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Abstract **- Computer network communications have become a popular and efficient means of computing. Most companies and research institutions use networks to some extent on a regular basis. This paper demonstrates the capability of computer-aided design (CAD) through computer networks. There are several benefits that make networked CAD tools desirable. A networked application can be used remotely through any network connection. Any operating system can be used to access a networked application, making the application operating system independent. Also the application can be made to run on a pay-per-use basis if licensing is desired, and much less installation time and configuration time is required because the application is located on one central machine. The Spice Intranet Package (SIP) is demonstrated as an example of such a networked CAD application. This particular application allows users to run SPICE simulations and view graphical analysis of electronic circuits through a network connection using a Web browser. The SIP application has many options that include simulation and analysis of Spice files, graphical analysis of data, online editing of Spice files, passwords with separate file areas for each user, and a user friendly graphical user interface.**

I. INTRODUCTION

Computer networks have become a popular and efficient means of computing. The following paper describes an actual implementation, and the programming technology used to develop a CAD tool, which can be used remotely through computer network connections [1]. The Spice implementation used in this presentation is just one example of a networked application. Several methods of computer network programming are available including Java and CGI (Common Gateway Interface). The focus here will be the advantages of network programming when used for Spice simulation and analysis. An application called the Spice Intranet Package (SIP) has been developed for use through Internet and Intranet networks. Internet web pages are available from all around the world, while Intranet networks provide connectivity for a smaller, more isolated domain like a company. The SIP provides an operating system independent interface which allows Spice simulation and analysis to be performed from any computer that has a web browser on the Internet or an Intranet. The SIP has a user-friendly GUI (Graphical User Interface) and features include password protection and user accounts, local or remote files for simulation, editing of circuit files while viewing simulation results, and analysis of simulated data in the form of images or formatted text.

Several network-programming tools, which are available today, include Java, CGI, ActiveX, JavaScript, VBScript, HTML, and PERL. During software development it is important to justify which part of the software should run on the client machine and which part should run on the server. The CGI is quite different from writing Java applets in this aspect. Applets are transferred through a network when requested and execution is performed entirely on the client machine that made the request. In CGI much less information has to be passed to the server and the server executes instructions based on the given information and sends the results back to the local machine that made the request. Fig. 1 shows the program component division and data flow in a network based application.

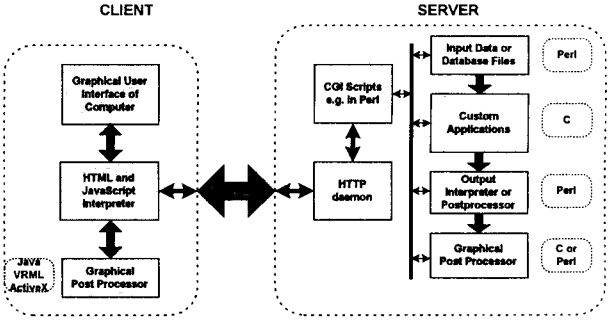


Fig. 1. Data flow in a network-based application.

In the case of the Spice Intranet Package it only makes sense to use CGI for the Spice simulation because it would be impossible to send the Spice engine through the network every time it was requested and this would be extremely slow. Java technology could also be used for functions like generating and manipulating graphs and implementing the graphical user interface on the client side. The SIP program currently incorporates CGI, PERL, HTML, and JavaScript. These technologies are briefly described below.

The CGI programming allows for dynamic web page generation in a web browser based on user selections in the initial page displayed in the web browser. Communication between a CGI program and the web browser is accomplished through a network connection between the web browser and a computer running an HTTP (Hypertext

should be granted and if the CGI program actually exists. If the authorization is secured the server executes the CGI program and returns the results to the web browsers that requested the processing.

PERL is a programming language especially suited for CGI network programming and commonly used for text processing and system shell programming. Sometimes a PERL program is called a PERL script because it is an interpreted language and is not compiled like a C program. A PERL script is similar to a Unix shell program. PERL has many features that make it well suited to processing CGI requests and generating HTML pages. HTML and JavaScript provide the front-end graphical user interface that allows a user to click a button or enter a circuit filename and start circuit simulations. Events in JavaScript are monitored and processing of information is initiated through features of these two technologies.

II. SIP DESCRIPTION

The SIP software package is a Spice simulation and analysis program implemented in the network environment. A unique feature of the SIP program is that it is operating system independent. Anyone that has access to the Internet and a web browser, such as Netscape Navigator or MS Internet Explorer, can run a Spice simulation and view the results graphically from anywhere in the world using any operating system. A network model of the SIP software package is shown in Fig. 2.

