

A Customizable Collaborative Virtual Environment on the Web

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Abstract

Collaborative Virtual Environments (CVE) support the collaboration, communication and social interaction among users in virtual spaces. In this paper we present a customizable CVE implemented on top of the Web that allows for the creation of various interactive environments. This CVE is designed mainly from the perspective of the desk, rooms and hall metaphors. The architecture of our CVE is based on design patterns and integrates a group of tools in order to support interaction among users in both synchronous and asynchronous ways.

1. Introduction

The World Wide Web is a platform conducive to the development of collaborative applications mainly because of their global presence. This facilitates the distribution of applications, communication and collaboration among work group users.

It used to be that the Web's nature was traditionally asynchronous. However, new "fourth-generation Web sites" [5] allow users to download HTML documents [1] with Java applets [7] which provide direct communication, one example being TCP/IP protocol among other Java servers. The presence of these applets on the HTTP server side, such as *servlets* [29], provide improved functionality over traditional CGIs [15]. With a high degree synchronism these recent advances have made possible the development of more interesting collaborative applications on the Web, [8, 12, 20, 21, 22]. However, this platform is little being used in the development of collaborative virtual environments [26, 25, 27]. Using this type of environment [3], users can perform a variety of collaborative activities. These collaborative environments can be more flexible than more traditional CSCW environments [19].

The communications support that defines most collaborative environments is focused on predefined meetings. However, collaborative work environments should also be focused to support non-predefined interaction. Ellen Isaacs [11] establishes that workgroups with informal interaction tend to be more productive than

workgroups with formal pre-established encounters, concluding that the better alternative in supporting non-predefined interaction is the application of *collaborative virtual environments* (CVE).

In order to support CVEs for students, lecturers and guests, we implemented a prototype called "DeskTOP" for the creation of different interaction environments and the support of collaborative work and informal social interactions. This paper highlights some of our experiences in constructing DeskTOP.

The remainder of this paper is organized into 4 sections. Section 2 describes the conceptual model of the DeskTOP system. Section 3 discusses the system's architecture. Section 4 illustrates the prototype we implemented. Finally, section 5 discusses some of our conclusions.

2. Conceptual model of the DeskTOP system

2.1. Functional features

The DeskTOP system was designed over the Internet in order to support improved social interaction. This social interaction implies the ability to meet and to talk with new people in order to discuss ideas with people belonging to other contexts. When people are geographically distributed, the problem of improving social interaction is physical distance. The Internet solves this problem because it has the ability of bringing people geographically separated people into contact with one another. The Internet is like a rich infrastructure for communication that can offer a wide variety of interactivity based on multimedia technology, and can be used to establish communication in real time at a low cost.

The design of the DeskTOP system provides users with a common interface in a shared environment. The DeskTOP interface attempts to give users the sensation of communicating as if they were in the same physical place. DeskTOP provides various communicative channels, using different communication applications. The use of multiple communication applications is the key to the success of groupware systems [18].

DeskTOP was designed from the perspective of a virtual environment to promote social interactions. Virtual environments have a great potential in promoting collaborative work [16], in organizing synchronous and asynchronous tools, information and resources, and in providing a shared workspace [17].

The DeskTOP design is metaphorically based in order to provide an interface that is more integrated and easy use. Metaphors allow people to work in familiar ways and to afford users with an improved understanding of the application domain [14].

2.2. Metaphors used in DeskTOP design

The DeskTOP system uses 3 metaphors: the *hall* and *collaboration rooms* as metaphors of places [24, 28] and the *desk* as metaphor of interface [23]. These metaphors are explained in the following sections.

2.2.1. The *hall* metaphor. The *hall* metaphor establishes a virtual environment which promotes casual and informal interaction among its users. The environment represented with this metaphor is used for the community members in order to familiarize themselves with new participants. DeskTOP allows two types of users: *community members* and *guest members*. The community members are all the members that are explicitly defined within the collaborative environment. The guest members are unknown users who arrive in any moment to the hall environment in order to exchange ideas with community members. Guest members can only visit the hall.

2.2.2. The *collaboration rooms* metaphor. The *collaboration rooms* metaphor helps to represent shared environments within which the user groups work. Through this metaphor a common area is created for private interaction which provides users with the sensation of being in a private limited space. In this limited space any interaction is carried out and information is shared. Figure 2.1 represents the idea of the hall and the collaboration rooms DeskTOP virtual environments.

Inside a *collaboration room* there are many resources that users can use to facilitate group interaction. For example, within a shared workspace a table is used on which the users can place information objects (such as documents, videos, etc.). Any objects placed on this shared table are considered public domain and therefore any member entering the room can use, visualize, modify, or update them.

