PHIDIAS II - In Support of Collaborative Design

Robert W. Knapp and Raymond McCall
Sundance Laboratory for Computing in Design and Planning
College of Architecture and Planning, University of Colorado, Denver
Boulder, CO 80309-0314
knapp@phidias.colorado.edu

ABSTRACT

The World Wide Web in combination with Java and Virtual Reality Modeling Language (VRML) create great opportunities for collaboration by distributed design teams. To take advantage of these opportunities, we have begun to create a version of the PHIDIAS hyperCAD system (McCall, Bennett and Johnson 1994) that will support communication and collaboration among designers over the World Wide Web. PHIDIAS is an intelligent hypermedia-based system for computer-aided design. Our strategy is to divide PHIDIAS into two parts: 1) a client-side user interface and 2) a server-side hyperCAD database engine. The client-side interface is being implemented using Java and VRML. Implementing the PHIDIAS front-end with Java enables program code distribution via the World Wide Web. VRML provides PHIDIAS with client-side computation and display of 3D graphics.

INTRODUCTION

For a number of years we have been engaged in the design of hypermedia-based computer systems for architectural design (McCall, Mistrik and Schuler 1981). Our current prototype, called PHIDIAS II, was originally designed as a single-user system. Recently, however, we have concentrated on extending PHIDIAS’ functionality to include support for collaborative design. This represents a return to the basic goals of the IBIS (Issue-Based Information System) method (Kunz and Ritel 1970) that PHIDIAS was originally created to support.

Our efforts at supporting collaborative design were first directed at the problem of supporting groups that work over a local area network. We are now extending this work to support distributed design teams; that is, teams consisting of designers at potentially great distances from each other. In particular, we have looked for software solutions that might minimize the effect of distance between team members. Face-to-face interaction, while probably the best environment for collaboration, places excessive limits on who can participate in a design project and thus limits the quality of the team that can be assembled for a project. We aim to create a system that enables design teams to work together without face-to-face interaction and that enables a synergy between the users. There are two dimensions of non-face-to-face interaction: different place and different time. In this paper we concentrate on the different place dimension.

Researchers explorations into collaborative work have opened channels of communication between designers with relatively new technologies for the time, such as video conferencing, FTP, E-mail and IRC (Cheng et al. 1994). Of course, the goal of using new technologies is to not confine or restrict a designer’s creativity (Kim 1995). We would like to see PHIDIAS support interactive, hyperCAD-based collaborative work where designers can share workspace and context. If such technology is applied correctly, the designer’s product will get pushed to a higher level because of the tools made available during the collaboration session (Dava 1995).

This paper assesses the feasibility of creating a new version of PHIDIAS built with a client-server system architecture whose client side is implemented in Java and VRML on the World Wide Web. We report here on an experimental prototype of a PHIDIAS front-end constructed to explore and advance the idea that distributed design teams can work effectively with this new technology.

The remainder of this paper is organized as follows. Section 2 describes the current capabilities of the PHIDIAS system. Section 3 discusses the difficulty distributed design teams have working effectively together. Section 4 proposes a solution for extending PHIDIAS to support distributed design teams. Section 5 demonstrates...
our solution and discusses advantages and disadvantages to integrating VRML and Java into PHIDIAS. Section 6 concludes with a summary of the project and addresses future work and other technologies.

**BACKGROUND**

PHIDIAS supports design by informing architects as they develop the form of a solution. The idea is not to make the design process faster or cheaper, but to improve the quality of the things designed. We believe that architects can create better buildings for their users if they have better information. This includes information about buildings of given types, user populations, historical and modern precedents, local site and climatic conditions, the urban and natural context and its historical development, as well as local, state and federal regulations.

![Figure 1. The PHIDIAS II hyperCAD system.](image)

The PHIDIAS II HyperCAD system combines the functionality of CAD graphics, hypermedia, database management, and knowledge based computation in a single, highly integrated design environment (Figure 1). PHIDIAS’s CAD functionality includes both 3-D and 2-D vector graphics. The hypermedia includes support for text,
PROBLEM: DISTRIBUTED DESIGN TEAMS

Most large, modern artifacts are designed by groups. The design of airports, corporate campuses, shopping malls, urban housing complexes and high rise buildings typically requires participation by many people in a collaborative process. Multiparty participation is often dictated by the complexity of contemporary design projects. This complexity is in turn due to the scale of the problems designers aim to solve, the technologies used to solve them, and the potential effects of proposed solutions. To deal with such complexities, the experience of many people is required: designers with experience in similar projects, designers who are potentially located at great distance from one another, past and future users as well as experts in manufacturing. Project success often depends on full participation of all these knowledgeable people.

Barriers to Collaboration in Design

Until recently, collaboration was possible only among participants who were in the same place at the same time. Communication difficulties limited participants to a single geographical location and collaboration became problematic when the architects, essential people, activities, or the site were a great distance from each other. Designers have become used to working in a design environment where people interact face-to-face.