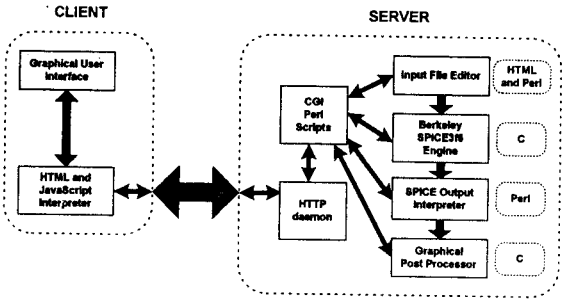


Fig. 2. Spice intranet package network model.

A server is configured to accept requests from web browsers through network connections. The server processes the request for Spice simulation or analysis and returns the results to the requesting web browser as an HTML document. The graphical analysis is embedded in the HTML as an image or returned as formatted text. Fig. 2 shows the flow of information and the distinction from the client and the server. Some of the SIP features include:

- Simulation and analysis of Spice files stored on the server or on your local machine.
- Graphing of DC/AC/Transient analysis data from a remote or local file. The data used for graphing is generated with the Spice ".PRINT <AC|DC|TRAN> ..." command.
- Multiple users can access the SIP program simultaneously.
- Password protection and separate file areas for each user password.
- Editing of personal input and output files stored on the server.
- Multiple windows open at a time to allow viewing or editing of circuit files while viewing simulation results.
- Analysis output can be specified as a GIF image, or raw text containing the data points.

The current versions of SIP are written both for the Unix and the Windows NT operating systems. (Respectively: http://atlantis.uwyo.edu/~regnier/sip and http://nn.uwyo.edu/sip-html/.) The two versions differ only slightly because of the operating system independence of the programming languages being used. PERL for example is available for Windows NT as well as the Unix system and JavaScript and HTML are totally platform independent. The image generation is currently done with the gnuplot program and netpbm utilities.

III. SIP EXAMPLES

The graphical user interface is shown in Fig. 3. It is necessary to select the radio button for ***REMOTE*** or ***LOCAL*** files depending on which you are using. This decision specifies whether the simulation and graphing programs will use the remote or local file names that you entered. If you use local files you have to save the output from simulation in a file on you local machine, and then enter that name in the ***Local OUT Filename*** edit box in order to plot the data. As an example of the use of the SIP program, consider the MOS Inverter in Fig. 4.

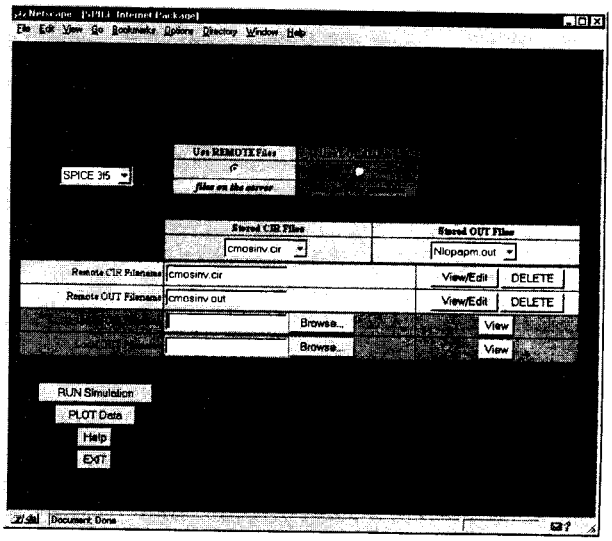
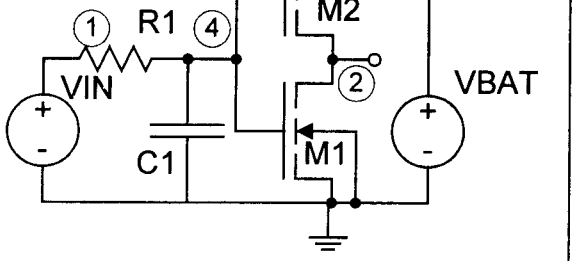


Fig. 3. Graphical user interface for SIP package.



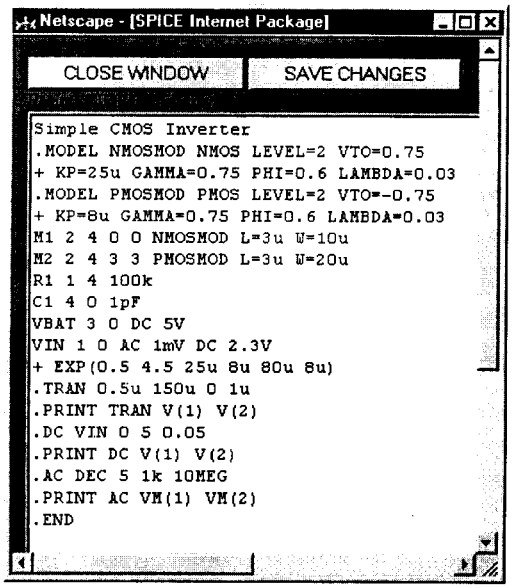


Fig. 4. Simple CMOS inverter: circuit diagram (upper) and editing window with Spice input file (lower).