Other resources include: shared whiteboards, allowing members can draw; shared datashows that can show presentations; message boxes where notes can be left for other users; wallpaper in order to leave public information on topics of interest.



Figure 2.1. Representation of the *hall* and *collaboration rooms* environments

When members of a group use a collaboration room, one of them assumes the coordinator role. The coordinator is the only individual who can modify the state of the room and the resources available within it. A collaboration room can be in three different states, depending on the member's needs. A room can be considered *open*, *closed* or *half-open* (public, private or restricted states). An open room implies that any community member can enter it. A closed room indicates the room is busy and that the members using it do not want to be interrupted. A half-open room indicates only pre-defined members can enter it.

2.2.3. The *desk* metaphor. In the real world, a desk is a workspace on which we have certain objects to help facilitate our work. These objects can be information objects (documents, books, papers), communication objects (telephone, fax) and other support objects (calculator, calendar, post-it notes). The *desk* metaphor is used to collect and to make an abstraction of these reality objects in order to facilitate the collaboration among the users of the group.

Some operative systems, such as Macintosh and Windows use the desk metaphor in the design of their interfaces. This metaphor is widely accepted because it offers users a correspondence in the appearance, use and behavior of the real life objects and their computational representations. DeskTOP uses the desk metaphor to provide users certain collaborative tools and to convey the sensation of being seated before personal work desks. The user desk is extended with a communication level in order to help transform it into a *collaborative desk* [18]. The main goal is for each user to feel that they are seated before their own personal desks and have a group of tools that they can use during the collaborative work process. Through such desk tools users can talk with other users, move between rooms, discuss ideas or carry out collaborative work.

Fortunately this set of tools is customizable allowing each member can participate in a way that he or she feels

comfortable. Users can personalize their interaction environment, they can use these tools and locate them within their interface, according to their interaction necessities.

Through this desk metaphor many collaborative applications can be integrated to provide various means of synchronous and asynchronous interaction.

2.3. DeskTOP desk tools

Interactions among the members of a group are not frequently predictable and may require flexible systems that can be adapted to different needs [13]. Flexible systems allow for the easier transition between informal interactions to formal interactions. User groups produce most of the collaborative work in formal interactions.

The desk provides tools for communication, collaboration, coordination, and awareness support. The table 2.1 highlights some of the tools, according to the type of service provided and their synchronous or asynchronous nature.

Table 2.1. DeskTOP tools classification

Service	Synchronous tools	Asynchronous tools
Communication	Chat, whiteboard, Telephone, Audio/Video	Mail, Post-it
Collaboration	Slider, Voting, Editor	Newsgroup, Editor, Voting, Calculator, Calendar, Notebook, Clock
Coordination	Control	Control
Awareness	Users, Environment, Virtual window, Collaboration Room	Users, Environment, Virtual Window, Collaboration Room
Others	Assistant, Desk	Card

DeskTOP tools are classified according to communication services, collaboration, coordination, awareness, and others. For communication tools different communication channels are provided. Collaboration tools support the group in sharing information. Coordination tools help to organize the interaction process. Awareness tools offer user information on the state of the shared virtual environment as well as users who are there. Tools categorized under the “others” topic provide additional interaction facilities inside the virtual environments.

In communication channels the *chat* is a basic tool that offers support for synchronous communication. The *whiteboard* allows users to draw lines or outlines in a drawing area and to achieve a better understanding on certain concepts during the interaction process. The *telephone* tool provides communication among users located among different collaboration rooms. The *Audio_Video* tool supports audio/video transmission in real time.

In the collaboration tools, the *slider* is an abstraction of a slide projector designed to display information to others members. The *voting* tool provides a mechanism for the group to take decisions. The *editor* tool to supports collaborative text edition.

The *control* tool is the only coordination tool. This tool is designed to manage an interaction order in the employment of the other tools through access restriction.

In the awareness tools, the *user* tool provides awareness about the presence and location of other users within the virtual environment. The *environment* tool represents the collaborative virtual environment of DeskTOP, constituted by the hall and adjoining collaboration rooms. The *collaboration room* tool is designed to represent a place for the private sharing of work. This tool provides awareness of users within the room, public objects, the state of the collaboration room itself and any temporal interruption of work by users inside the room. The *virtual window* tool provides awareness through a video reception.

The *note* tool enables members to leave text notes on other member's desks. The *newsgroup* tool was designed for the exchange of information, ideas and positions on specific interest topics. The *card* tool provides personal information about any DeskTOP user.

