

Usability of a Collaborative Authoring System Preferences, Problems, and Prognosis

Michael Spring, Restiani Andriati, and Vichita Vathanophas

Department of Information Science and Telecommunications
University of Pittsburgh

INTRODUCTION

This paper reports on a series of informal usability studies of a collaborative authoring system. These studies have been conducted as a prelude to more formal studies scheduled for 1998 using groups of individuals engaged in the collaborative development of documents in real world situations -- standards development, strategic planning, and instructional materials development. The studies are being conducted using a prototype collaborative authoring system known as CASCADE¹. CASCADE, which stands for "Computer Augmented Support of Collaborative Authoring and Document Editing", is a client-server software system that facilitates groups of people working together on documents. Most specifically it is designed to support collaborative authoring. This paper reports on preliminary usability studies designed to determine user preferences for such a system and to provide a preliminary analysis of usability problems. The studies are also being used to form some preliminary questions about productivity using CASCADE.

The interested reader will find more information about the various versions of CASCADE at the CASCADE web site -- <http://www.sis.pitt.edu/~cascade>.

Conducting usability studies of a collaborative authoring system presents some problems in that CASCADE endeavors to provide a service for which there are few well-known computer based systems[1-3]. Thus, it is difficult to measure the performance of CASCADE against existing systems that do the same thing. The problem is compounded by the fact that collaborative authoring outside the electronic realm is also limited, so it is difficult to compare CASCADE performance to performance by a group working in "traditional" mode[4-8].

The CASCADE research program at the University of

¹ The CASCADE research effort is a long term research effort investigating various aspects of network based collaborative authoring. The current studies are supported in part by contracts from the Information Technology Laboratory of the National Institute of Standards and Technology. The goal of the project is to provide a working prototype of system that provides augmentation, visualization, and agent support to groups of people working together on documents across a network. In particular, the researchers wish to thank Dr. Shukri Wakid and Dr. Sharon Laskowski for their support.

Pittsburgh is both technical and behavioral in focus. Some of the studies being conducted are looking to determine the requirements and efficiencies of various network protocols and document modeling approaches. These include examination of caching schemes, locking mechanisms, and access control approaches. Results of these studies have been or are being reported in other papers[19]. The current study reports on some very early studies of user behaviors and interactions with the system. Previous reports have discussed some findings related to micro activity analysis[9] and navigational tools[10].

This study looks at user preferences, usage problems, patterns of use, and possible measurement criteria for more formal assessment of CASCADE. The results of this study will be used specifically to structure more formal studies of the system planned for 1998.

OVERVIEW OF CASCADE

CASCADE is a client server application. A number of clients located on the personal workstations of users communicate with a single server located at some central site using a communications protocol. The server makes use of a DBMS to assist in the storage and organization of data and objects.

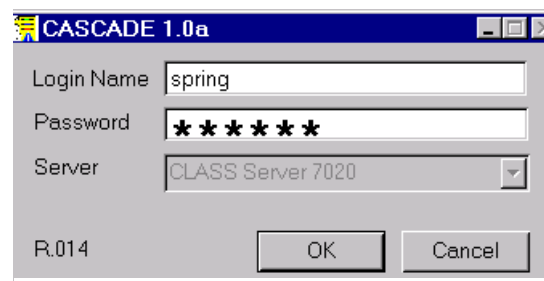


Figure 1: Login Screen

A user starts CASCADE on their PC, Mac, or Unix workstation and is prompted for a login and password. Figure 1 shows this initial screen. It should be noted that the user may choose one or another server to log into. At the time of this writing, three CASCADE servers are in operation—two at the University of Pittsburgh and one at the National Institutes of Standards and Technology.

After logging in, the server presents the user with a list of one or more projects on that server to which they are authorized access (see Figure 2).

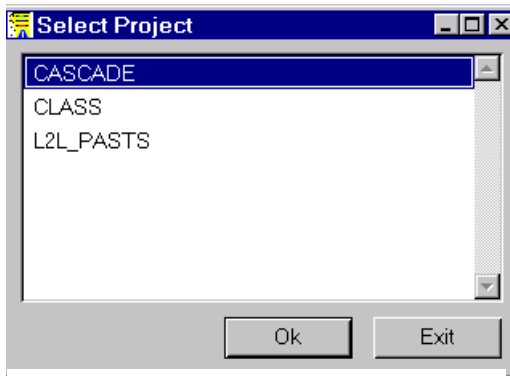


Figure 2: Project Selection Dialog

CASCADE is designed to manage large document spaces where many documents and document components are required for a given project. Consider as examples:

- An IEEE server that manages group efforts on 10 or

- 20 active standards projects.
- A publishing house server that manages articles for three issues of a half dozen journals.
- A state legislature server that manages a couple dozen pieces of legislation under active development.

Once the user has selected a project on a given server, they may access any number of distinct documents associated with that project. Our informal tests have included projects where the total number of documents has ranged from a few hundred to several thousand. In our work to date, there have been some small numbers of focal documents, and a relatively larger number of auxiliary documents related to these documents.

