# NLS: Collaborative Virtual Environment to Promote Shared Awareness


**Noriyoshi Osumi**
**Mikio Shinya**
**Takeaki Mori**
Human Interface Laboratories
NTT, USA
+1 415 903-0660
osumi@ntthi.com

**Takeshi Sunaga**
Design Department
Tama Art University
+81 3 3702-1141
nag02122@niftyserve.or.jp

**Chandrajit L. Bajaj**
**Steve Cutchin**
**Raimund Merkert**
Department of Computer Science
Purdue University
+1 317 494-6531
bajaj@cs.purdue.edu



## ABSTRACT

A collaborative virtual environment called the NLS (Networked Learning Spaces) is proposed which promotes collaborative-space awareness by symbolically visualizing and sending participant embodiments and social information. Our assumption is that by sending cognitive and social information, distance collaboration can be greatly facilitated. We present details of an experimental prototype of NLS built using the SHASTRA collaborative substrate. We also explain a preliminary experiment involving elementary and middle school students engaged in collaborative drawing tasks. The paper concludes through the experiment that the NLS virtual environment is intuitive enough for students to understand the virtual physical presence and relationships, even though they are depicted by color, shape and proximity abstractions in the virtual world.



### Keywords

virtual reality, CSCW, embodiment, workspace awareness, user interfaces


## INTRODUCTION

Cross-site distance collaboration is increasingly put into educational practice in a multiple-school project such as promoted by Challenge 2000 in Silicon Valley because of the importance of collaborative learning and also because of having students better prepared for workplace practice and style for the 21st century. However, there do not seem to be proper tools for K-12 education, especially real-time groupware, that support collaborative learning among remotely located students, and facilitates interaction and participation.

A fundamental requirement of collaboration is a common environment of shared recognition and experience (Schrage, 1990 and Fjuk, 1995), which is not created by simply a process of information transmission and distribution (Lave and Wenger, 1993), but in a process in which the students have a certain degree of commitment and participation. However, most of real-time collaborative systems such as video conferencing systems only focus on the discrete transmission of various types of information, and do not consider visualizing and sending other types of cognitive and social cues, which are evident, consciously and subconsciously, in face-to-face collaboration in education.

Several authors discuss that the design of Collaborative Virtual Environments (CVEs) should be considered in terms of how they afford social interaction, and not just in terms of their navigability, capability for presenting information (Bowers, et al., 1996). In particular CVEs have a potential of supporting collaboration better than conventional meeting room or teleconferencing technologies and also of providing low cost alternative to video transmission (Benford, et al., 1994). A conceptual framework in designing this kind of social awareness is well presented in the work of (Gutwin, et al., 1996).

Our position is in line with these authors and that by sending also cognitive and social types of information other than video and audio, distance collaboration can be greatly facilitated, especially for students who are less capable of creating a mental model of collaborative situation and of perceiving the reality of remote-sites. Information we focus on in this paper as important information to visualize and share is the process of participation, participant relationships, degrees of commitment (or participation), and the flow of information among participants.

Here, a CVE called NLS (Networked Learning Spaces) is proposed which promotes collaborative-space awareness by symbolically representing and visualizing the above-mentioned information based on the navigable 3D spatial environment with embodied participants (Avatars). Embodiments of participants are made of geometrical shapes (cubes in this paper), participants' relations are represented by connectivities of these cubes and states of interactivity (degrees of participation) by the dimension of cube connectivities (point-to-point, edge-to-edge and face-to-face). The process of participation is visualized by a series of actions such as navigating in the environment and interconnecting to start communication. This also enables mutual awareness of other participants' activities in the environment.

In order to conduct experiments on our assumptions, an experimental prototype of NLS was built on the SHASTRA collaborative substrate developed at Purdue University (Anupam and Bajaj, 94) which provides distributed collaborative tools and a library. based API (Application Programmer's Interface). In the following, the concept of collaborative virtual environment is discussed, reflecting the potential use in the context of geographically distributed collaborative education, and then illustrates the present prototype system running on Silicon Graphics machines. A preliminary experiment with elementary and middle school students engaged in collaborative drawing tasks is also explained and discussed with future issues to be addressed.

## THE NLS CONCEPT

The NLS is a distributed collaborative virtual environment in which students interact and learn, allowing for multiple-participant communication over textual, graphical, audio and video media. It also allows users to form groups, create tools provided by toolboxes and mechanisms to save, retrieve and review the product of these tools.

