJECTS

James O. Henriksen

Wolverine Corporation
2111 Eisenhower Avenue, Suite 404
Alexandria, VA 22314-4679, U.S.A.

Peter Lorenz

Institut für Simulation und Graphik
Otto-von-Guericke-Universität Magdeburg
Universitätsplatz 2
39106 Magdeburg, GERMANY

André Hanisch
Stefan Osterburg

Fraunhofer Institut für Fabrikbetrieb und
-automatisierung IFF, Sandtorstraße 22
39106 Magdeburg, GERMANY

Thomas J. Schriber

Computer and Information Systems
The University of Michigan
Ann Arbor, MI 48104-1234, U.S.A.

ABSTRACT

Simulation projects are usually cooperative endeavors that involve not only the work on the simulation model itself but also a lot of communication among project partners. In the past, support for communication and cooperation in simulation projects has been poor to non-existent. The Web Based Simulation Center is designed to bring simulation and cooperation together. Because this approach requires and benefits from making simulation tools available on the Web, it is also a first step toward introducing Application Service Providing (ASP) for simulation.

1 INTRODUCTION

The Web Based Simulation Center (WBSC) is a concept and a prototypical solution for supporting specialists from different fields who are involved in a simulation project, phase by phase, supported by Web-based resources. The impetus for the WBSC comes from experience gained because of involvement in mining-simulation projects. Email communication among mining engineers, project engineers in a consulting company, and simulation specialists working together on a project and located in different countries and continents leaves much to be desired. The B2B Simulation Initiative was founded at the University of Magdeburg and is supported by the Fraunhofer Institute for Factory Operation and Automation in order to bring together people interested in Web based support for simulation project management and for business oriented relations among the organizations involved in the project. Some B2B Simulation components have been bundled in the WBSC prototype, currently installed on a server at the University of Magdeburg (Osterburg 2002). Core WBSC features are project and document management, which includes user and file management and simulation service providing as a special mode of Application Service Providing. The WBSC prototype can be modified to fit different demands. The basic variant is suitable as an operational basis for a simulation service center. A modified WBSC variant could be a Web portal for a simulation software vendor, to provide improved means for demonstration purposes and customer support. Another variant could contain special data and tools for an application area like mining simulation. It could contain pictures (drawings), attribute and method specifications for object classes in this application area, a dictionary, and methods for computer supported model construction using the object classes.

2 EXPERIENCE IN MINING SIMULATION PROJECT MANAGEMENT

Practical experience in mining simulation projects revealed a number of common characteristics that resulted in inefficient project management due to unsatisfactory IT support.

The projects involved at least three groups of people with different expectations and requirements with regard to participation in the project work and the use of its results. *Mine management* wanted to develop a new (subsystem of a) mine and needed a detailed plan for building, equipping and running it. To that end, a consulting company (*mining consultant*) was contracted, which had the expertise to collect and evaluate all relevant information. As a part of this process, simulation was one means to compare and evaluate different alternatives for equipment and control strategies to guarantee the required throughput of the newly designed mine or mining subsystem. The simulation model was not developed by the consulting company but was subcontracted to a separate consulting company with specific knowledge in building simulation models (*simulation consultant*). All three participating groups were situated in different geographic locations. Occasionally two or three model developers collaborated from different locations.

The simulation model had to be created with close cooperation among these three groups. Simulation models are usually constructed in a prototyping approach. This means that a first version contains only parts of the final model, or simplified versions of the eventual model components. This first version is then modified and developed to include more details and to reflect the intended system more closely. This iterative approach has to be executed with close cooperation among the groups involved in the project. This is usually the best approach because not all model requirements are known at the time the project is started. Intermediate results influence the planning process and lead to model extensions and variations. It is in the very nature of simulation that the model itself is used to determine certain rules and specifications. Continuing communication among the mining and simulation consultants ensures that bottlenecks and problems can be identified and solved at an early stage. At important milestones, the state of the work is also presented to mine managers to ensure that the mine design will fulfill their expectations.

As a result, these projects required a very high degree of communication and cooperation. In the authors' experience, email was the tool most commonly used to exchange information, opinions, input data, model versions, output data, and comments on data and models. Although email may be satisfactory when only two people are involved, efficient communication is hardly manageable by email with three or more people. Problems occur due to lost emails or emails not sent to all relevant participants and because of the limitations email has with respect to transferring large amount of data: Many email server configurations reject emails of a certain size. In effect, the sender of an email could not be sure that all project participants consequently had access to the same state of the project. Problem discussions become very inefficient if the subjects keep changing and different discussion partners are viewing different versions of the project.

Use of the prototyping approach led to strong involvement of the mining consultant in the testing and running of the model versions. For correctly identifying and fixing errors or problems, it was essential that mining and simulation engineers used the same model versions and input data for their tests. The inconsistencies in their view of the project state caused by the use of email led to additional problems. A further difficulty can come from using different versions of simulation and visualization software installed on the computers of the partners involved in the project.