Once a project has been selected, the user is presented with the main screen as shown in Figure 3. A document display/editing window dominates the main screen. Menu choices appear across the top, and a folder/document selection panel is located on the left side of the screen. At

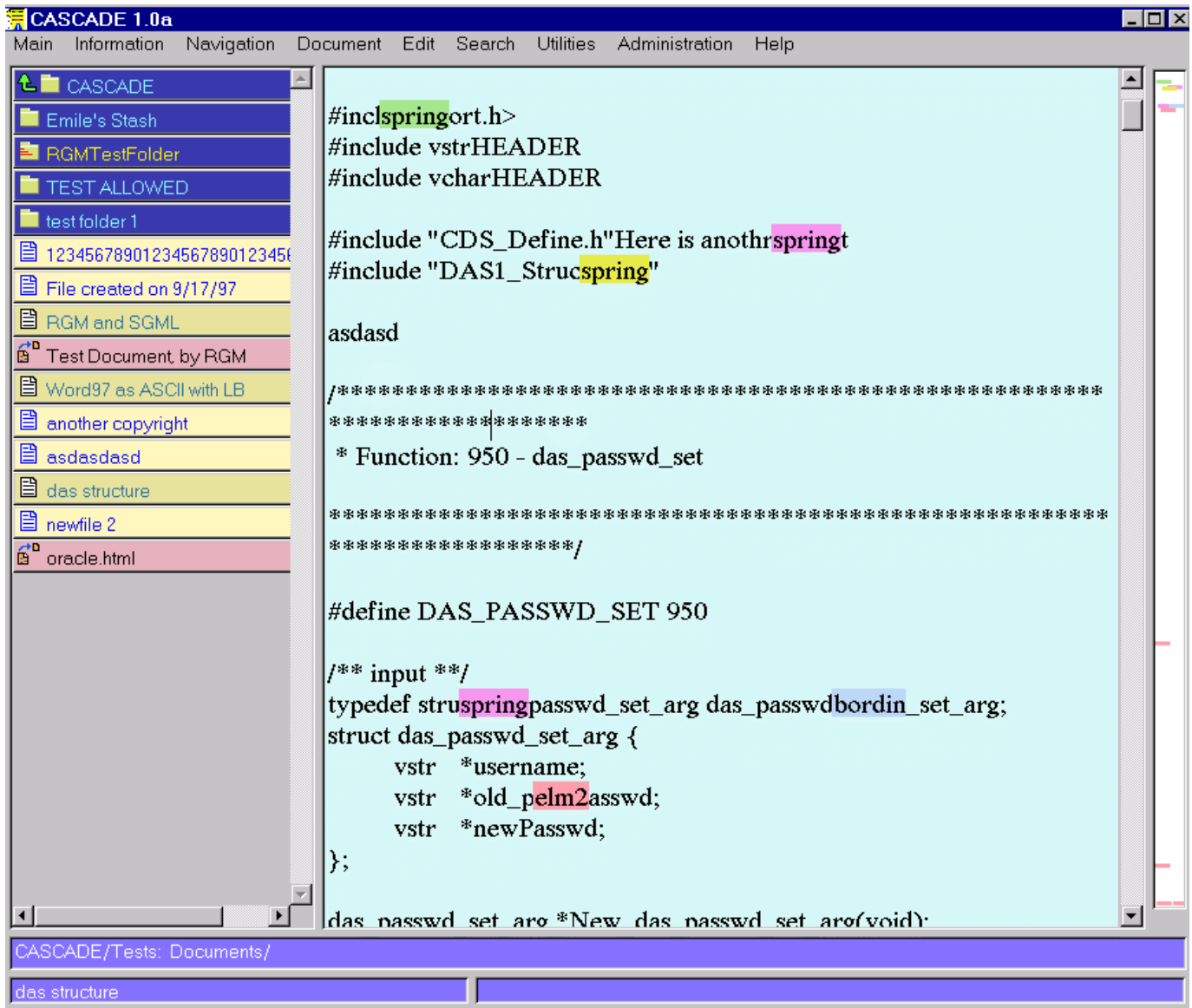


Figure 3: Project Selection Screen

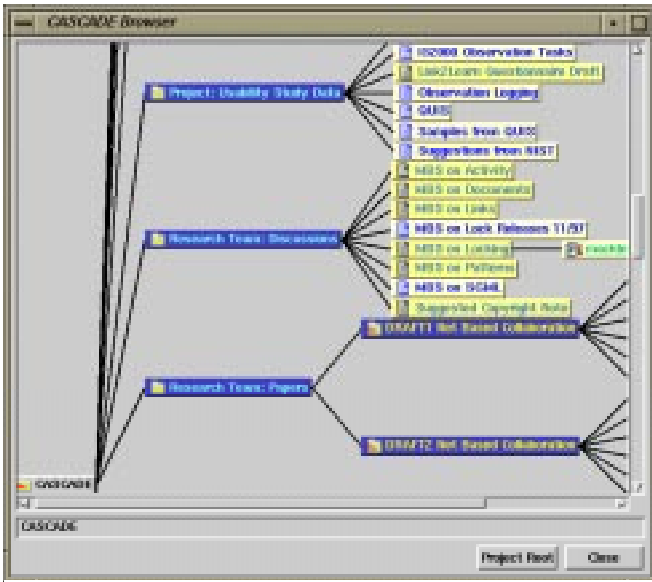


Figure 5: Browser Window

the bottom of the screen information about the current location and status of the document is displayed along with system status messages.

CASCADE presents the user with a number of unique tools. These include a variety of visualization tools and a number of ad hoc hypertext constructs. CASCADE includes not only the traditional bookmarks and history lists, but a variety of ad hoc hypertext constructs and visualization tools that aid navigation. Consider for example the visual browser shown in Figure 4. (See [10] for a full discussion of the multi-level navigation system in CASCADE.) The browser shows a variety of

documents and their relationships. It is presented to the user as a separate scalable window. By clicking on folder, which are currently depicted as light type on dark backgrounds, the user recalculates the browser with the selected folder as the root of the tree. The way the browser is displayed and the number of levels displayed are user selectable. When the user selects a document in this display, the CASCADE environment is changed to focus on the document and the document is displayed.

As another example, Figure 5 shows a project activity dialog depicting a number of user actions on documents. The set of actions displayed is in response to a user specified query which may specify a complex or simple query based on actor, object, action, and time sorted and filtered in any number of ways. The resulting report is again an active ad hoc hypertext construct.

