Simulations and the Need for Free Software

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1 INTRODUCTION

Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system [1]. Simulation is used for the solution of many problems in many areas, such as: design of (nonexistent) systems, where experimenting with the real system is impossible or inconvenient (due to ethical reasons), for evaluation and prediction purposes, and for training. Because simulation is such an important area, there is a demand for *free* packages and language compilers. This is even more so in the 3rd World, considering the usually high cost of these software packages.

This paper analyzes the current options that users have when choosing simulation software, enlightening free alternatives to commercial solutions. It provides an overview of current free software, as well as identifies potential needs and areas for further developments.

2 DISCRETE SIMULATION

2.1 General-Purpose Language Extensions (Libraries)

There exist several simulation solutions that are based on language extensions; they usually employ C or C++ and are distributed in the form of a library. Most of them are free for non-profit use. One of the few exceptions is Mesquite **CSIM18** ([2]), which employs a "per-seat" license, and allows the creation of process-oriented, discrete-event simulation models. CSIM18 works with most UNIX boxes with GNU compilers, like Linux, as well as MS Windows 95/98/NT, and Solaris86.

One of the free alternatives is **SimLib/C++** ([3]), a SIMulation LIBrary for C++, that allows the creation of models directly in C++ language with the use of predefined simulation tools from the library. It has been developed using Linux, and is also available in FreeBSD, SCO Unix, and MS-DOS. It allows a description of continuous, discrete, combined, 2D-3D vector, and fuzzy models. The Library sources are licensed under LGPL. Another free option is **SimPack v.3.0** ([4]), a collection of C++ library routines and programs that provides a "starting point" for simulations, with event scheduling and queuing model simulations. Currently, SimPack has 160 users, and supports platforms Solaris, MSDOS, OS/2, and MS Windows 3.1/95/NT.

C++SIM ([5]) and **JavaSim** ([6]) are two popular language extension packages written at University of Newcastle upon Tyne, both of which are free for non-profit, research or educational use. C++ design was influenced by object-orientation concepts that Simula introduced; C++SIM extends C++ even further towards Simula, adding classes that mimic SIMULA's simulation functionality. C++SIM is available for many Unix systems, like Linux. JavaSim is the C++SIM Java counterpart, and hence portable like Java. JavaSim is much smaller than C++SIM, as Java Language already embodies many required features, like thread support.

2.2 Simulation Languages & Compilers

Simulation-oriented languages form the oldest set of tools dedicated to assist the development of computer simulated models. Simulation languages have been around since the 60's. The first languages were changed in many ways, and in some cases were fully integrated with modeling and simulation development environments. Among these first languages emerged Geoffrey Gordon's GPSS and Simscript. GPSS has two general-purpose commercial versions, Wolverine's **GPSS/H** ([7]) and Minuteman's **GPSS/PC** ([8]). Both of them offer MS Windows based integrated development environments (IDEs). Like GPSS, **Simscript II.5** ([9]) is a general-purpose discrete simulation language with graphic capabilities. It was created by Rand Corp. and is currently developed by CACI. It is available on UNIX systems, MS Windows, and IBM OS/2.

Tecnomatix **Simple++** ([10]) is an object-oriented simulation language that offers graphical resources and IDE, being available on UNIX systems and MS Windows. Sierra Simulations & Software created **Simple-1** ([11]), a language (and an IDE) that supports discrete and continuous modeling through its network modeling orientation. Though it is commercial, Sierra offers a free student version. **SLAM II** is a commercial general-purpose simulation language developed by Pritsker Corp. Available on MVS, VMS and UNIX systems, SLAM-II has several constructions adequate for manufacturing simulations.

Fortunately, there are not only proprietary simulation languages and compilers. One example of free alternative is the **CSIM** ([12]), a Simula to C compiler. CSIM takes as input a Simula program and generates C code, which in turn is fed to a C compiler (GNU gcc). This scheme, which is portable and free, allows users to explore all Simula discrete modeling and simulation facilities. **Parsec**, or PARallel Simulation Environment for Complex systems ([13]), is the next-generation of the **Maisie** parallel and simulation language. The language is similar to C, and was designed for sequential and parallel execution of discrete-event simulation models. Parsec has been developed by the Parallel Computing Laboratory at UCLA. Available for Linux and some other Unix systems, as well as MS Windows, Parsec is freely available without fee for education, research, and non-profit purposes.

2.3 Generic Simulation Environments

During the last two decades, there has been a strong trend in the software development field: the increasing use of IDEs. This trend has had remarkable influence on the development of simulation tools, leading to a wide range of products with new capabilities. Examples of new capabilities were graphical formalisms integrated with programming languages to describe users' models, mechanisms to allow complete control over a simulation session, and visual interactive resources so that users could follow and steer the model behavior. The great majority of packages included in the present category are commercial software, like **Arena** ([14]) from Systems Modeling Inc., which offers a generic environment for discrete simulation. It is available only for MS Windows. F&H **Taylor II** ([15]) is another commercial simulation environment that delivers modeling capabilities integrated in a user-friendly interface. It aims mainly at industry business modeling and currently is available only for MS Windows.