3. DeskTOP architecture

The DeskTOP system architecture is based mainly on the *broker (client-broker-server)* design pattern [Busch96]. The shared context of the DeskTOP system is maintained in the *server* component, and the desk tools are run in the *client* component. The *broker* acts as an intermediary component between the client and the server, abstracting the communication aspects over the Internet. The broker architecture is combined with the *model-view-controller* design pattern [9] in order to design the interface of the collaborative tools in the client component. The complete DeskTOP architecture is illustrated in figure 3.1. The following sections explain the DeskTOP architecture components that are shown in the above figure.

3.1. The server component

Three types of servers constitute the *server* component: the Web server, the audio/video server and the TOP server. Client browsers use the Web server to download the DeskTOP interface. The commercial RealServer [30] provides both audio and video in the DeskTOP system and to store the audio/video signal in a file, in order to be recovered by demand.

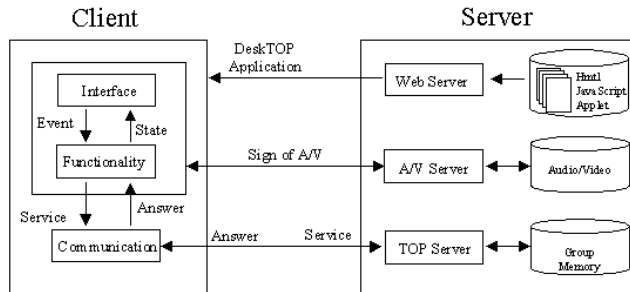


Figure 3.1. DeskTOP system architecture

TOP ("Ten Objects Platform") [10] is a platform designed to aid in the construction of collaborative applications. The TOP server provides the shared environment of the DeskTOP application. TOP provides services for group memory management, user communication, floor control mechanisms, and work sessions management. DeskTOP invokes the TOP services through the broker component.

3.2. The broker component

DeskTOP uses the broker pattern to abstract all the aspects of Internet communication among DeskTOP clients and the TOP platform server. The broker is responsible for coordinating the communication, sending requirements and receiving any results and/or exceptions.

By using this pattern an increased independence between the client and server components is achieved. DeskTOP clients use the functionality of the TOP server by sending request services via the broker. The broker initiates communication by sending the requirements to the TOP server and returning the results and exceptions to the DeskTOP client.

The broker component allows DeskTOP clients to use the TOP's services without any knowledge of its whereabouts or worrying about the communication protocols.

3.3. The notification service

A common feature of synchronous collaborative applications is the *notification service*. A notification takes place when the state of the shared context or shared environment of an application changes [4]. In our approach, TOP provides the shared environment of the DeskTOP application and through its services the notifications are propagated. The broker component is extended to capture any notifications the TOP server generates and forwards them to DeskTOP clients [10].

The figure 3.2 outlines the notification generation through the TOP platform's broadcast service and the figure 3.3 shows the notification behavior diagram in the client-broker-server architecture.

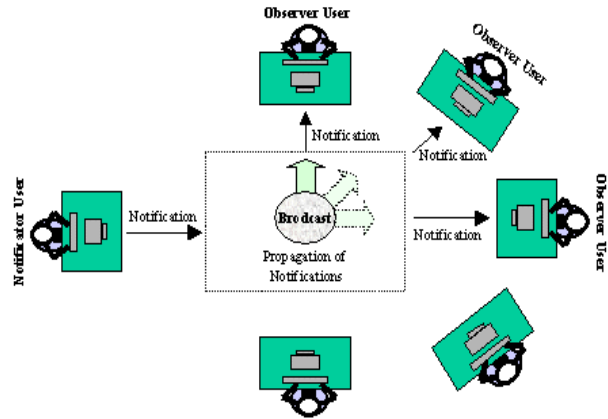


Figure 3.2. Outline of notification propagation

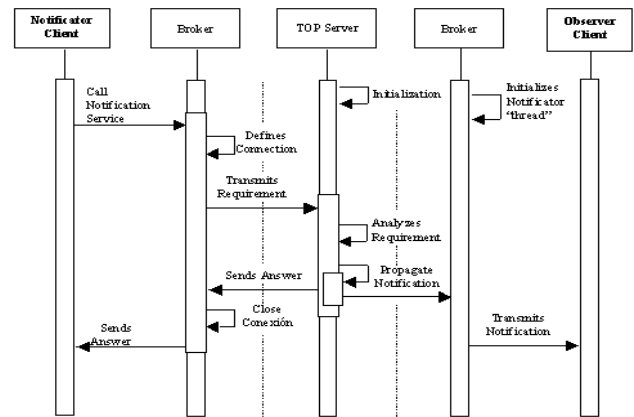


Figure 3.3. Behavior diagram of notifications propagation

Two non-excluded situations exist where DeskTOP users can be: in *notifier* state or in *observer* state [6]. A user is a *notifier* when he or she produces an event that is sent to other users. Meanwhile, any other users are in the *observer* state. A user is an *observer* when they receive an event notification that was emitted by a notifier user.