CASCADE offers people many new choices, particularly related to visualization. CASCADE also tracks a lot of information about users and documents. This reflects CASCADE's focus on helping groups of people to work together. One of the difficulties in group authoring is in coordinating the actions of the authors and reviewers. CASCADE doesn't control what people can and can't do so much as it keeps track of and reports on what the members of a group do. CASCADE is intended for use in situations where groups of people need to work together on rather complex documents that are the critical component of the work effort. When a dozen people are working on a proposal or a policy statement, or some other inherently group document, it makes a lot of sense to have the system let your teammates know what you have done. Similarly, CASCADE can address mail about a change for you, or to let others know what your work schedule is. As indicated, this study endeavors to establish some

The screenshot shows a window titled "Project Activity Display". It features a "Quick Query" dropdown set to "First 300 recent activities", a "Search" button, and a "Query Builder" button. Below the query section, there are sorting options: "Ordered by 1st key Time" and "2nd key None", with "asc" and "desc" radio buttons. The main part of the window is a table with the following columns: "Read", "Active", "Action", "Time", "Primary Doc", "Secondary Doc", and "Person".

Read	Active	Action	Time	Primary Doc	Secondary Doc	Person
X		Update Doc Info	1997-12-05 17:00:07	Visual Languages	Emile's Stash	elm2
X		Update Doc Info	1997-12-05 16:58:30	Visual Languages	Emile's Stash	elm2
	✓	Update Content	1997-12-05 16:57:14	another copyright	Tests: Documents	elm2
	✓	Update Content	1997-12-05 15:32:39	new document	test folder 1	resti
X		Update Content	1997-12-05 14:04:06	beta 54321	TEST ALLOWED	wasu
X		New Document	1997-12-05 14:04:00	beta 54321	TEST ALLOWED	wasu
X		Update Content	1997-12-05 14:03:17	alpha 54 project 3	TEST ALLOWED	wasu
X		New Document	1997-12-05 14:03:10	alpha 54 project 3	TEST ALLOWED	wasu
X		Update Content	1997-12-05 14:02:44	alpha 54321	TEST ALLOWED	wasu
X		New Document	1997-12-05 14:02:38	alpha 54321	TEST ALLOWED	wasu
X		Update Content	1997-12-05 14:01:58	all group 54 project at 3	TEST ALLOWED	wasu

Figure 5: Project Activity Dialog

benchmarks in terms of preferences and modes of operation.

CONDUCT OF THE USABILITY STUDIES

In late 1997, we conducted a set of preliminary usability studies on CASCADE with an eye to conducting more formal usability studies in early 1998. The goals of these preliminary usability studies were five-fold:

1. Gather some data about user preferences and expectations related to the system.
2. Reveal bugs and flaws in the design of CASCADE.
3. Get some indication of how difficult it would be for people to learn to use CASCADE.
4. Gather some preliminary data on how well CASCADE accomplished group authoring tasks.
5. Provide some data to serve as indicators of possible collaborative authoring research questions.

Each of these goals is briefly described below.

Data about user preferences and expectations

CASCADE presents some new challenges and opportunities in design. The project has a strong commitment to using visualization to help users. Based on informal studies with our X Window System prototype, it was clear that we could accomplish this goal. The question now was how to insure that our color selection matched any preconceptions the user might have[11-13]. To this end, we wanted to determine what colors the user might associate with objects of a given type or objects having a given characteristic. Where we found no preference, we would be free to select a random color or a color consistent with some scheme. Where the users experienced a strong preference, we would want to follow that preference[14]. Related to expectations, consistent with the hypertext literature we called the graphical depiction of a document space a browser. Unfortunately, between the time that decision was made, and the time the study was conducted, browser has come to mean a hypertext viewer such as Internet explorer or Netscape. Thus, after having observed user confusion on this matter, we have had to go back and rename the browser so that the user had a better sense of what they were looking for.

Design bugs and flaws

There are bound to be a series of bugs that need to be found in the software and there is now better way to uncover them than to subject the software to increasingly stressful testing. In addition to unanticipated bugs in the software there are both structural and logical design flaws that need to be uncovered. For example, we designed a very modular communications protocol that enabled us to use the component pieces of the protocol to accomplish several different tasks. Testing showed us that this protocol became unwieldy as the size of the document set increased. While there were no bugs in the protocol or the code that used it, there was a design flaw in that the solution chosen did not scale well to large document sets over wide area networks.

Learning CASCADE

We wanted to determine how long it would take user to begin to feel comfortable with CASCADE. Thus we wanted to begin to gather data on how rapidly novice users moved toward expert users over usage of the system. We also wanted to identify any major obstacles to learning that were presented by the system. Keep in mind that for many users, CASCADE was not only the first exposure to electronically mediated collaborative authoring, but to collaborative authoring of any kind.

Group authoring task data

Obviously, the most critical data points about CASCADE have to do with whether or not it speeds the process of collaborative authoring of a document or improves the quality of the final product[7, 15-17]. We wanted to begin to gather data here about this process to see what the most important factors and variables would be.

Collaborative authoring research questions

Finally, this set of experiments offered us an opportunity to begin to explore the nature of questions that might be posed for further research on collaborative authoring. What are the dominant activities in the process? How much time to people spend on line? How do the work patterns of leaders and participants differ?

SUBJECTS

We looked at three different groups using CASCADE. First, we conducted a series of tests on expert users, those involved in developing CASCADE. The data on expert users would be used as a benchmark in comparing initial performance and learning curves for novice users. Second, we made CASCADE available to a group of individuals working on a project to develop an RFP for the State of Pennsylvania related to the acquisition of telecommunications services for the state. We collected data on problems the encountered in using the system. In addition we gathered survey data from them to provide an initial indication of how CASCADE might be accepted by the general population. Third, we conducted a series of mini studies with beginning graduate students in School of Information Sciences, Department of Information Science, who took the course "Introduction to Information Sciences". The goal of these studies was to gather user preference data, learning curve and bug data, concurrent use problems, and simulated group authoring usage patterns.