3 THE B2B SIMULATION INITITATIVE

The desire to alleviate the aforementioned problems for future projects led to the idea of Web based software that integrates project management and simulation tools into one portal supporting simulation projects during their entire duration. In order to promote and coordinate efforts to create this kind of solution, the *B2B Simulation Initiative* (see Lorenz 2002) was founded by the Otto-von-Guericke University of Magdeburg (UMD) in cooperation with the Fraunhofer Institute for Factory Operation and Automation in Magdeburg (IFF).

In terms of this Initiative, B2B Simulation does not mean to simulate business-to-business (B2B) relations, but to support business relations in the field of simulation. An example for such a network of business relations was discussed in the previous section. As a result, the B2B Simulation Initiative focuses on creating the means to make simulation and visualization tools available on the Web, to adapt or implement Web based project and document management solutions, and to integrate all these solutions into a common framework that offers its users easy access to the tools and ensures compatibility among different tools.

The B2B Simulation Initiative is not a project. It is a *framework for projects*, for the work of students and professional developers, engineers, planners, business administrators, and lawyers. It is a *virtual community of institutes and corporations* with a common field of interest – the promotion of Web based simulation services and simulation service providing on the Web.

B2B Simulation has some analogous areas. Web based simulation might be the closest neighbor. Miller et al. (Miller, Fishwick, Taylor, Benjamin, and Szymanski 2000) have suggested that Web based simulation should have a wider scope than just running a simulation model on the Web. The B2B Simulation Initiative has adopted this vision. Supporting all steps and phases of a simulation project and supporting collaborative work among the project partners belongs to its field of interest as well as supporting the relations among vendors of simulation software, simulation service providers and simulation service clients.

Most past and current activities in the B2B Simulation Initiative have been carried out by students at the UMD (e.g., Gebert and Osterburg 2002; Hanisch 2001; Masik, Prahl, and Lommatzsch 2002; Osterburg 2001). Tools for collaborative work have been created, such as a discussion tool and a collaborative writing tool. A couple of tools to convert the proprietary, but widespread, file format of Wolverine Software's PROOF Animation (Wolverine 1992) to several Web-enabled formats are under construction. In particular, there are tools for converting PROOF to the Scalable Vector Graphics (SVG) format (PROOF2SVG), to the

Shockwave Flash File (SWF) format (PROOF2SWF), and the Virtual Reality Markup Language (VRML) format (PROOF2VRML). Another development supports post processing of simulation results on the Web by providing the means to generate business graphics by processing specific output of simulators, such as GPSS/H. The major objective of the B2B Simulation Initiative, which is the integration of these tools into a common framework, has led to the development of the *Web Based Simulation Center* (WBSC).

4 WBSC REQUIREMENTS

For supporting Web based work on simulation projects, the WBSC includes project and project management facilities combined with simulation and visualization tools. As a Web based solution, users can access the WBSC from anywhere in the world with a common Web browser and have access to the same tools and data. Figure 1 illustrates this concept.

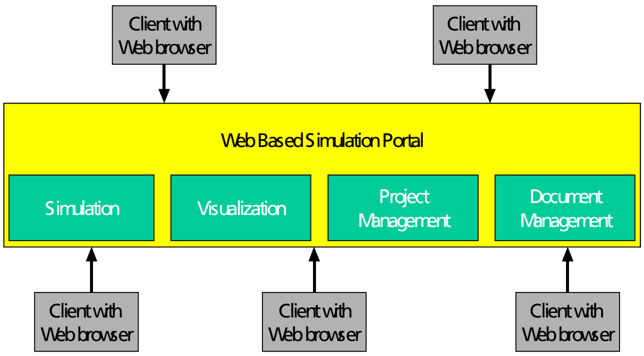

Figure 1: WBSC Concept

The WBSC provides the framework for tools supporting these different tasks and combines them in one common environment. As a result, the WBSC must fulfill several requirements:

- It must provide a *developer framework* that supports easy integration of tools provided by different developers. That includes basic user management and project management and the support of *Application Service Providing* (ASP).
- In addition to the user and project management support software itself, specific *tools for project based communication and cooperation and the support of B2B relations must be provided*.
- Tools for *Web based* simulation (e.g., simulation, visualization and animation tools) must be provided and integrated.

4.1 WBSC Framework

The WBSC framework provides a common environment for cooperative work on simulation projects. Additionally it offers the means to integrate different tools (components) that support and facilitate this work.