Promodel Corp. has some simulation environments, such as **ProModel** ([16]), suited for generic discrete simulation, **MedModel** for healthcare simulations, **ServiceModel** for service modeling and **ProcessModel** for BPR (Business Planning Redesign). Promodel offers student versions of these software and special deals for professors and universities. **GSS** (General Simulation System, [17]) from Prediction Systems is a complete simulation environment that supports non-linear analysis; it consists of several different modules, some of which include VSE (Virtual Reality System Environment). GSS is available mainly for the UNIX platform.

A free alternative is **SIMOO** [18], a general-purpose, object-oriented platform for multi-paradigm, discrete simulation developed at UFRGS. The SIMOO library implements the tool-oriented approach to interaction and visualization. SIMOO allows the graphical specification of the static structure of a system by means of hierarchical classes and instance diagrams, and also visual interactive modeling. A co-simulation environment coupling SIMOO to a VHDL simulator has been developed.

2.4 Manufacturing Simulation Environments

There are plenty of commercial simulation packages for manufacturing applications. In contrast, there seems to be no free package or language compiler for manufacturing simulations. This is probably related to the area of application where this software is mainly used, that is, industry-oriented applications: automotive, electronic, paper, etc. There are many examples; some are CACI **SimProcess** [19]; Lanner Group **Witness** [20]; Deneb Robotics **Quest** [21];

AutoSimulations **AutoMod** ([22]); **APROS** (Technical Research Centre of Finland, [23]) and Flite Software **FluidFlow** ([24]).

2.5 Network Simulation Environments

With respect to network simulation environments, there exist both commercial and freeware solutions. In general, commercial solutions are more sophisticated, contain more features and a better graphic interface. On the other hand, they are costly. CACI offers a product for discrete event network simulation and engineering called **COMNET III** ([25]). This software is used to predict network performance (cost, traffic, etc.) on LANs and WANs; users graphically create a hierarchical model of the proposed network through a drag-and-drop tool palette and libraries of hardware devices and protocols. COMNET III is available for some Unix systems and MS Windows 95/NT.

Sophisticated network simulation software can cost as much as US$ 40,000. One example is MIL 3's **OPNET** Modeler Optimized Network Engineering Tools ([26]), which is a CAE tool for communication network design and analysis which aims to reduce simulation software development in the network design and analysis cycle. It simulates networks using an object-oriented graphical user interface, helped by a library of standard protocol models and hierarchical editors. Post processing and animation viewers provide a powerful analysis capability. OPNET runs on top of several Unix systems as well as MS Windows NT/2000. The list of commercial simulation software goes on, and includes software such as **POSES++** ([27]), a simulation environment for simulation of large network models.

There are free alternatives as well. The most notable example is the **NS** network simulator software ([28]), a discrete event simulator targeted at networking research. NS provides substantial support for simulation of TCP, routing, and multicast protocols; its environment provides library/classes, a command-line interpreter and a post processing viewer (nam, or network animator). NS is part of the VINT Project (Virtual InterNetwork Testbed), which is funded by DARPA. It runs on several Unix systems (including FreeBSD and Linux), though there is a port for MS Windows.

UNICAMP has developed **SimATM** ([29]), an event-driven simulation environment for ATM network simulation. As its name indicates, SimATM is tailored for research, analysis, and design of ATM networks. It is written in C++, and only available on MS Windows 95/NT.

3 CONTINUOUS SIMULATION

The problem of continuous simulation is basically a problem of integration of differential equations. Because there are too many mathematical packages with this capability, they will not be discussed here. Further, there are a lot of packages for visualizations with some analysis capacity; they will not be treated here as well. This section *does* provide is an example of continuous simulation language and applications: ACSL, GEPASI, and AERO. MGA Software **ACSL** (Advanced Continuous Simulation Language, [30]) is a commercial language which extends FORTRAN-77 for modeling the dynamics of continuous systems. The commercial package includes a graphic modeler utilizing block diagrams.

GEPASI ([31]), on its turn, aims at the simulation and optimization of the kinetics of systems of chemical and biochemical reactions. It is free software, though it runs only on proprietary platforms (MS Windows 95/NT and on DEC Alpha). GEPASI has many capabilities, such as 3D plots (based on Gnuplot, also free under the GNU license) and exporting and importing of data to/from other programs. **AERO** ([32]) is a free package for simulating rigid body systems, with a built-in 3D editor and ray tracing. It can create fully rendered animation sequences, e.g. MPEG videos. It runs on several Unix systems, including Linux.

4 CONCLUSION

Simulation is a technique that can be used in many areas: management, economy, engineering, biology, etc. This paper covers most existing simulation software. Even though a good deal of simulation software has been covered, there are many other categories that have been left out. Examples include simulation of operating systems, hardware architectures, integrated circuits, biological simulations, and military training systems.

One of the paper's contributions is to identify several categories of simulation software, weighting alternatives of free and commercial software in each category. Because it pinpoints categories, which are particularly weak regarding free software, it brings attention to areas that deserve concentrated efforts, like the modeling of manufacturing processes.

In contrast, there are several encouraging examples of free general-purpose application packages. Examples are the language extensions C++SIM, SimLib/C++, SimPack, and JavaSim, or CSIM Simula to C compiler. Many of these could be used right now in the 3rd World.

Besides, current free software could be, and should be, used as a starting point in the development of more complex simulation packages (also more specialized), aiming at replacing expensive simulation software for free software solutions.

5 REFERENCES

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