Expert Users

The expert users were the authors and other members of the research team. In the case of the PI, CASCADE in one form or another has been a tool used in teaching and research for more than five years. All of the other "expert users" are Ph.D. students who have used CASCADE for at least a year and who have been actively involved in coding one or more of the prototypes. While these users can not be trusted to represent the typical user, their performance of given tasks can be assumed to be a reasonable upper bound for the measurement of speed in accomplishing given tasks.

Sample Target Population

(Data has not yet been collected from the subjects who represent a sample target population. It is currently being collected and analyzed and will be available for inclusion in the final paper.) Briefly, the subjects consisted of 100 individuals invited to a conference sponsored by the Governor of the Commonwealth of Pennsylvania to help in identifying needs for a state wide telecommunications network. The conference participants working in ten groups of 7-15 members during the conference and were then charged with developing a contribution to the RFP to be developed by the commonwealth. The groups and the facilitators were invited to use CASCADE to complete their work during six weeks following the conference.

Student Subjects

There were 50 students, most of them were familiar with computers, but none of them knew CASCADE before. This group participated in three separate studies related to CASCADE. It should be noted that about half of the group are non-native speakers of English. In particular, we found that non-English speakers had some trouble understanding tasks instructions.

It should be noted that the subjects used in this component of the study were first term students in the Department of Information Science and Telecommunication at the University of Pittsburgh. As such, part of their education will involve the design and conduct of usability studies. Thus while using students as observers would generally be considered strange, for this population, it is a part of the skill set that they must develop in their program of study.

INSTRUMENTS

Several instruments were used in the study.

Preferences Questionnaires

A preferences questionnaire was administered to all of the student subjects before they began to use CASCADE. The goal of this questionnaire was to determine if there were any a priori associations that might exist in the population between colors and types of objects. CASCADE makes extensive use of colors for many different objects and functions in the CASCADE space. Therefore, users' preferences and intuition will be very useful in improving CASCADE usability. The questionnaire used is available at: <http://www.sis.pitt.edu/~cascade/task1.html>.

Basic Tasks Test

Several "basic" tasks were defined for CASCADE. These included logging in, finding documents, making comments, etc. These tasks were assigned to users, both novice and expert, who were then observed completing the task. Prior to undertaking the task, users read a brief set of instructions on how to use CASCADE. In addition, some basic demographic and background data was collected to determine if any experience factors contribute to or detract from CASCADE usability. As subjects used the system, an observer recorded the actions they undertook as well as the mistakes they made. The instructions, task list, and record sheet forms are available at:

<http://www.sis.pitt.edu/~cascade/task2.html>.

Group Observation

The same task set defined above was also administered to a group of users simultaneously in order to study CASCADE's system performance under a load. It should be noted that several of the tasks in the task set were run multiple times during the observation in order to study the impact of concurrent usage on the server and on user response time.

We selected five simultaneous users, observed by five student observers, as a "load" situation. Our informal experience suggests that while users sometimes work synchronously, it is more often the case that while there is some overlap, sessions tend to be spread out over the day.

Conference Participant Questionnaires

The conference participants were broken down into two groups. Those who had used CASCADE more than once were sent a questionnaire that asked them about the system. Those who had never logged into CASCADE, or who had logged in only once were sent a questionnaire about why they had chosen not to participate. The questionnaires may be found at: <http://www.sis.pitt.edu/~cascade/confques.html>.

Document Construction Tasks

The student subjects were broken up into 5 groups. They were given three tasks.

1. Revise reading notes prepared by the instructor.
2. Draft, review, and polish a set of lecture notes.
3. Construct a multiple choice quiz.

Subjects were asked to keep a log of their activity both on line and off line as they went about the task. The instructions and log sheets that were used may be found at: <http://www.sis.pitt.edu/~cascade/task2.html>.

SUBJECT DEMOGRAPHICS

The student subjects who participated in the preferences component of the study, the basic task study, the concurrent user study, and the document construction study may be characterized as follows:

- The group of 28 participants was about equally divided between male and female (12 male 14 female).
- 65%(17) of the participants were in their 20's and 27%(7) were between 30 and 40.
- 58%(15) of the participants were native speakers of English, and 42%(11) were from European and Pacific rim countries.
- The subjects would be defined generally as computer literate -- all had been using computers for at least a year and more than 75%(20) have used computers for more than 5 years.
- Experience with graphical user interfaces was similar, although not as dramatic. While 12%(3) had less than a year experience with WIMP interfaces,

62%(16) reported between one and five years experience and 27%(7) reported more than five years experience.

Of the student subjects 70%(18) were using cascade for the first time when they undertook the basic task study. 27%(7) had used it between one and five times at the time of the study. One individual had used it more than five times. Consistent with this, the amount of time spent using CASCADE prior to the task study was zero for the non users, less than two hours for the seven who had used it one to five times, and more than five hours for the one subject.

Most of the subjects used machines within the school. These platforms are all Pentium 166Mhz with 15 inch screen set to a resolution of 1024x768. They are connected by an Ethernet LAN. Because some of the subjects were connecting from home or their office, it was important to gather information about the nature of the platform they were using and the type of connection they had. Data on platform, and connection was as follows:

Screen Resolution	
640x480	1
800x600	6
1024x768	11
Higher	0
don't know	8

CPU Speed	
less than 100MHz	1
100 - 166MHz	14
Higher	4
Other	0
do not know	7

Connection Type	
Modem	6
LAN	16
Other	0
Don't Know	4

The typical user demographics for the conference participant are being collected at the current time.

PROCEDURE

Student Subjects

Student subjects were paired and one student observed while the other completed the task. Both observer and observed completed a preferences questionnaire before the observation. A digital clock showing minutes and seconds was placed on the screen at a convenient location for making timing observations. The observer was encouraged to complete the task list prior to the experiment so that they would be able to answer questions asked of them. After the observation the subject completed a post observation questionnaire.