Until very recently communication and computation technologies were unable to provide the communication needed by distributed design teams. The telephone, fax, E-mail and even video conferencing do not do enough to make collaborative design possible. While these technologies allow information exchange, they do not enable the interactive, multimedia, task-related communication and sharing of workspace and work context that are needed. They inhibit the rich, ad hoc, and spontaneous communication needed for successful team design.

Platform dependence in computing has been another barrier to collaboration in design. Users of different hardware and operating systems cannot easily share data and applications. For example, if designers wanted to share a drawing, they first created it—usually by hand—then scanned the sketch with one application and sent it to other people with another application. The recipients then must view the drawing with yet another application. Users with the same hardware systems, more than likely, will not have similar software for communication. Different operating systems complicate communication in that software designed for one system may be unavailable for another. It is even sometimes difficult to get the same software package running on different machines of the same basic type—e.g., different Intel-based systems.

Now, however, technological developments associated with the World Wide Web enable us to interact in new ways without being face to face. In particular, we believe VRML and Java when integrated with PHIDIAS can provide an interactive based design environment that is ubiquitous and that meets the requirements for collaborative design.

SOLUTION APPROACH / TECHNOLOGIES

We are building a prototype of the PHIDIAS system using the World Wide Web, Java and VRML. Java is a programming language that enables the creation of platform independent software that functions as executable content on World Wide Web pages. With Java, the World Wide Web can deliver software as well as information. To overly simplify the point, Java makes the computer more like a telephone in the following sense: it can used without having to understand or cope with the complexity that make it function. The user simply uses the device (Fallows 1996). In more technical terms, Java code is portable over the Web through two means; it can be run on any computer enabled with a Java interpreter or a Just-In-Time (JIT) compiler. Such an interpreter or compiler functions as a 'virtual machine', i.e., an instruction set without specific platform dependent calls.

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The notion that computers are moving into society and the idea of "ubiquitous computing" (Weiser 1991) may become reality due to Java. The code is loaded via the World Wide Web and runs seamlessly, consistently, effortlessly by the user's local machine. The user's machine will run the executable content Java code on any platform be it, PC, Mac or UNIX. When code is written in Java, it is written for PCs, Mac and UNIX platforms automatically, because the code is interpreted by, or compiled for, the local machine.

VRML (Virtual Reality Modeling Language) is based on Open Inventor (Werneck 1994), which is a higher level implementation of Open Graphics Library, a machine-independent graphics standard based on the Silicon Graphics Library (GL). OpenGL is a display-list-driven, hardware-supported rendering system. It has been the basis of the so-called "Siliconwood" collaboration between Silicon Graphics and Hollywood for generating special effects in the majority of films featuring such effects—e.g., Star Gate, Jurassic Park and Twister. VRML is downloadable via the World Wide Web browsers and there is hardware support for PCs. VRML will make animated Gouraud shaded vector graphic models available to designers that can be edited and viewed. With the release of VRML 2.0 (called Moving Worlds), users will be able to directly manipulate vector graphic models as they are rendered. The VRML 2.0 standard allows fully integrated, interactive VRML/Java applets.

The World Wide Web provides uniformity from platform to platform. It is cost-effective, ubiquitous, and has the ability to close large distances as a communication medium. Netscape Navigator is the most common Web browser on each platform and this provides a high level of continuity among platforms. However, if each user/platform employs a different browser, the net result will be the same — if they are similarly enabled with a Java interpreter/compiler and a VRML viewer.

![Image](image.png)

**Figure 2.** The Java applet is launched.
Implementation Approach

The use of Java accomplishes two primary goals: changing static HTML content to a dynamic executable content and achieving portability from platform to platform via the World Wide Web. Achieving these goals means a designer can obtain a piece of software as easily as his peers, without having to install it, wait for it to arrive in the mail or pay the full purchase price. For example, if an architect needed a piece of software that aided the design of large tent structures, he might find and use a Java applet over the Web. High-quality, specialized software of that type might be prohibitively expensive if purchased outright. But if it can, in effect, be leased for a limited period of time — i.e., as a Java applet — the cost might be much less. Being able to run software over the Web from a Java enabled browser on any major platform will greatly improve the likelihood that the design software will be used. Java is poised to revolutionize the way we obtain, use and pay for software.

VRML has the functionality and the solid reputation of OpenGL to support high-level, graphics-based collaborative work. Presently, some OpenGL hardware support exists for the PCs; such hardware is likely to become both common and inexpensive in the near future. VRML is independently becoming the de facto standard for 3-D graphics on PCs because of its history of use, hardware support and high quality. To emphasize this point, Netscape Inc. bought Paper Software Inc. — the makers of the most widely used VRML viewer, WebFX; and has since incorporated it directly into Netscape's browser plug-ins. Furthermore, OpenGL has been accepted by Microsoft as a standard for 3-D graphics for Windows NT and Windows 95. In sum, these technologies situate themselves to become an integrated package. This integrated package could potentially make the Web browser itself an operating environment.

