UNIVERSITI PUTRA MALAYSIA

A PROTOTYPE OF WEB-BASED SIMULATION ENVIRONMENT (WEBSIM)

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By

TAN KEE LEONG

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DEDICATION

This book is dedicated to my parents:
Mdm. Koo Kim Lai and my late father Mr.Tan Guat @ Tan Ban Po (1945 –1998)
– from whom I learned the value of hard work and perseverance.

Abstract of the thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

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November 2000

Chairman : Associate Professor Borhanuddin Mohd. Ali, Ph.D.

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Computer simulation is the discipline of designing a model of an actual or theoretical physical system, executing the model on a computer, and analysing the execution output. Among the popular simulation tools are Mil3 Opnet, Mathworks MATLAB and even self-developed simulation program (using language such as Pascal, Fortran and C/C++). However, these simulation tools have limitations such as platform dependent, expensive cost, maintenance difficulties and limited in reusability.

One of the methods to overcome this limitation is by implementing web-based simulation. Web-based simulation allows simulation to be carried out over the Internet using a standard web browser. The usage of web browsers make the Internet a very user-friendly environment by integrating all related resources into a single tool that eliminates the steep learning curve for novice simulation users.

In this thesis, we present the web-based simulation environment project (Websim). Websim uploads a simulation program (developed using C/C++) in

binary format, generates a web-interface for the program and allows users to access the simulation program via the Internet The results generated from the simulation program would be translated into an image file Finally, the image file is embedded into an HTML file, and returned to Websim users Websim is mainly developed using the combination of CGI and Javascript technologies The server-side CGI scripts, written in Perl process the various requests from users, while the client-side Javascript is used to perform user inputs validations Thus, lessen the workload of the server and tightens the security

Websim is able to receive the simulation program in executable format and provide a web interface for it This gives the flexibility and convenience of using the programming language of choice for the simulation modeller, and to integrate it with the web Besides that, Websim also allows the storage of simulation program on a web server, thus could act as an online store for simulation programs This permits the sharing of simulation program over the Internet, to an exclusive user groups or to the general public Finally, Websim could act as a teaching tool in school and universities, especially for courses involving modelling and simulation It allows teaching and learning to be done through the Internet, hence could assist students in having a better understanding on certain topics or concepts

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia untuk memenuhi keperluan ijazah Master Sains.

SATU CONTOH PERSEKITARAN SIMULASI WEB (WEBSIM)

Oleh

TAN KEE LEONG

November 2000

Pengerusi : Profesor Madya Borhanuddin Mohd. Ali, Ph.D.

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Simulasi komputer merupakan satu disiplin yang melibatkan proses merekabentuk model sebenar atau model sistem fizikal teori, melaksanakan model tersebut pada komputer, dan menganalisis hasil perlaksanaan model tersebut. Antara perisian simulasi yang popular ialah Mil3 Opnet, Mathworks MATLAB, dan perisian yang ditulis sendiri menggunakan bahasa paras tinggi seperti Pascal, Fortran dan C/C++. Namun, perisian-perisian simulasi seumpama ini mempunyai kelemahan seperti tertakluk kepada pelantaran, kos yang tinggi, kesukaran dalam memelihara serta menyokong perisian, dan penggunaan-semula yang terhad.

Salah satu cara untuk mengatasi kelemahan tersebut ialah dengan melaksanakan simulasi web. Dengan simulasi web, proses simulasi boleh dilaksanakan pada Internet dengan menggunakan sebarang pelayan laman biasa. Penggunaan pelayan laman juga menjadikan Internet satu persekitaran yang mudah, iaitu dengan menggabungkan sumber-sumber yang berkaitan untuk menjadi satu perisian yang senang dipelajari.

Dalam tesis ini, kami melaporkan satu projek persekitaran simulasi web, kami kenali sebagai 'Websim" Websim menerima satu aturcara simulasi (ditulis menggunakan bahasa C/C++) dalam format binari, menyediakan satu perantaraan web (dalam bentuk fail HTML) kepada aturcara tersebut, dan seterusnya membenarkan ia dicapai melalui Internet Hasil daripada aturcara simulasi tersebut akan diterjemah menjadi satu fail grafik Akhir sekali, fail grafik tersebut dimasukkan ke dalam fail HTML tadi dan dihantar kembali kepada pengguna Websim Websim dibina menggunakan gabungan teknologi CGI dan Javascript Aturcara CGI yang ditulis dalam bahasa Perl melaksanakan pelbagai proses di peringkat pelayan Sementara itu, Javascript digunakan untuk memeriksa input pengguna sebelum dihantar kepada pelayan, dengan itu mengurangkan beban pelayan dan meningkatkan tahap keselamatan sistem pada keseluruhannya