A basic task of the common framework is to handle the exchange of data between the users of the WBSC on the one hand and its different components on the other hand. The former requirement enables project-based work, the latter enables the WBSC to present itself as a single application instead of an unrelated collection of tools. To fulfill the specific needs of project based work (e.g., the data that belongs to a specific project must not be accessible by unauthorized users) and make this support available to all WBSC components, the project concept must be part of the developer framework.

Additionally the WBSC must provide the basis for ASP, because several components – such as simulation systems – require users to own a license. The WBSC must be able to manage the licenses and the respective access rights to each component. The WBSC must therefore implement access authorizations or restrictions not only for the data stored in projects, but also for the components and tools that the WBSC integrates. Initially it may be enough to manually assign access rights for specific components to users or projects. To fully implement the ASP concept, it will be necessary to extend such a rudimentary system with mechanisms to buy licenses from within the WBSC.

Finally, yet importantly, it is a design goal to integrate many different components, e.g., a discussion tool; calendar; task management; simulators such as GPSS/H, SLX, and Simplex; tools for animation; and tools for business graphics or statistical analysis. To facilitate a simple incorporation of these components into one environment that provides a unified look and feel for WBSC users, it is necessary to provide an Application Programming Interface (API) for software developers to access WBSC functions and resources, such as

- The WBSC user and project management,
- Access authorization and verification for components,
- Stored user or project data, enabling components to share data, and
- The common user interface.

Such common management of all resources and unified data storage is a prerequisite for easy maintenance of the entire WBSC.

To facilitate easy integration of existing components, the API must impose as few restrictions and rules on components as possible.

4.2 Tools for Communication and Cooperation

“Simulation results can only be as good as the cooperation between the persons involved in the simulation project” (VDI 1993). This statement explains why the WBSC is not

limited to Web based simulation but takes a broader approach that includes communication and cooperation. There are two aspects of communication and cooperation that the WBSC must handle: the communication that takes place before a project starts; and the communication and cooperation that takes place during a project.

As a platform that is designed to support B2B relations, the WBSC must support the steps that lead to the initiation of a simulation project. That includes a request for proposal (RFP) from a customer who requires a simulation based study, followed by corresponding proposals coming from simulation experts. Eventually, the members of a project are determined.

During the simulation project, there are several requirements for the support of communication and cooperation:

- An efficient method to support communication among all project members is needed. While most "conventional" methods such as email focus on "one-to-one" communication, the WBSC must facilitate "one-to-many" communication, to account for the fact that often there are more than two people involved in simulation projects.
- Mechanisms for transferring (electronic) documents (i.e., files) to allow the customer and the contractor(s) to exchange specifications and results are required.

These two requirements must be seen as a minimum. Additionally there may be "optional" requirements, such as tools for cooperative writing of text documents and communication facilities such as chats or whiteboards.

4.3 Tools for Web Based Simulation

A collection of Web based tools for cooperative project work is not an innovation as such. There are a number of free and commercial sites on the Web that offer communication, file exchange and other tools, e.g., Yahoo; Microsoft. The added value of the WBSC comes from the close integration with simulation tools that creates *simulation awareness*.

That means the WBSC must include at least one simulation system. The more the WBSC is able to cover all possible needs in the development and testing of a simulation model, the better it is suited for Application Service Providing by eliminating the need to install simulation software on a local computer. As a result, these typical tasks of simulation modeling must be supported with Web based tools:

- Easy changes in the model.
- Input data handling.
- Controlling the design of experiments by changing model parameters.
- Model execution.
- Graphical display of results.
- Availability of results for further processing, e.g., statistical analysis.
- Animation.

5 A WBSC PROTOTYPE

In accordance with the requirements established in the previous section, a prototype of a WBSC has been specified and implemented.

5.1 WBSC Architecture

To achieve the necessary modularity that facilitates an easy integration of a variety of tools into the WBSC, a layered architecture was chosen, as illustrated in Figure 2.