Preferences

Both the observer and subject were given questionnaires

that asked them to specify preferences based on first reactions. These were to be completed before work on CASCADE was initiated.

Basic Tasks

Subjects were given CASCADE manual/instructions on how to use CASCADE. This document was designed to help them complete the basic tasks. The subjects were divided into three groups: subjects connected to the departmental local area network, subjects connected via modem. The subjects were asked to complete 10 tasks with one as an observer and one as a user. For each task, the observer's jotted down what the user was doing at five second intervals. They were encouraged to write as much as possible, and as can be seen on the record sheets, recording was made somewhat simpler by the provision of check box categories to indicate thinking, mouse clicks or typing. As appropriate, the observer wrote down detailed descriptions of the activity.

A group of 10 students in 5 pairs did the Basic Task Activity simultaneously. This was done in laboratory adjacent to the augmentation laboratory where work on CASCADE is conducted. Client and server development staff were present and monitored server and network load while the experiment was conducted. The PI oversaw the experiment and introduced several repetitions of tasks that showed interesting system interactions.

Document Construction

Both the student subjects and the conference participants were engaged in document construction tasks. The conference participants were engaged in a more real task, but with much less control than the student group. In contrast the student task was more constrained, but also more contrived.

The student subjects were broken up into 5 groups ranging in size from 7 to 13 members. They were given one month near the end of the term to complete the assignment. The group leaders were volunteers and they were given the option of selecting group members (or accepting individuals who asked to join their group). Individuals unassigned after the groups had formed were randomly distributed by the instructor to the groups with a low number of members. Each group was assigned a lecture in the course for which there were "reading notes" that had been prepared by the instructor. They were given three tasks.

1. Review and revise the reading notes prepared by the instructor.
2. Draft, review, and polish a set of lecture notes based on notes made by the group members during class.
3. Construct a multiple choice quiz, similar to those administered at various points in the course, that would assess whether or not an individual was familiar with the readings that had been assigned for the lecture.

Subjects were asked to keep a log of their activity both on line and off line as they went about the task. They were encouraged to define one or more individuals to be responsible for final editing. The subjects were required to submit their activity logs and to sign a sheet at the end of the process indicating that they were satisfied with the final product of the effort.

Conference Participants

The Commonwealth of Pennsylvania hosted an invitational working conference on September 22-23, 1997 in Pittsburgh Pennsylvania "Pennsylvania Acquisition Strategies for Telecommunication Services, Systems and Infrastructure". It was organized by the Governor's Office to gather input from vendors, suppliers, academics, and community organizations for a telecommunications services RFP for the Commonwealth. Working groups of 6-18 people were formed in the following areas:

1. Partnerships
2. Creating and aggregating demand
3. Leveraging existing resources
4. Procurement
5. Network management
6. State-wide infrastructure investment
7. Service and market orientation
8. Network design and interoperability
9. Electronic commerce
10. Policy

The membership of the working groups varied widely. One of the smaller groups consisted of the following types of individuals:

- Telecommunications provider
- Local community network organizer
- 3 Telecommunications integrators
- Representative of a large software house
- CIO of a large merchandise chain
- CIO of a major city
- University professor
- Community/economic development officer

Each conference participant was given a prepared packet that include an installation disk set, a login and password, and printed instructions as well as e-mail and phone contact points for getting additional help. In addition, a web page was set up for conference participants where they could get updated information on the system. Group facilitators were given access to CASCADE a week before the conference and were given a personal demo of the software. All conference participants were given a 20 minute demonstration of the system at the close of the conference. How the working groups used CASCADE, or whether they used CASCADE was up to the facilitator and the members of the working group. Some of the groups used CASCADE extensively, other not at all.

RESULTS

By way of introduction, it should be noted that the study endeavored to gather data while CASCADE was being refined. During the study, there were 7 software releases ranging from minor bug fixes to major feature introductions. At each point we had to make a decision about whether to tell people about a new version and cause more work to down load it or let them use the older version given that the bug fix wouldn't really affect them. The results are described below in terms of user preferences, system usability, and usage patterns.

User preferences

User preferences are very important in the design of CASCADE for several reasons. The most important of these has to do with the effort to use visualization techniques in CASCADE. In order for this to work, it is essential that the colors used be a consonant as possible with user expectations. Similarly, we are concerned about the placement of menu choices and with the naming of new features. We gathered some preliminary data in this area via the pre-test questionnaires referenced above.

Colors

The reader should keep in mind that almost everywhere color is used in CASCADE, it may be adjusted to suit individual user preferences. At the same time, we believe that there are certain color schemes and choices that will provide significant benefit to the user if adopted. At the current time, all mechanisms which show documents and folders show documents as pastel backgrounds with dark type and folders as dark backgrounds with light type. Thus it is possible to understand the mix of documents and folders in a large set at a glance. Some of the strong preferences for color included the color of objections and suggestions as types of comments. In contrast, there was little agreement about the color of a question or an elaboration.

Similarly, there was strong agreement about the color of folders and text files, but less about documents and almost none about images. The preference data related to color is summarized in the two tables below.

Color Preferences for Different types of Comments											
	No Preference	Yellow	green	red	blue	black	orange	pink	purple	brown	white
objection	1	6	1	28	2	6	6	0	0	0	1
Suggestion	2	6	18	4	9	1	1	2	2	4	2
question	1	5	2	4	6	6	1	3	2	1	1
elaboration	1	4	6	0	7	4	2	1	3	3	0
Correction	1	3	2	11	4	1	5	3	2	0	0

Color Preferences for Different File Types											
	No Preference	Yellow	green	red	blue	black	orange	pink	purple	brown	white
folder	1	18	3	0	5	2	0	0	1	1	0
document	1	2	1	0	3	6	0	1	0	1	10
text file	1	1	1	0	3	15	1	0	0	1	5
image file	1	2	6	1	7	1	2	4	3	2	0

Menus

Because CASCADE has some new menu items and because it seeks to provide an environment that is integrated with the desktop, we wished to determine if there were any user expectations about menu item placement. As with color preferences, the questionnaire was administered before the subjects began to use CASCADE.