Our position is that by sending cognitive and social types of information, distance collaboration can be greatly facilitated. Important information we visualize and share in this paper is social in nature such as the participation process, participant relationships, degrees of commitment (or participation), flow of information among participants which are evident in the physical world.

We attain this goal by symbolically visualizing a physical metaphor. A navigable 3D world is created in order to accommodate participant embodiments in the world. Embodiments are made of cubes because they are easily manipulable in the 3D space, computationally inexpensive, and can represent different connectivities among the cubes. The connectivity represent the social relationship among the participants. In this way, the social state or relationship becomes obvious at a glance of the world and social awareness in a distributed collaborative situation can be promoted.

The states of interactivity (degrees of participation) can be represented in the way cubes are connected (point-to-point, edge-to-edge and face-to-face). A process of participation is visualized by a series of actions such as navigating in the environment and interconnecting to start communication. Flow of information can be made visual by using symbols and their movements like, for example, an arrow shooting from one place to another when a participant sends an E-mail to another.

The shared virtual world is a navigable 3D space provided by the graphical user interface, and includes self and other participants represented by cubes as depicted in Figure 1. A participant embodiment is represented with the participant's name or other kind of representations attached onto the cube. The virtual space is called a field representing a classroom or laboratory administered by a teacher or mentor. A field is created based on the assumption that there will be multiple projects in the network and the projects are supervised by several teachers, each of whom has a field collaboratively or independently.

The 3D view window in Figure 1 is called the 'They-World' and has a group with four connected cubes and a toolbox in a field. Connectivity means that a relationship of continuous communication and collaboration is established as in a group project at school. This relationship is enabled by obtaining a shared toolbox which is also an entity represented by a cube in the field. We decided to visualize toolboxes since shared tools such as a whiteboard are evident in the physical world, and most of the time collaboration is conducted pivoting around the shared tools. The shared tools for each group can be obtained by copying (click and connect operations) a toolbox in the They-world. There is supposed to be a sense of sharedness in terms of resource and experience in this way.

Connection can be made by highlighting a target cube (a person or toolbox) and connect operation, each done only by clicking the representative object and icon. With the connect operation, the NLS system automatically navigate the self cube to the target and make a connection. In this way, a user does not have to conduct a cumbersome walkthrough to the target, but still can experience a participation or group-forming process. We assume that an act of establishing and recognizing a collaborative relation in the virtual world is socially meaningful to promote a sense of reality in the remote location and a sense of togetherness.

There are cases in the educational practice when the level of participation varies as in the case of peripheral participation and should be made obvious because various levels of privileges are attached to various levels of participation. In these cases, we could represent degrees of participation by different cube connectivities such as point-to-point, edge-to-edge and face-to-face. The prototype system, however, does not support various connection modes.

NLS also has an I-World. While the They-world provides spatial and spontaneous information, the I-world provides temporal and sequential information. Collaboration and communication tools such as whiteboard and chat are activated on the desktop of each of the participants. once the participants and a toolbox are connected to each other. The part of the desktop set aside for these tools is called the I-World (Figure 1). It is important for both worlds to interact with each other and have links at cognitive levels between attributes of They-world objects and those of I-world objects in order to make clear who are doing what in the collaborative activity. to provide multiple-form information around one participant's action, and to make clear flow of information: The color of participant. say A, should be matched with that of the lines A is sending in the chat or drawing on the whiteboard. The multiple-form information is existent in the physical world as multisensory information. How to design such workspace awareness by linking the they-world and I world is left for future work.

## ARCHITECTURE OF THE NLS PROTOTYPE

The NLS prototype was developed using the Shastra Collaboration Substrate. It provides a collaborative virtual environment. and communication tools for communicating amongst the various participants in the environment such as collaborative Video. Audio. Text and E-mail communication tools. The system is accessed through an X-Window-based graphical user interface. and an OpenInventor-based They-world is provided for interactive navigation of the virtual environment. The NLS Virtual Environment is made up of three executable programs as in Figure 2: NLS User Interface, Session Manager. and Kernel, each of which is explained in the following.