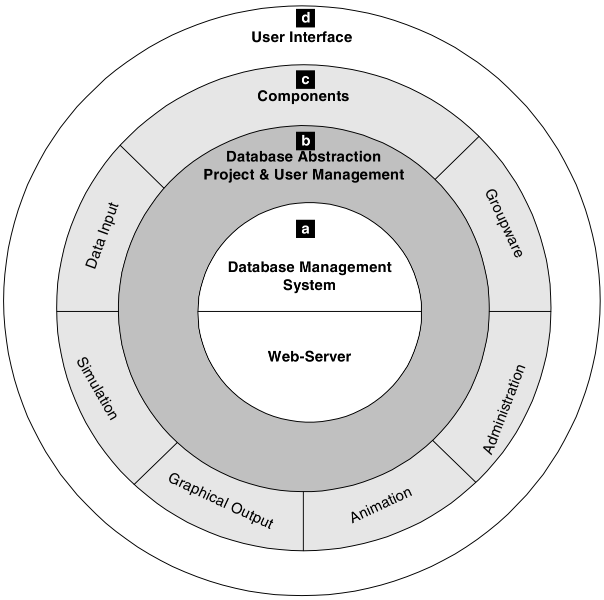

Figure 2: WBSC Layered Architecture

The lowest layer (layer "a") consists of the Web Server and a database management system (DBMS). Generally, the vision to implement a Web based environment that can be accessed by any standard Web browser requires a server-side solution for the dynamic creation of Web pages, which allow the WBSC to interact with the user. The most common alternatives to realize server-created dynamic pages are the Common Gateway Interface (CGI), Java Servlets, the PHP Hypertext Preprocessor (PHP) and Active Server Pages (ASP). Historically, the CGI was one of the first practical techniques for creating dynamic content. However, the CGI has a number of disadvantages, such as waste of system resources and security insufficiencies. These shortcomings have led to the development of several alternatives, among which two scripting languages have prevailed in the past few years – Microsoft's Active

Server Pages and the PHP Hypertext Preprocessor. The advantage of PHP over ASP is its availability for different platforms. Platform independence is also a characteristic of Java Servlets, which share many advantages of PHP. Because of the expertise available among participants in the B2B Simulation Initiative, PHP was chosen as the central programming language for the WBSC. For a DBMS, the smallest common denominator that offers the required function and performance was chosen – the freeware DBMS MySQL (<www.mysql.com> accessed July 8, 2002) Because most MySQL language constructs also work in commercial DBMS such as Oracle or Microsoft SQL Server, this choice ensures that a transition to such a system can be easily accomplished, if the need arises.

Layer "b" in the layered architecture comprises all those functions and data structures that fulfill the tasks of the WBSC framework described in section 4.3. That means that it implements the basic user and project management to facilitate project-based cooperation on the one hand and user authorization mechanisms in preparation for ASP on the other hand. Each user can belong to different projects. Access rights to WBSC tools (*components*) can be granted to individual users or to specific projects (i.e., all users of the project can use the component). These relations are illustrated in Figure 3.

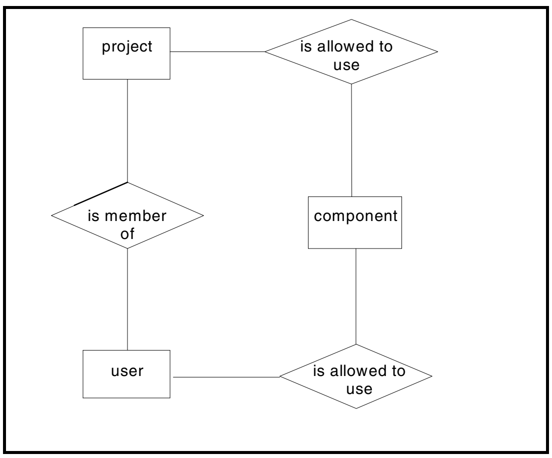

Figure 3: Users, Projects and Components

Additionally, layer "b" defines the rules for a file management that is used for the interoperation of individual WBSC components and for the exchange of data between project partners of the WBSC. In order to meet both requirements, the WBSC uses two different kinds of file spaces. Each user has a file space that no one else can access. It is used to store files that are processed or created by components. The project file space for each project can be accessed by all members of the project. In order to facilitate a documentation of the project's history, files in the project space may not be deleted or overwritten. To enforce this rule, components cannot access these files.

Layer "b" also provides the means to display the output of all WBSC components in one common user interface. Thus, a component programmer does not have to be concerned about the general navigation or layout of the WBSC.

All functionality of layer "b" is provided in the form of PHP files that can be included by each component. Components are all tools for communication, cooperation, simulation or visualization that are integrated in the WBSC. The WBSC components make up layer "c" in the architecture described above. Many PHP applications can be integrated into the WBSC without much effort by adding only four lines of code (and changing output statements like `echo` or `print`). Here is an example of a simple "Hello world" program using the WBSC framework:

```
<?
    $wbsc_app_name="sampleapp";
    $wbsc_page_title="Hello world";
    include ("../wbsc_api/wbsc_init.inc.php");

    // <actual application>
        $wbsc_app_out.='Hello world!<br>';
    // </actual application>

    include ("../wbsc_api/wbsc_finish.inc.php");
?>
```

The output of these few lines is shown in Figure 4.