As shown in the table below, more than 95% of the subjects expected that the exit item would be in the main menu, consistent with other windows applications. Little guidance was provided about where to place the item that would provide information about the activity of other group members. While the menu item for changing the password was placed where the plurality thought it should be, more than half of the subjects would have put it under another choice.

The creation of a new Document presents a problem. Consistent with most windows applications, the function to create a new document or import one is located under that Main menu. However, as can be seen in Figure 3, CASCADE offers a "Document" menu. Given this as a choice, more than 50% of the users imagine this as the location for these menu items. (The document menu contains a series of items that have to do with the currently viewed document. The primary set of functions have to do with locking the document for editing.)

Windows applications are not consistent in the placement or naming of the menu item which deals with setting user preferences. Sometimes it is under Tools and sometime under file or main. In our case, it has been placed under the main menu as utilities was reserved for items that pertain to "desktop services". Like other windows applications, CASCADE is designed to make use of services provided by other applications on the desktop. Because full integration of services is not the norm for most users, this concept is still somewhat foreign to most users. Some care will have to be taken to rename the main menu currently called "Utilities" so that it better depicts the fact that it is a gateway to other applications on the desktop that might be served by CASCADE or that CASCADE might use.

User Preferences for Menu Item Placement								
Main Menu >>>	Main	Navigation	Document	Search	Utilities	Administration	Undecided	Total
Menu Item VVVV								
Exit	48	0	1	0	0	0	1	50
User Activity	7	14	0	1	18	8	2	50
Create New Doc	14	0	34	0	1	0	1	50
Import Document	8	4	26	2	9	0	1	50
Change Password	11	0	0	1	15	23	0	50
Change Project	15	16	2	3	6	7	1	50
Preferences	6	1	0	1	24	18	0	50

Miscellaneous -- Naming

The preferences questionnaire and the preliminary task analysis study have also highlighted some naming problems with the system. Specifically, four problems were encountered during the study.

1. The menu bar has drop down menus for "Editing" and "Document". The document menu includes items that relate to informing the server that the user wishes lock and document for editing. Thus, the edit decision is made on the document menu!
2. Similarly, the prototype has drop down menus for "Navigation" and "Search". The navigation items include history lists, bookmarks, and hypertext browsers. The search menu includes items for intra document searching. When asked to "find" a document or phrase, users confuse these two menus.
3. Related to this issue is the issue of "browsing". As shown in Figure 4, CASCADE provides an active classical hypertext browser window. Unfortunately, while the research team can easily distinguish this graphical browser from the "Explorer" and "Navigator" document browsers, the term browser has come to mean a web browser which navigates, but does not display the web!
4. Finally, we chose to call a little utility editor that allows inter document editing a "Notepad". While this makes sense in terms of the functionality provided, it causes some confusion with the Windows "Notepad" program.

The research team is currently exploring ways to clarify naming, menu item location, and default color assignments so as to create options that seem natural to the user and that minimize confusion with other products and systems.

System usability

System usability is a key concern in the development of CASCADE. One major goal of the project is to reduce the time it takes to complete a collaborative authoring task[18, 19]. While we would hope to have the tasks be intuitive, we are prepared for the fact that users of the system may need to learn how the system works before they can begin to benefit from it[20, 21]. So long as the

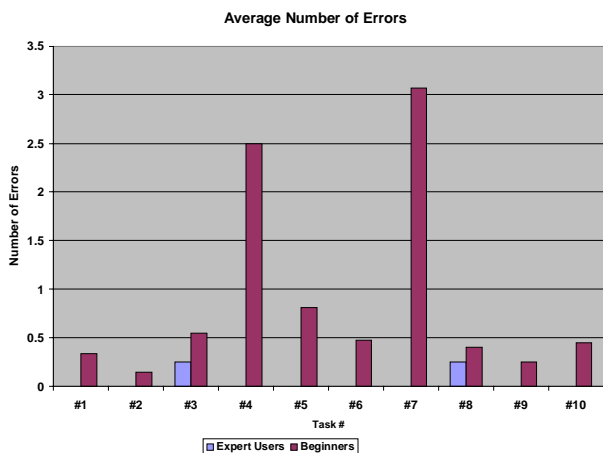
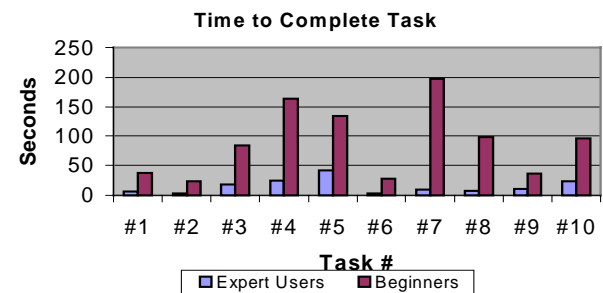
potential benefits of the system are clear well in advance, we believe that users will make the effort to learn the system.

A set of ten tasks were defined to measure novice problems in using the system. They included:

1. Logon to CASCADE, selecting the project "CLASS."
2. Open the file "Social Impact Statements" in the folder "Articles".
3. Make a comment after the third paragraph, and classify the comment as type question, disposition instructor, status open.
4. Open up help and find help on "Change Project"
5. Using the browser, find how many comments have been made on "Heat and Light".
6. Open and read any comment in "Heat and Light" document.
7. Change the view-mode to edit-mode, then exit edit-mode without saving.
8. Copy "Lecture 1" to a Notepad.
9. Change your password.
10. Find the word "Ziv" in "Lecture 3". Find all other occurrences in "Lecture 3" – how many are there?