3.4. The client component

The design of the DeskTOP clients was based on an adaptation of the design pattern *Model-View-Controller* (MVC) [Busc97]. Through this pattern data stored in the group memory (the shared context) is separated from the application interface. This allows for the possibility of independent programming languages for building the clients and server.

The DeskTOP client's design, which is based on MVC, is established in the following way: the view component is responsible for presenting and organizing the elements of the client's interface, such as buttons, text areas, selection areas, menus and others. Next, this component defines the events that are triggered when the user initiates the

DeskTOP interface. The actions associated to these events are then managed by the controller component. When necessary the controller component is responsible for activating the change propagation mechanism in order to maintain consistent the user's interfaces.

3.5. Integrating the DeskTOP tools

DeskTOP provides users with a set of tools in order to configure the collaborative environment interface according to any interaction needs. An interaction environment is constituted by a sub-set of tools, which are selected by the user from the desk tools.

The tools are independent of each other and the only interaction among them is through notifications. Figure 3.4 illustrates how the desk tools are integrated within the client-server architecture of DeskTOP.

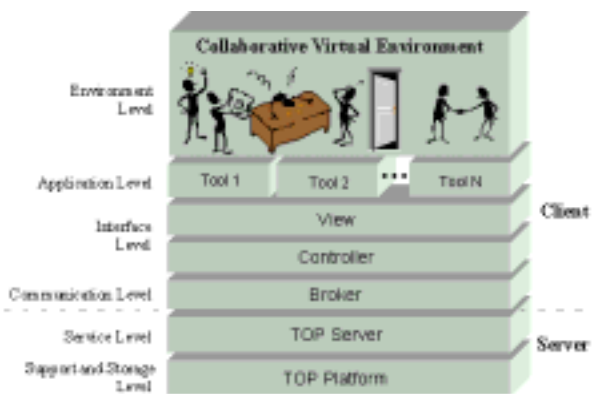


Figure 3.4. Integral structure of the DeskTOP system

Six levels constitute the integral architecture of DeskTOP. The *environment* level is composed of a subset of the available tools in the DeskTOP desk. All the tools are available in the *application* level. Moreover the view and controller components of the *interface* level define each tool interactive interface. The *communication* level implements the broker component allowing each tool to communicate with the TOP server. These prior four levels are implemented in each client's machine while the following levels run in the server machine. The TOP platform server comprises the *service* level. This server solves the requirements of the tools which are invoked by the controller component and further transmitted by the broker component. The TOP platform is located in the *support and storage* level. In this level each tool's shared environment is provided. This environment's information

is stored with the group memory information generated by each tool.

4. The DeskTOP system prototype

The Desktop system prototype only has implemented the tools that provide the services of communication, awareness and control.

The prototype starts when users request the DeskTOP application through the Netscape browser. Once the application is initialized, the login tool is activated so that it will request the user's access information. When a user enters to the DeskTOP system he or she is located, by default, in the *hall* virtual place. The users can activate the tools of the DeskTOP desk according to their interaction needs. Figure 4.1, for example, illustrates an instance of the DeskTOP desk tool in the hall environment.

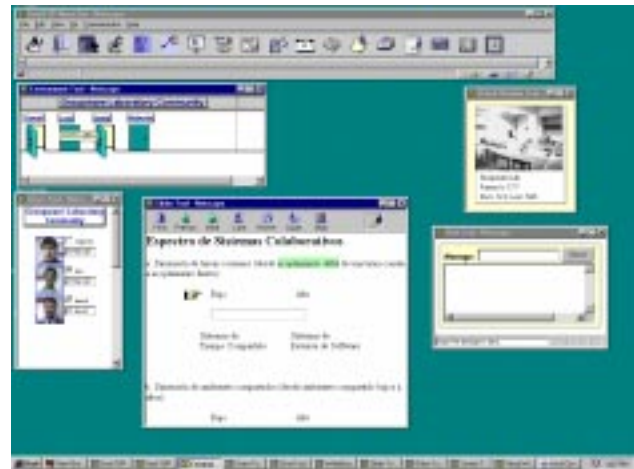


Figure 4.1. A DeskTOP interaction in the *hall* virtual place

The *desk*, *environment*, *users*, *slider*, *virtual_window*, and *chat* tools form the desk in figure 4.1. Through the *user awareness* tool one can identify other users present in the virtual environment, in order to initiate an informal interaction. The *environment* tool, on the other hand, displays each of the predefined collaboration rooms, its status and the name of the coordinator of each one.