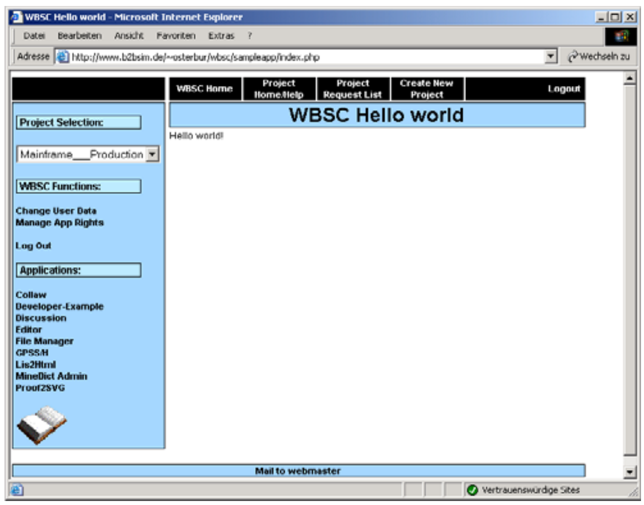

Figure 4: Output of WBSC "Hello world" Component

Figure 4 illustrates how the WBSC provides the entire user interface and integrates the component output into this interface. For accessing this interface, only a standard Web browser is required. The Web browser represents layer "d" in the WBSC layered architecture.

One of the main goals during the specification as well as the implementation phase of the WBSC prototype has been to achieve continuous platform independence. The system should be platform independent in the sense of supporting a wide range of Web browsers running on different operating systems as well as different hardware. Since only HTML (and a little JavaScript) is presented to the client, there is no need for a special browser on the client side. The use of PHP as the predominant programming language and the database MySQL for implementing and running the WBSC framework and its basic components result in a positive side effect: server-side platform independence.

A PHP enabled Web server as well as a MySQL implementation are available for many operating systems. UNIX, the free derivatives Linux and BSD, and Microsoft Windows are all supported.

However, the decision to use one or another of the above as the server platform is not trivial. There has been (and probably will always be) an ongoing discussion about usability and performance issues of the Windows and Linux operating systems. A key argument in the debate is the question about which system provides the tightest security. In the context of the WBSC and the connected simulation components, the set of decision criteria is more complex. Programs such as GPSS/H or SLX, just to mention two out of the wide range of existing simulators, are not platform independent but demand quite specific operating systems, e.g., GPSS/H and SLX require DOS and Microsoft Windows.

Nevertheless, Linux has some advantages that led to the decision to choose it as the preferred server platform. It is a cost effective native server operating system with a multi-user environment. However, the above-mentioned problem of embedding platform specific components remains: there will always be components that are not supported by the chosen operating system.

At the current stage, the WBSC offers three different ways to partly overcome this problem and to support the deployment of components that utilize binary code written for operating systems other than UNIX/Linux (e.g., Windows). All three are explained subsequently.

DOSEMU stands for DOS Emulation, and is a Linux user-level application that uses certain special features of the Linux kernel and the 80386 processor to enable Linux to run many DOS programs - including some DPMI (DOS Protected Mode Interface) applications. DOSEMU therefore features a so-called “DOS box” that is a combination of hardware and software “trickery”. Some of its interesting capabilities, which are illustrated in more detail at <www.dosemu.org> [accessed May 27, 2002], are:

- The ability to virtualize all input/output and processor control instructions.
- The ability to simulate a hardware environment over which DOS programs are accustomed to having control.
- The ability to provide DOS services through native Linux services (for example, a virtual hard disk).

Wine is an implementation of the Windows Win32 and Win16 APIs on top of X-Windows and UNIX to allow many unmodified Windows 3.x/95/98/ME/NT/W2K/XP binaries to run under Intel UNIXes. Wine works on most popular Intel UNIXes, including Linux, FreeBSD, and Solaris. Similar to DOSEMU, Wine is a freely distributable application that comes with complete sources, documentation and examples – all covered by the GNU Lesser General Public License. However, there is a big difference between the two packages. Where DOSEMU requires an xxDOS, which of course can be a free version such FreeDOS, to create the DOS box – Wine does not require Microsoft Windows, as it is an alternative implementation consisting of 100% Microsoft-free code. It can optionally use native system DLLs if they are available. A long list describing the areas of compatibility, graphics, networking, and others can be found at <www.winehq.org> [accessed July 8, 2002].

VMware (<www.vmware.com>, accessed July 8, 2002) is the last of the three ways to support different operating system on the WBSC server side. In contrast to the two previous applications, VMware is commercial software.

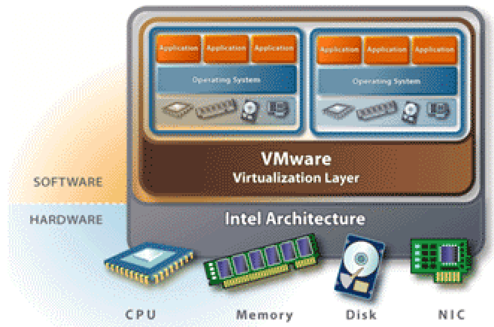

Figure 5: VMware Architecture [www.vmware.com]

VMware Workstation enables multiple operating systems to run on one physical computer in virtual machines. Figure 5 illustrates two different operating systems and software applications that run isolated in these secure virtual machines and that co-exist on a single piece of hardware. VMware runs on Microsoft Windows NT 4.0, Windows 2000, Windows XP, and Linux and can host all Microsoft Windows versions, MS DOS 6, and popular Linux distributions including Red Hat, SuSE Linux, and Linux-Mandrake. Furthermore, it supports FreeBSD.