### NLS User Interface

The NLS User Interface is an X-Window based graphical user interface that provides the user with a simple easy-to-use way of interacting with all features of the NLS system (Figure 1). It provides full access to the collaborative communication services, the NLS 3-D Virtual Environment and the collaborative production tools.

The 'They-World' is accessed through an OpenInventor viewer window within the NLS User Interface. The viewer provides the user with a view of the learning space that can be manipulated by the user. The user can move his representative cube around, rotate it. select other students cubes, toolboxes and other objects. The selected objects can then be used for further activities such as sending e-mail, gathering information. forming new groups.

The collaborative services component of the NLS User Interface provides users with full access to the multimedia collaboration services such as video. audio. chat, drawing and E-mail incorporated into the NLS user interface. Each collaborative service is placed in a region of the user interface with all controls for that particular user interface located within the same region.

### Session Manager

Session Manager is a program that maintains group information and responsible for routing network messages and requests from NLS User Interfaces involved in an NLS Session to the respective NLS recipients involved in the session. The session manager program controls the formation of groups, manages service broadcast messages and is responsible for tracking the collaborative behavior of NLS User Interfaces. The session manager acts as a server that listens for collaborative requests from clients. handling audio. video, text, whiteboard and e-mail. It then processes these requests and performs the desired action. The session manager specifically responds to a set of predefined collaboration requests that provide methods for joining a session, leaving a session. ending a session, setting the permissions of a session as well as specific sets of requests that deal with application specific operations.

### Kernel

Kernel is a program that is used to maintain a list of services that are available on all machines currently involved in the SHASTRA collaborative system. One kernel is executed on every host involved in an NLS session. The kernel acts as a distributed nameserver for network services. It provides methods for initiating sessions, starting services, and making remote service requests. It also provides methods for terminating all of the above as well.

## PRELIMINARY EXPERIMENT

A preliminary experiment was conducted with 11 5th-8th graders in two days. The purpose of the experiment was (1) to see whether students actually understand the notion of, and reflect themselves on, simple and abstract embodiments of themselves, (2) to see whether they understand the meaning of connectivity of embodiments and a shared tool, (3) to see whether they feel reality of remote sites, and (4) to extract GUI issues in designing the They-world and I-worlds. Tasks they were assigned were first to play in a group of two or three among three distributed sites (one group for each site) without prior instruction about the system, and second to conduct collaborative drawing with the three groups.

In the first task, they all started by trying to manipulate the They-world. Obviously, the 3D space drew their attention most. It took little time before recognizing group's names on the cubes and navigating through the They-world. They also realized without instruction that the connect button under the 3D view window was used to connect to the cubes and a tool. Highlighting a cube by clicking came after the discovery of the connect procedure. This is understandable since the connect operation (verb) needs an object and the way students are used to to select an object is to click the object. They were excited when they found out that their cubes were automatically navigated and connected. They were aware of the existence of the toolbox since it was floating from the beginning and most of the groups tried to obtain the toolbox as children would usually do. Some of the groups even started to communicate by chatting, especially older students who were used to use a chat.

From these observations and interviews afterwards, it can be concluded that the they-world is intuitive enough for students to understand on their own the concept of virtual simulation of the physical presence and relationships, even though they are simple and abstract representations in the virtual world.

In the second task, they conducted collaborative drawing after connecting each other. Because collaboration could be started only after the connection procedure, the students seemed respectful enough for the groups at remote sites to let collaboration going smoothly. However, the problem of perception of remote-site reality needs further investigation through carefully designed experiment, which was not exactly in the scope of the present experiment.

A lot of issues were learned through this experiment. One of the issues is that there is a comfortable range of viewing parameters (angle and distance) to display the They-world which decides the sizes of cubes. This issue is important along with the issue of easy navigation without being lost during the navigation. Other issues include interaction between the They- and I-worlds to visualize cognitive links between happenings in the they-world and the correspondent occurrences of I-world. This is important in order to make clear who are doing what in the collaborative activity. How to design such workspace awareness is left to future research.

## CONCLUSION

A CVE called NLS (Networked Learning Spaces) was proposed which promotes collaborative-space awareness by symbolically representing and visualizing the social information based on the navigable 3D spatial environment with embodied participants in connected groups.

In order to conduct experiments, an experimental prototype of NLS was built using the SHASTRA collaborative substrate. A preliminary experiment involving elementary and middle school students engaged in collaborative drawing tasks was conducted.