Websim memberi kemudahan fleksibel kepada pengguna untuk menggunakan bahasa pengaturcaraan pilihan sendiri Selain itu, Websim juga membenarkan aturcara simulasi disimpan di dalam pelayan web, lantas boleh dijadikan tempat simpanan aturcara simulasi yang boleh dicapai secara langsung Ini mengizinkan aturcara simulasi tersebut dicapai pada Internet, sama ada kepada kumpulan tertentu yang terhad ataupun kepada semua pengguna am Akhir kata, Websim juga boleh dijadikan satu alat bantuan mengajar di sekolah dan universiti, khasnya kepada kursus-kursus yang melibatkan pemodelan dan simulasi Websim membenarkan pengajaran dan pembelajaran dibuat melalui Internet, dan ini akan dapat membantu meninggikan pemahaman para pelajar bagi sesuatu topik

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I share the happiness and joy with all of you!

I certify that an Examination Committee met on 6th November 2000, to conduct the final examination of Tan Kee Leong, on his Master of Science thesis entitled "A Prototype of Web-based Simulation Environment (Websim)" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions

Candidate
Name **TAN KEE LEONG**

Date 7 November 2000

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LIST OF ABBREVIATIONS

API	-	Application Programmer Interface
AWT	-	Abstract Window Toolkit
CGI	-	Common Gateway Interface
CORBA	-	Common Object Request Broker Architecture
GBN	-	Go Back N.
HTML	-	Hyper Text Markup Language
HTTP	-	Hyper Text Transfer Protocol
IP	-	Internet Protocol
JVM	-	Java Virtual Machine
LAN	-	Local Area Network
ODBC	-	Open Database Connectivity
ORB	-	Object Request Broker
PERL	-	Practical Extract Report Language
RMI	-	Remote Method Invocation
S&A	-	Simulation and Animation
SMTP	-	Simple Mail Transfer Protocol
TCP	-	Transport Control Protocol
GUI	-	Graphical User Interface
UML	-	Unified Modelling Language
VRML	-	Virtual Reality Markup Language
WAN	-	Wide Area Network
WWW	-	World Wide Web

CHAPTER I

INTRODUCTION

Computer Simulation

Computer simulation is the discipline of designing a model of an actual or theoretical physical system, executing the model on a computer, and analysing the execution output [Fishwick, 1995]. In general, simulation is to pretend that one deals with a real thing while really working with an imitation. In operational research the imitation is a computer model of the simulated reality. Models are used in industry and commerce and military because to make experiment with real systems is very costly, dangerous and sometimes impossible. Provided that models are adequate descriptions of reality, experimenting with them can save money, suffering and time [Pollatschek, 1999].

There are generally two types of simulation:

- **Discrete Event Simulation**. When the numbers of events are finite and between two consecutive items nothing happens, we call this kind of simulation a discrete event. Car arrivals and departures occurred at distinct points of time are example of discrete event simulation.

- **Continuous Simulation** In some systems the state changes all the time, not just at time of some discrete events For example water level in a reservoir with given in and outflow may change all the time

Simulation is often performed by writing a computer code to represent a system model, or as some kind of input into a simulator software. Simulation may be carried out:

- On a spreadsheet
- By running a computer program written in some general language (such as Fortran, C/C++ or Pascal)
- By running a computer program written in some special language for simulations
- By running specially built simulator with appropriate input.

These four methods are the most popular methods of performing simulations. But due to the dependency on the local standalone system they are running on, these simulation methods suffers several disadvantages such as platform-dependent, machine-dependent, and require longer learning curve With the current advancement in Internet and web technology, we propose a partial solution to the above problems with a Web-based Simulation Environment (Websim) project. Websim provides a dynamic web interface for a standalone simulation engine and allow the performing of simulation works over the World Wide Web (WWW). Websim also provides a simulation environment where users can examine the simulation outputs to verify and validate their system model. The outputs can either be in text or graphical representation.