A configuration used in the WBSC is shown in Figure 6. A Linux Red Hat 6 serves as the host operating system and Windows XP is installed in the VMware guest environment.

The communication between the WBSC and a Microsoft Windows component that runs in a VMware virtual machine is handled via Hypertext Transfer Protocol (HTTP). A HTTP request is sent to the guest operating system, which then starts the respective component. The resulting output is sent back via HTTP response to the WBSC. Furthermore, file access to the WBSC framework is given through a suitable Samba (compare <www.samba.org>, accessed May 27, 2002) configuration.

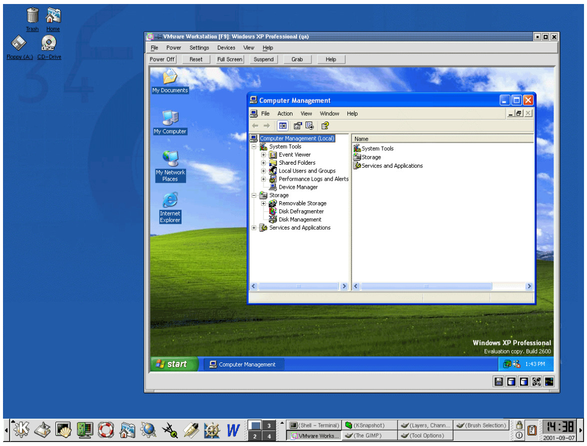

Figure 6: Windows XP Guest Running on Linux Host

Of course, the above-described workflow could also be performed with the specific component running on a separate machine with a native Microsoft Windows installation. However, at the current stage of the WBSC prototype, questions such as easy deployment of different components, minimal hardware maintenance, and cost effectiveness are more important than load balancing and high performance.

5.2 WBSC Components

Using the framework described in the previous sections, several components have been integrated into the WBSC prototype to demonstrate important functions.

A discussion tool provides a replacement for email. It allows the participants in a specific project to see all communication that is related to this project in one glance. Like many other discussion boards on the Internet, the component allows threaded discussions or sorting messages by author or date. Project members can receive notification emails when new messages arrive.

The file manager provides the user interface for accessing the different file spaces that were described above. It allows uploading, downloading or viewing files. Files can be copied between user and project file spaces and organized in a directory structure. When files are uploaded or copied to the project file space, notifications can be emailed to the members of the project.

A tool called Collaw (Collaborative writing) supports collaborative work on text documents. Each project member can suggest changes to a certain text passage. Changes will be displayed in different colors (depending on the author) and can be accepted or rejected by the owner (creator) of the text document.

GPSS/H was the first simulation system to be integrated into WBSC. Users who have the appropriate authorization (i.e., they must own a GPSS/H license) can run GPSS/H models that reside in the user file space. As a WBSC component, GPSS/H runs in a normal file system environment. It can therefore make use of input and output files.

Several tools convert Proof Animation™ layout and trace files into Web enabled formats. There are currently three different approaches for this:

- Proof2SVG converts Proof animations into the Scalable Vector Graphics format specified by the World Wide Web Consortium.
- Proof2SWF converts proof animations into Macromedia's widespread but proprietary Flash format.
- Proof2VRML creates animations in the Virtual Reality Modeling Language (VRML).

Although none of these solutions can or wants to replace Proof Animation™, they can be used to preview certain results without leaving the Web browser.

5.3 A UMD/IFF Site

The prototype of the WBSC that includes all components developed within the B2B Simulation Initiative is run in cooperation between the University of Magdeburg and the Fraunhofer Institute of Magdeburg. This WBSC prototype is used to test the WBSC itself and its components and to run example projects to evaluate additional needs for practical work with the WBSC.

One of these examples is the "HighBayStore" model. Several people have worked together using the WBSC to prepare this model for Web based use and experiments. The discussion tool was used to confer about problems or progress of the project. Figure 7 shows a snapshot of this discussion.

In the file manager shown in Figure 8, a directory structure was created that contains different versions of the model. The model itself can be parameterized through a text file that can either be uploaded or edited using the editor integrated in the WBSC.

To run the model, the required files must be copied to the user file space. Subsequently the GPSS/H component can be used to execute the model. The model creates a Proof Animation™ trace file that, combined with the provided layout, can be used as input for Proof2SVG. Figure 9 shows the output of Proof2SVG – an SVG animation that is embedded into the WBSC layout.