Through the experiment, we can conclude that the They-world is intuitive enough for students to understand the concept of virtual simulation of the physical presence and relationships, even though they are simple and abstract representations in the virtual world. In the collaborative drawing, the students seemed respectful enough for the groups at remote sites because of the group-forming and participating procedure. However, to study the problem of perceived remote-site reality needs more carefully designed experiments.

Important issues learned in the experiment include (1) a comfortable range of viewing parameters to display the They-world, (2) easy navigation without being lost during the navigation, and (3) visualization of cognitive links between happenings in the they-world and the correspondent occurrences of I-world. These issues are left to future research.

## ACKNOWLEDGMENT

We are extremely grateful to Jeff Pajor of Purdue University for his help in the GUI programming. Thanks also go to Yumiko Nagai, Mituhiro Takeda and Nao Iiyama of Tama Art University for their help to create the NLS concept. We would also like to thank Tokiichiro Takahashi and Takafumi Saito for their continuous support and discussion.

## REFERENCES

Lave, J. and Wenger, E. Situated Learning. Legitimate peripheral participation, Cambridge University Press, Cambridge, 1993

Schrage, M. Shared Minds. The new technologies of collaboration. Random House, New York, 1990

Fjuk, A. Towards an analytical framework for CSCdistanceL, in Proc. CSCL '95, LEA, 1995

Gutwin, C. and Greenberg, S. Workspace awareness for groupware. In Proc. CHI'96 (Vancouver, 1996), 208-209.

Gutwin, C. and Greenberg, S. Workspace awareness support with radar view. In Proc. CHI'96 (Vancouver, 1996), 210-211.

Bowers, J., Pycock, J. and O'Brien, J Talk and embodiment in collaborative virtual environments. In Proc. CHI'96 (Vancouver, 1996), 58-65.

Benford, S., Bowers, J., Fahlen, L., Mariani, J. & Rodden, T. Supporting cooperative work in virtual environment. The Computer Journal, 37, 8 (1994), 653-668

Anupam, V. and Bajaj, C. L. Shasta: An architecture for development of collaborative applications. International Journal of Intelligent and Cooperative Information Systems, 3,2 (1994), 155-166