Web-based Simulation

The Internet is a loosely connected world-wide network of heterogeneous computers and the WWW is a set of on-line hypermedia documents that resides on the Internet The WWW was conceived as a set of simple Internet-based client/server protocols for transferring and rendering documents of a primarily textual nature What distinguished the web's mode of communicating information from other Internet-based tools that preceded it (e-mail and FTP) was the provision for embedding hyperlinks that allows users to easily navigate between related documents Hypermedia documents are built using a language called Hypertext Markup Language (HTML) Access to the web is afforded using the web browser such as Netscape Navigator or Internet Explorer

Web-based simulation was introduced to perform all steps needed for simulation over the Internet and the web In other words, it uses the web as a means of access to simulation models as well as its use as a platform for the creation, execution and distribution of simulation models [Nam and Kim, 1999]

Most of the existing Web-based simulation tools focused mainly on the development of the runtime simulation libraries and mechanisms on the Web, such as Simjava [Howell, 1999], Javasim [Javasim, 1999], Silk [Healy and Kilgore, 1998] and the development of the distributed simulation environments using ORB technology such as JavaRMI and CORBA [Orfali and Harkey, 1997] Some of these tools require simulation model developers to be good at C/C++, Java and simulation languages However, performance of web applications developed in Java are relatively slow in speed To ease the burden of modellers, GUI based modelling

environments are essential Simulation tools like OPNET [MIL3, 1997] and Digital Workshop [Fishwick 1998] support the visual development environments, but OPNET could not support Web-based simulation capability, and Digital Workshop could be used only for digital circuit design

Most of the existing commercial and non-commercial simulation tools are typically platform-dependent and are not designed to work in the Internet or the Intranet We acknowledge that it is easier to write a simulation model using a general-purpose language such as C/C++ because the C/C++ is very popular and easy to learn The only problem with programs written in C/C++ is that they are typically machine dependent and standalone In this thesis, Websim project acts as the missing jigsaw which encapsulates the standalone programs in C/C++ with a web interface, and allows it to be accessible through the web

Characteristics of Web-based Simulation

A web-based simulation environment refers to a web application system, which provides a dynamic web interface for a simulation tool, and allows the performing of simulation works over the WWW This environment is accessible with a web browser and has the following characteristics

- Supports a modelling tool which is independent of hardware and software platforms
- Supports a graphical user interface for easy modelling
- Supports execution over the web
- Able to store and display the simulation results over the web

In this thesis we develop the Websim, a simulation environment for self-developed simulation tool Websim shows how one could extend the capability of simulation tools into the web Websim allows a simulation model to be uploaded to a web server, and automatically generate a web interface for the simulation model Websim can be accessed on any platform (Unix, PC or Mac) using a standard web browser. With this simulation environment, an easier and faster integration of simulation and visualization techniques and tools into the Internet can be realized.

Significance of Websim

There are three significant aspects of this thesis. First, it is the ability of Websim to produce a web-based simulator on a standalone simulation engine. Websim simply receive the simulation engine in executable formats and provide a web interface to it. Secondly, Websim act as the online store for a collection of simulation models. For example, researchers from the same group could upload their simulation models to Websim, so that their simulation works could be easily referred and executed by other researchers from other parts of the world. Finally Websim could act as a teaching aid / tools in schools and universities. This would be very helpful especially for courses involving modeling and simulation, where lecturers could ask several students who are good in C/C++ programming to develop simulation engines, and upload them to Websim. These web-based simulation engines could assist other peers in having a better understanding of certain topics or concepts.

Objectives

One important property of Websim is that the execution of simulation runs on a remote server It is designed to provide distributed and platform independent features to multiple concurrent users For instance, a user could perform the simulation works at home using the simulator located at his office, while another colleague at the office watches the results shown on the computer screen via a web browser The aim of the thesis is to develop a server-side web application of a web-based simulation environment for self-developed simulation program by utilizing Common Gateway Interface (CGI) and Javascript technologies

The objectives of this thesis are as follows

- To enable a standalone simulation program to be executed by multiple concurrent clients over the web
- To produce web interface for the simulation program based on its input and output data
- To develop a server side application which could receive the self-developed simulation program (executables C/C++ program file)
- To provide an interface to support execution of the simulation program over the web
- To develop some useful server-side administrator modules to manage Websim This include features such as uploading, editing, maintaining, and the like
- To develop several simulation program as samples to test and evaluate the performance of Websim

Organisation of Thesis

This thesis is organised into six chapters. Chapter 1 provides a brief introduction to web-based simulation systems and the significance of Websim. Chapter 2 presents the literature review on various web-based simulation topics. The history and the development of web-based simulation are also included. Chapter 3 describes the design methodology employed and the system architecture defined for Websim. As CGI plays an important role in this project, various issues pertaining to this area are highlighted. The system implementation is described in Chapter 4. The performance testing, evaluation of results and general limitations of Websim are presented in Chapter 5. The final chapter discusses the significance and contribution of Websim, its future works and conclusion of this project.