Because of the experience with the HighBayStore project, it was possible to make improvements to various components and the WBSC itself. Additionally the project demonstrated that the WBSC is able to satisfy most basic needs associated with simulation projects. It shows that for simple models it is not necessary to leave the WBSC environment during any stage of the project.

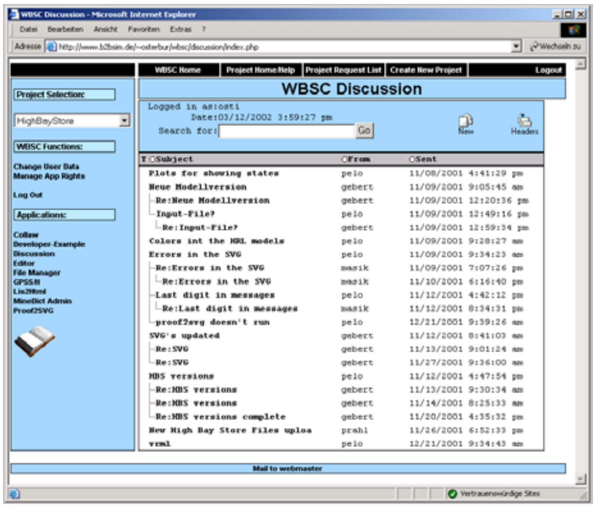

Figure 7: Discussion in the HighBayStore Project

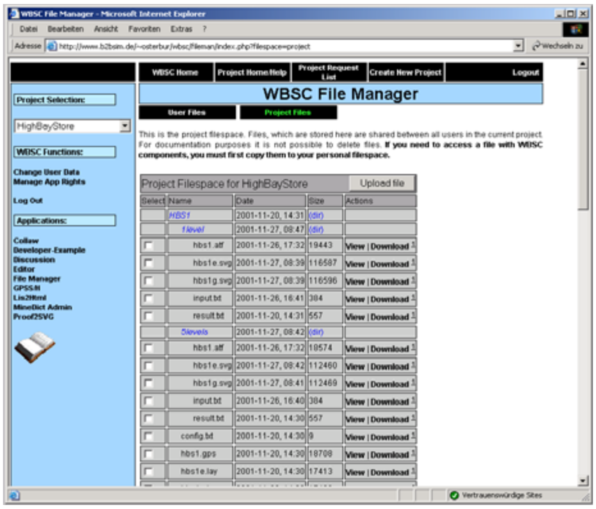

Figure 8: File Manager for HighBayStore Project

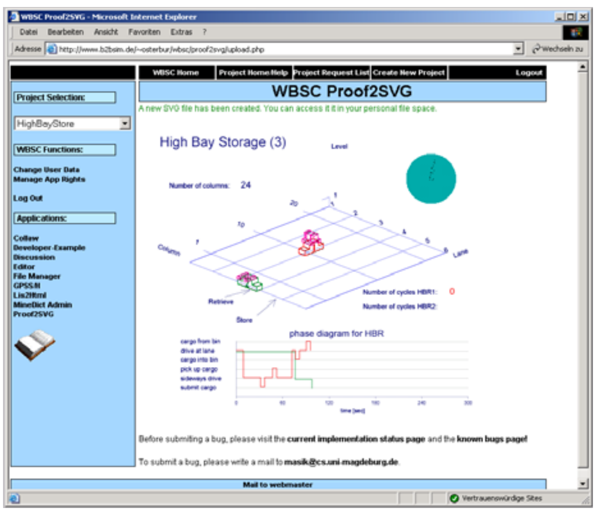

Figure 9: HighBayStore SVG Animation

5.4 A Wolverine Site

In a next step, the WBSC will be used to provide Web based access to the student versions of Wolverine's simulation systems GPSS/H and SLX. Using the WBSC's communication and cooperation functions, GPSS/H and SLX developers can discuss their experiences or problems. By uploading respective code fragments and executing them, online discussion about a specific problem becomes easier because all partners have access to the same model, the same data and the same simulator version.

5.5 A Mining Simulation Site

Mining systems have their special object classes and methods. Shafts, trucks, trains, crushers, bins, shovels and wagons are examples of these classes. A mining simulation site could contain a mining dictionary for these classes, including specifications of attributes, methods and pictures for each class. The pictures could be used as patterns for constructing layouts for the animation. A Web Based Mining Simulation Center does not yet exist. The development of a WBMSC is under discussion with Prof. J. Sturgul (University of Idaho).

6 SUMMARY

This paper has discussed the Web Based Simulation Center (WBSC) that is a framework for tools supporting Web based simulation in general and cooperative work on simulation projects in particular. As such, it can be seen as a prototypical software implementation of the goals of the B2B Simulation Initiative that is a framework for support of projects dealing with Web based Simulation, the business-to-business relations that accompany simulation projects, and communication and cooperation in these projects. In order to make certain commercial software available in a Web based environment, it has also been necessary for the first time to develop solutions for Application Service Providing (ASP) in simulation.