The Spice3 input file in Fig. 4 describes the MOS circuit in terms of the Spice3 language. The Spice2 and Spice3 input code significantly differs from other popular Spice versions as PSPICE for example. All differences between various Spice programs are well described in [2]. Notice in the Spice code there are commands for the Spice simulator to analyze the dc sweep, the ac analysis, and the transient response of the circuit and to print the output of V(1) and V(2).

To enter a Spice input file select the filename from the CIR drop down box or type the name into the ***CIR Filename*** edit box and then press the ***VIEW/EDIT*** button. After entering or modifying the input file press ***SAVE CHANGES*** in the edit window to save the changes to the file. After entering the input file and saving it, the simulation is then run by selecting the ***RUN SIMULATION*** button. The output from the simulation is displayed in the output window. If remote files were used the output is also saved to the file in the ***Remote OUT Filename*** edit box automatically. Next generate a graph of the output data by pressing the ***PLOT DATA*** button. A window will open allowing you to select what variables you want to plot and other customization variables as shown in Fig. 5. Select ***PLOT DATA*** again and the analysis is returned to the output window as shown in Fig. 6. To close all the windows and return to the original web browser window press the ***EXIT SIP*** button. There is generated by MS Excel or other plotting packages.

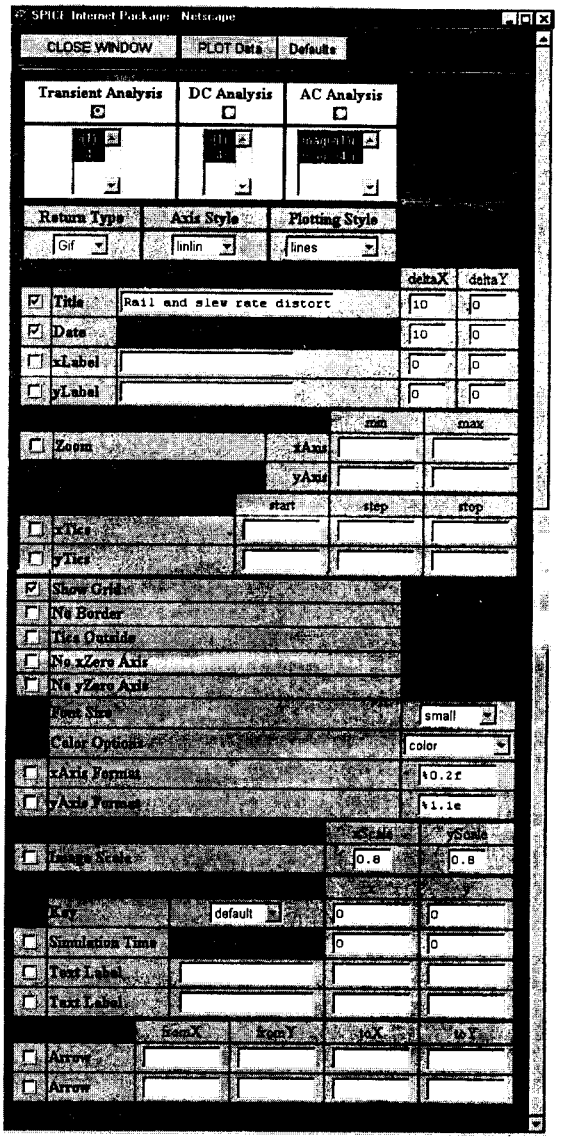


Fig. 5. Plotting configuration screen.

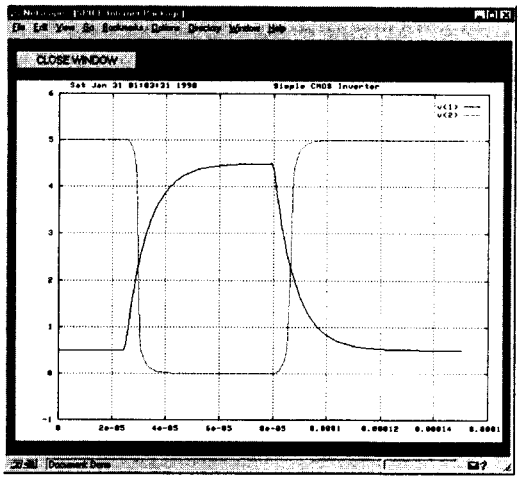


Fig. 6. Results of a transient analysis of CMOS inverter.

types of analysis are performed. Fig. 8 shows both the transient response of the amplifier and the AC analysis. Note two types of distortions one due to rail voltage limitation and another due to the slew rate limitation. One unique feature is ability to copy the resulted graphics into reports or documents as it is demonstrated in Fig. 8. The SIP package uses the compressed GIF graphics formats, which are small and handy in comparison to the large bitmap files used in other Spice packages.