The bar charts below show the average time to task completion and the average number of errors for 20 novice users versus 4 expert users. As noted in the previous section, some of the discrepancy is explained by terminology confusion. Notably in tasks 4(meaning of find), 5(use of a browser), 7(how to edit/lock), and 8(what does "Notepad" mean).

The menus and terminology are being changed to be more



consistent with user expectations. While the error rates were high during these initial tests, and while users who lacked experience using computers and client server applications did have problems, we observed a dramatic reduction in errors as users became comfortable with the system.

We have noted anecdotally that users are very reluctant to read any documentation and expect system set up and startup instructions to be a part of the install process. Despite our efforts to include small amounts of specially prepared documentation, we found that users did not read this but instead followed their recollection of verbal instructions.

Bugs and Problems

Several bugs were uncovered in the application during this initial testing. To some extent, the intent of these preliminary tests were to do just that. Most of the bugs were of one of two types -- coding oversights and user interlocks. Examples of the coding oversights are more numerous than we would like to admit, and things like recovery and reassignment of memory and mismatched protocol interpretations. Examples of user interlocks include things such as graying out menu choices that should be invalidated by the current mode.

One very nasty implication of this second kind of bug is illustrated by locking. Should the user lock a file on the server and then exit without unlocking it, the file will remain locked on the server. Indeed one of the early problems that we encountered was that locked files were occurring with some regularity. Anticipating that people might exit CASCADE without exiting edit mode, we had established an interlock which grayed out the exit menu item while editing. Unfortunately, we had overlooked the fact that the "X" button located in the upper right corner of the main application window causes an exit that is not subject to the menu choice interlocks.

Another problem that we encountered when we began to use CASCADE outside academia and government research centers has to do with fire walls. CASCADE is designed to use an optimized application protocol that makes the transfers and messages between client and server more effective. In anticipation of more widely distributed CORBA compliant systems, the protocol it uses is similar to a CORBA IDL. In conjunction with this, and as "good Internet manners" prescribes, the CASCADE server and client run on a non standard port above 5000, thus subjecting the protocol to fire walling. A variety of solutions are being examined to overcome this problem. These include running the CASCADE server and clients on the http port -- 80, tunnelling the CASCADE protocol through the http protocol, running a SOCKS server with the assumption that many fire walled organizations are adopting SOCKS as a mechanism for making fire walls semi-permeable, and finally, doing nothing until the market adopts a more general CORBA/IOP solution and moving CASCADE to that.

System loading

We were interested on how the system would function under a heavy user load. How long would operations take? What happen if everybody tried to comment, read a comment, or edit a document at the same time? We used a group of students to simulate load and in general, we found few problems. The effort to overload the server used ten subjects, in pairs of two, try to undertake the basic operations described above at the same time. Some of the tasks, such as using help, require no interaction with the server and thus showed no signed of performance degradation. In addition, a review of the user sessions shows that during the tests the period when the server was being heavily used by the students to edit documents, there was still a relatively light load

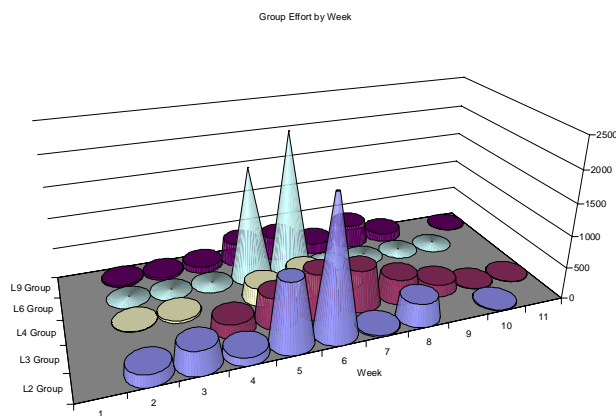
Class Usage Over 57 Days			
Time Period	Average Number Of Users	Maximum Number of Users	% of Days Period is Used
Midnight	1.3	2	7.0
1:00	1.0	1	1.8
2:00	0.0	0	0.0
3:00	0.0	0	0.0
4:00	0.0	0	0.0
5:00	0.0	0	0.0
6:00	1.0	1	1.8
7:00	1.0	1	3.5
8:00	1.2	3	19.3
9:00	1.6	6	24.6
10:00	1.6	3	14.0
11:00	1.6	2	21.1
Noon	2.3	8	31.6
1:00	2.5	8	36.8
2:00	2.4	7	33.3
3:00	1.7	6	43.9
4:00	2.0	6	38.6
5:00	2.4	7	29.8
6:00	1.9	5	29.8
7:00	2.1	5	17.5
8:00	2.0	6	14.0
9:00	1.7	3	22.8
10:00	1.0	1	8.8
11:00	1.3	2	7.0

A couple problems related to server load and slow network speeds have begun to emerge. In particular, we found that what we thought was a smart approach to a protocol for the browser results in very undesirable side effects when

the server is busy. Specifically, construction of a browser image can require dozens of exchanges between the client and server. When the document tree is large and when many people make requests simultaneously, the requests from the various clients are interleaved and none of the browser windows is built until all the requests have been filled. This can lead to long delays. A related problem exists for clients that are making requests over low speed connections. The number of round trips required for a large browser tree can reach 20-30 seconds making the service much less desirable. We are in the process of rewriting and simplifying this protocol.