The WBSC demonstrates solutions for each of these aspects of the overall initiative. It implements user and project management to support cooperative project work, handles authorizations for accessing integrated software tools, and includes a discussion tool and a file manager to support communication and cooperation. It also provides for simulation and animation, currently with GPSS/H and Proof Animation, and offers tools for converting Proof Animation to Web enabled formats.

As a result, the WBSC prototype can already be used in its current state to perform most tasks in common cooperative simulation projects without leaving the Web browser.

REFERENCES

Gebert, B., and S. Osterburg. 2002. Solutions for Web Based Simulation Services. In *Proceedings of the Simulation and Visualization Conference 2002*.

Hanisch, A. 2001. Groupware Components for Collaborative Work in a Web based Mining Simulation Center. Diploma Thesis, Department for Simulation and Graphics, Otto-von-Guericke-University, Magdeburg, Germany.

Lorenz, P. 2002. B2B Simulation – Web Supported Simulation Services. <www.b2bsim.de> [online, accessed July 8, 2002].

Lorenz, P., and M. Schenk. 2001. The B2B Simulation Initiative – Simulation Services in the Web. 46th International Scientific Colloquium. Ilmenau Technical University, September 24 - 27, 2001.

Masik, S., C. Prahl, and V. Lommatzsch. 2002. Showing Proof Animations in Web Browsers. In *Proceedings of the Simulation and Visualization Conference 2002*.

Miller, J.A. (moderator), P.A. Fishwick, S. J.E. Taylor, P. Benjamin, and B. Szymanski. 2002. Research and Commercial Opportunities in Web based Simulation. *Panel discussion at WEBSIM'2000 Conference*. <chief.cs.uga.edu/~jam/jsim/websim> [online, accessed July 8, 2002]

Osterburg, S. 2001. A Portal for B2B Simulation. Diploma Thesis, Department for Simulation and Graphics, Otto-von-Guericke-University, Magdeburg, Germany. <www.b2bsim.de/~osterbur/diplom.pdf> [online, accessed July 8, 2002].

Osterburg, S. 2002. Web Based Simulation Center. <www.wbsc.biz> [online, accessed July 8, 2002]

VDI - Gesellschaft Fördertechnik - Materialfluss - Logistik (ed.). 1993. VDI 3633 Blatt 1 - Simulation of systems in materials handling, logistics and production.

Wolverine Software Corporation. 1992. *Using Proof Animation.*

AUTHOR BIOGRAPHIES

ANDRÉ HANISCH is a Research Engineer in the Department for Logistic Systems and Networks at the Fraunhofer Institute for Factory Operation and Automation in Magdeburg, Germany. In his diploma thesis that was concluded in January, 2002, he dealt with "Groupware Components for Collaborative Work in a Web-based Mining Simulation Center". His e-mail address is <hanisch@iff.fhg.de>.

JAMES O. HENRIKSEN is the president of Wolverine Software Corporation. He was the chief developer of the first version of GPSS/H, of Proof Animation, and of SLX. He is a frequent contributor to the literature on simulation and has presented many papers at the Winter Simulation Conferences. Mr. Henriksen has served as the Business Chair and General Chair of past Winter Simulation Conferences. He has also served on the Board of Directors of the conference as the ACM/SIGSIM representative. His e-mail address is <mail@wolverinesoftware.com>.

PETER LORENZ is Professor Emeritus at the Institute for Simulation and Graphics at the Otto von Guericke University in Magdeburg, Germany. He continues to teach discrete event simulation and animation there, and consults as well. His research interests include advanced Web-supported teaching concepts, applications of simulation and animation in mining, manufacturing, logistics and traffic, and moving simulation and animation to the Web. In 2001, he founded the B2B Simulation Initiative. His e-mail address is <pelosim@yahoo.com>, and his web page is <isgsim1.cs.uni-magdeburg.de/~pelo>.

STEFAN OSTERBURG is a Research Engineer in the Department for Information Logistics at the Fraunhofer Institute for Factory Operation and Automation in Magdeburg, Germany. In his diploma thesis that was concluded in December, 2001, he dealt with "A Portal for B2B Simulation". Research interests include the support of cooperative work on simulation projects. His e-mail address is <osterb@iff.fhg.de>.

THOMAS J. SCHRIBER is a Professor of Computer and Information Systems at The University of Michigan. He has been involved with discrete event simulation since 1967, and has been active in each Winter Simulation Conference from 1968 forward. He has received the Lifetime Professional Achievement Award and the Distinguished Service Award from the INFORMS College for Simulation. His e-mail address is <schriber@umich.edu>, and his web page is <www.bus.umich.edu/academic/faculty/schriber.html>.