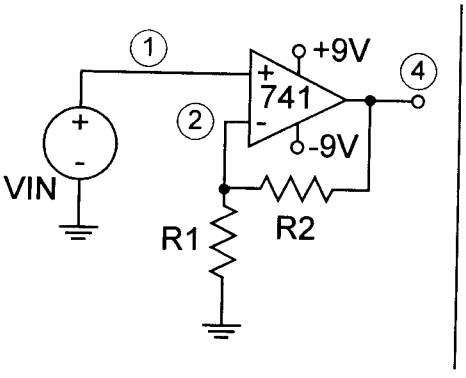


Fig. 7. Application of a non-ideal operational amplifier.

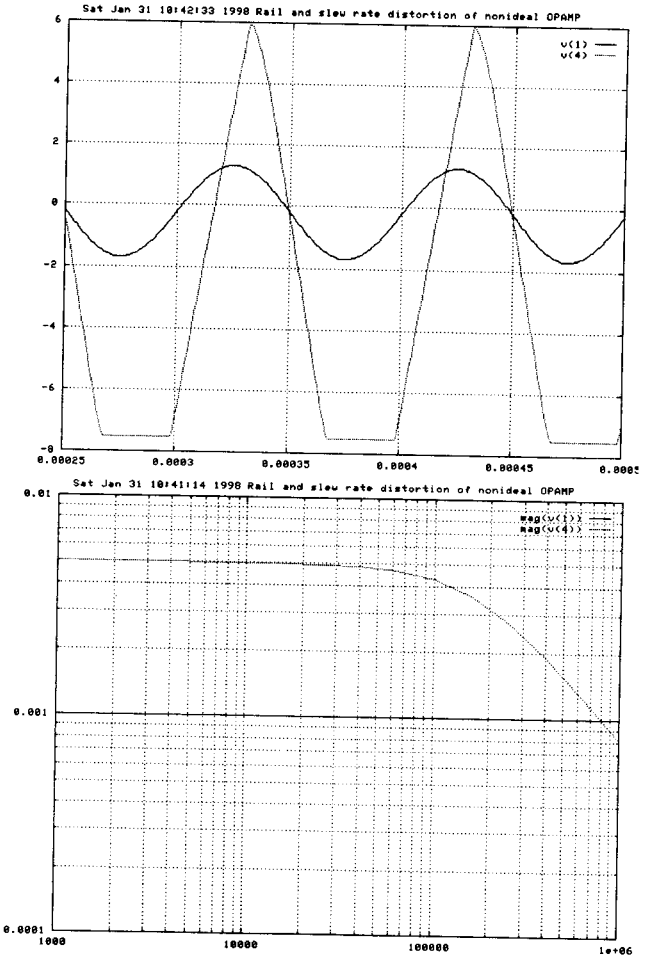


Fig. 8. Results of analysis of non-ideal operational amplifier: transient analysis (upper) and ac analysis (lower).

The purpose of this presentation is to show how CAD tools can be used through the Intranet, and the SIP is just an example of using Spice. Several features make the Spice Intranet Package a desirable program for computer-aided engineering and design. Only one copy of the Spice engine needs to be installed and configured. One machine acts as the server and other machines can simultaneously access the Spice engine through network connections. Remote access to SIP allows users to run Spice simulations from any computer on the network, and that might be from home or another office in another building or town. Also the current Spice engine being used is Spice3f5 from Berkeley [4] which allows an unlimited number of transistors, unlike various "student versions" of Spice programs that are available.

User passwords are required because the SIP program is accessible from around the world and a heavy number of users would slow the server down noticeably. For undetermined time you can access the Spice Intranet Package and try some examples with the password "**sip**" at the following URL:

- http://atlantis.uwyo.edu/~regnier/sip
- http://nn.uwyo.edu/sip/

The Spice Intranet Package is successfully used in several classes at the University of Wyoming. Students appreciate a convenience of using it on any computer platform at the University or at home. It was designed originally for the Intranet, however it works also very well on Internet.

VI. REFERENCES

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[4] Quarles T., A. R. Newton, D. O. Pederson, and A. SangiovanniVincentelli, *SPICE3 Version 3F5 User's Manual*, Department of Electrical and Computer Science, University of California, Berkeley, CA, 1994.

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