Our approach has been to extend the PHDias system to provide this functionality using the technologies described above. The first step was to divide the PHDias functionality into two parts, a server-side and a client-side. The server-side system has two functions. The first is to contain the database and provide searching and ref-
erence capabilities in the database. The second is to retain records of conversations among team members during design. In the next section we explore the implementation of the client-side system using VRML, Java and the World Wide Web.

**SOLUTION**

We have created a Java applet that displays text in outline format. This applet is downloaded from the PHIDIAS VRML/Java testpage, over the World Wide Web. The applet has a window which contains a set of text data in outline form. This textual data could also link to photos or sound; however, in the current version we have only included VRML files. The VRML model we created was a space habitat used in the PHIDIAS II system. Through the Java window the hypertext link is selected and the appropriate data downloaded. When our VRML file is being downloaded, the viewer is launched, the model is loaded into the viewer and then viewed.

In Figure 2 the Java applet is launched from the PHIDIAS testpage. This is done by simply clicking on the word 'here'. Next, the VRML viewer is launched when the 'VRML model view 1' is clicked on, in Figure 3. With all three models opened and Netscape minimized the screen appears as in Figure 4. In this context, the Java applet is controlling the organization of the outline text and its links. The current VRML 1.0 standard does not yet enable direct manipulation of a model by the user. This seems to have been a political decision to get the VRML standard out the door and accepted by the graphics computing industry, due to potential controversy at the time of release about how manipulation should occur. As of the submission of this paper the first VRML 2.0 standard browser has just been released.

![Figure 4. Three views of the model launched from the applet](image.png)
Experiences

Getting our Form-Z and AutoCAD models saved as DXF files, imported into 3D Studio and then exported as VRML files was not difficult. We had problems with Java that are typical with learning any new language — often due to subtle differences in syntax and structure from C/C++. Overall, the construction went smoothly and was without significant problems. The PHIDIAS test page and the executable Java code appears to be consistent between different platforms. Users can get to the software easily and view the space habitat model quickly and effortlessly.

Advantages

The World Wide Web’s ubiquity, uniformity and platform independence make it the perfect vehicle for sending data between a PHIDIAS client-side front-end and a server-side hypermedia database. The executable content of the downloadable Java code is useful since we can demonstrate our progress on our lab’s PCs, Macintoshes or UNIX machines. Linking the applet to the VRML files was simple enough, and we see the potential for interesting improvements.

VRML is rising as a standard, and its basis in OpenInventor and OpenGL provides a strong foundation. The available hardware support is near workstation quality and improving. The viewers are also improving and currently there are more than 20 different ones for the VRML 1.0 standard. Moreover, Netscape’s purchase of Paper Inc. demonstrates the commitment by the industry to implement 3D graphics via VRML. There are more than 50 internet companies who have agreed to support VRML 2.0 as the next-generation implementation of Virtual Reality Modeling Language.

Limitations

Creating a fully functional, Web-based version of PHIDIAS in Java involves complexities beyond those dealt with in this paper. The current project was simply an exploration into what system construction will involve and how the technologies work as they pertain to design. The World Wide Web is presently adequate for communication; however, it is always somewhat slow and sometimes data transmission and retrieval times become large. In the near future, the hardware will become available to speed the Web so it will be possible to maintain constant high speed duplex communication between each user and the server.

Using the Java command-line compiler/debugger was tedious at times but functional. We are looking forward to the availability of a high-level programming environment for Java. Currently the Java applet test is static with the links to VRML models. With the coming VRML 2.0 standard we look forward to more complete integration.

We used a PC with OpenGL hardware support for speeding VRML. This is first generation hardware support, so the improvement of having hardware support is noticeable, yet not remarkable. Further improvement will be needed if workstation-quality graphics is to be practical on the desktop. There was no support for texture mapping; and though the renderings were processed more quickly, there was still flickering and an inability to maneuver in close quarters.

Conclusion

We have demonstrated proof of the concept that the World Wide Web, VRML and Java can be integrated to aid collaborative design. While the system we developed is functional, there are several points that we would like to address in the future and several issues we are dealing with in the scope of other projects. Some of the questions to be addressed in the future are as follows: If fully developed, how useful would a fully VRML, Java enabled PHIDIAS actually be? How can the Java-based PHIDIAS be connected to several distributed designers at the same time to enable effective sharing of data in real time? How can we enable VRML models to be manipulated by many designers simultaneously?

In sum, we are excited and optimistic about further development of PHIDIAS as a collaborative design tool. Java and the World Wide Web will provide the ubiquity required for global use of PHIDIAS. With VRML 2.0 inte-

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grated into PHIDIAS, powerful interactive vector graphics will be provided to designers. We believe that there is in fact a real and tangible opportunity to create an environment that designers can use wherever they are.

REFERENCES