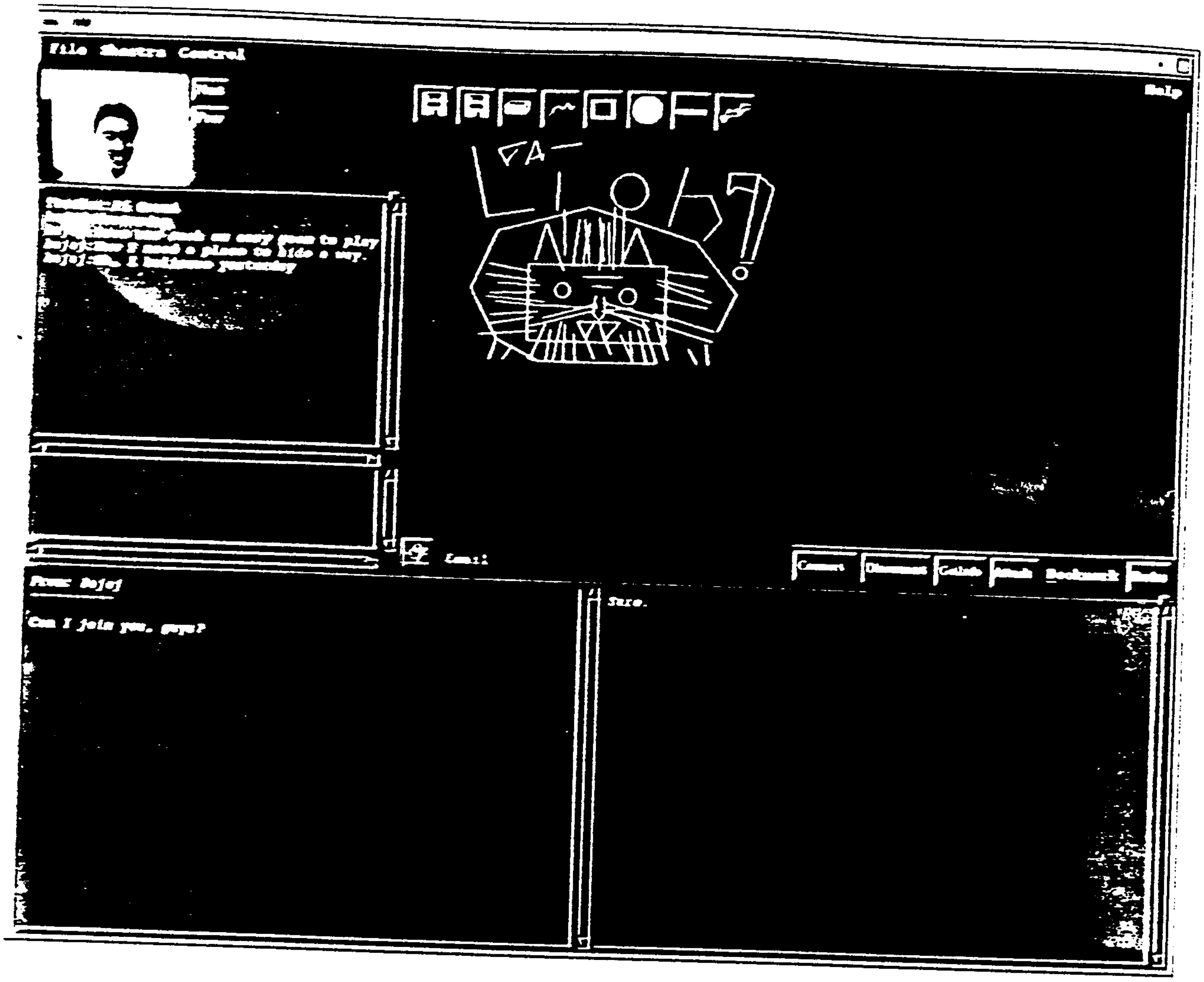

Figure 1: NLS Graphic User Interface

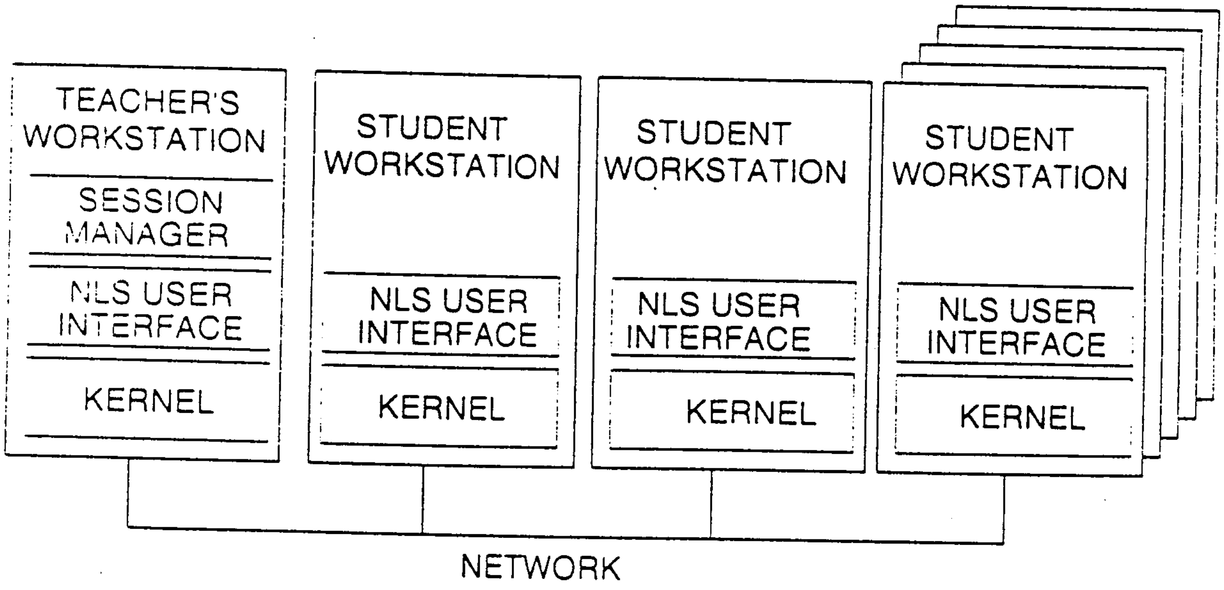


Figure 2: A typical NLS Runtime Configuration