The *user* tool establishes the environment user list. For example, in the figure 4.2 the user "Luis" has selected in his user tool (with a check next to each photo) the users "Oriol" and "David" and he can communicate with them through any desk communication tool.



Figure 4.2. Information about the users in the virtual environment

Figure 4.2 also shows the arrival of a private message to Luis's user desk, which was sent from "Oriel". The *card* tool is used to display the personal information of the user "Oriel".

The users can move from the virtual hall to any collaboration rooms in which they are defined. The user location inside the virtual environment is updated in the *user* tool when the user moves between the virtual hall and the collaboration rooms. Figure 4.3 shows a group of users working inside a collaboration room in which the user "David" is the coordinator.

In figure 4.3 the collaboration room is in a restricted state, meaning that only the defined users (a coordinator's decision) for this room can enter. Inside the collaboration room the user "Sergio" is temporarily disconnected and the user "Roberto" is transmitting an audio/video sign through the *audio_video* tool. Additionally, this desk has activated the tools: *whiteboard*, *users*, *environment*, and *chat*.

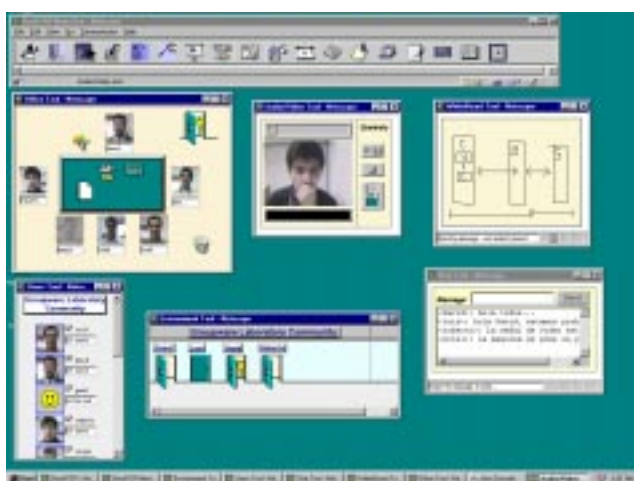


Figure 4.3. Some users working in a collaboration room

5. Conclusions and further work

The developed DeskTOP prototype proves the feasibility of developing a customizable collaborative virtual environment on Web which supports the creation of various interaction environments that promote the collaboration, communication, coordination, and social interaction among people. Each user in the DeskTOP system has their own virtual space (the *desk* tool) which provides tools according to specific interactive needs. Each user can customize their interaction environment with a corresponding set of tools. With these DeskTOP tools it is possible to cover different interaction modalities, affording individual users with the capability to participate in a way they feel most comfortable.

The DeskTOP virtual space model contains *halls* and *collaboration rooms* virtual places. The casual and informal interactions are supported by the virtual hall and the communication tools. The collaboration rooms provide users with private shared workspaces, where users can collaborate with other users to study, work, exchange ideas, or simply share information.

DeskTOP is a customizable system because, at *user level*, each user can customize his work desk with tools that he consider advisable for one better interaction; and at *collaboration rooms level*, each room can be formed with respect to: what users can enter and what tools will be available, in it.

DeskTOP is a highly portable system due to the programming languages in which it is developed. The languages JavaScript and Java-Applet were used to implement client and broker components, respectively, and the Java language was used to implement the server component.

At the moment we are contemplating the use of a new technology in implementing a new DeskTOP prototype. For example, we are studying the use of SMIL language ("Synchronized Multimedia Integration Language") for the synchronization of audio, video, images, and text. The Java Media Framework (JMF) can also be used for improving control over audio/video transmissions. JavaSpeech can facilitate the use of voice technology, support voice recognition, dictation systems, as well as other voice technologies. VRML language ("Virtual Reality Modeling Language") can be used to introduce DeskTOP to a three-dimensional virtual reality model.

Finally, we are planning to create distributed collaborative-learning communities, in order to promote the interaction between students and lecturers among different universities. The DeskTOP system can be used by many universities, affording each of them with the opportunity to configure their local virtual communities so that students, lecturers and guests from other universities can visit it in a virtual way.

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Acknowledgments

This work was partially supported by the Chilean Science and Technology Fund (FONDECYT), grant 198-0960.