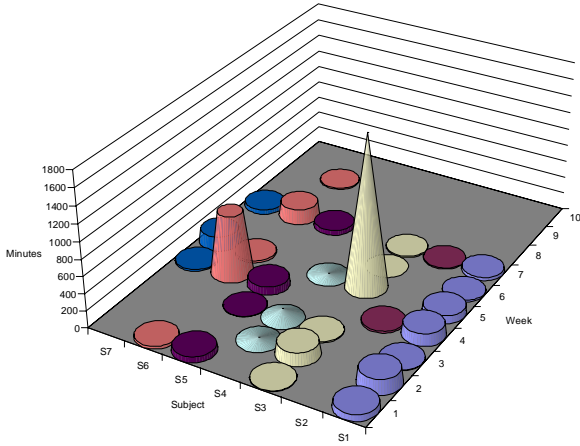
Usage Patterns

An important part of the CASCADE research effort has to do with coming to better understand the collaborative authoring process. The document construction task provided an opportunity to examine how small groups of individuals would coordinate their efforts in a collaborative authoring task. The chart below shows the total number of minutes worked by the members of a group over the ten weeks during which the task was being worked on. The due date for the completed task was week 7, but the deadline was not enforced by any penalty. The subjects were told that they all had to sign the submission form indicating that they were in agreement with the document as it was presented -- equivalent to the consensus requirement in voluntary standardization efforts.

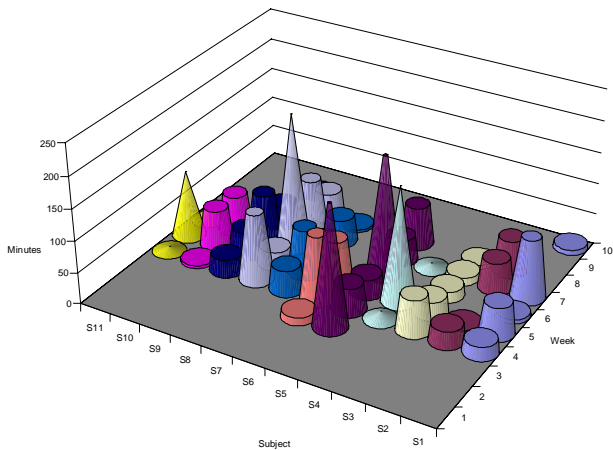


While the overall pattern of activity would appear to be relatively consistent, as is shown in the next two charts, the pattern of activity at the level of individual subjects tends to vary a lot. Group L2 started very early on in the process with one person organizing and setting up the initial effort. Then, activity dies down for almost two weeks and picked back up again in terms of the efforts of two individuals. S2, 4, and 5 monitored activity, and contributed to the project through comments, but basically spent very little time in the initial or final editing. S3 and S6 did the majority of the editing on different documents, and spent a great deal of time on task. It should be noted that the component of CASCADE that augments the process of moving comments back into the text has not

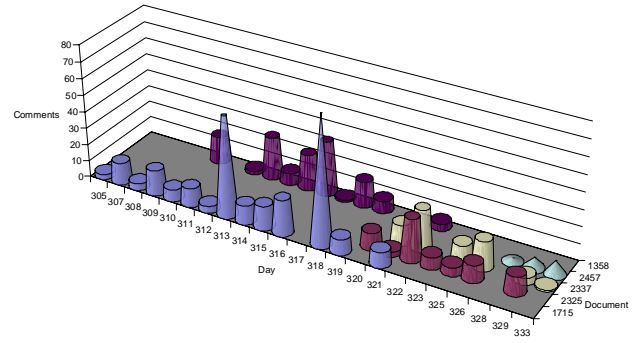
Time Effort of Group L2



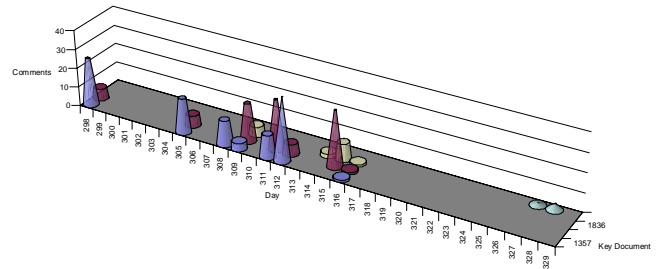
Time Effort of Group L3



Comment Activity by Group L3



Comment Activity by Group L2

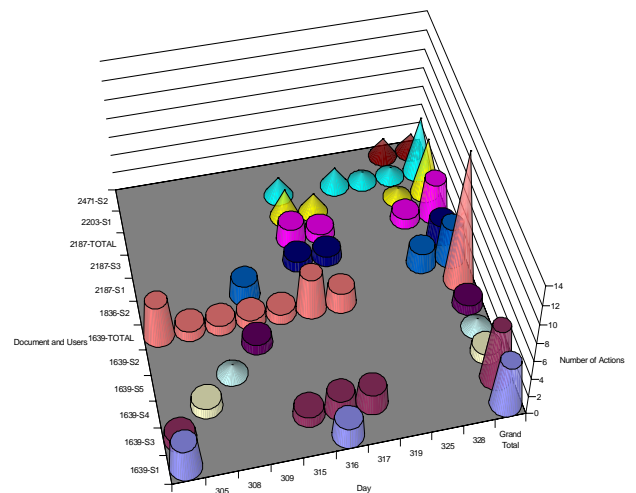


been coded into the client server prototype. When this coding is complete, we expect the large editorial spike to decrease in size.

In contrast to Group L2, Group L3 started late and distributed all tasks more democratically among the group. As shown in the appendix, it is important to note that the Z axis on these two charts is different. While it appears that many of the people in L2 worked very little, such is not the case. As shown in the appendix, the number of minutes on task is actually quite high for every member of group L2.

The next two charts show two different patterns of commenting on key documents. The charts show the number of comments made or amended during the process of working on the documents. In the first case, for group L3, two of the subjects do much of the early commenting and two three other individuals take over later in the process. In general there seems to be a reasonable amount of activity on a daily basis. In the case of the second chart, for group L2, much of the commenting is done by two individuals and it is done in one spurt. While this would

Activity on Key Documents for Group L2



seem to be a somewhat unbalanced division of labor, a closer examination suggests that group two did more of the work directly in the document. As is shown by the final chart that shows direct activity on the main documents.

CONCLUSIONS AND FUTURE WORK

The data reported in this current study is most preliminary in nature and is intended as a prelude to more formal studies. The study suggests several ways in which user expectations might be anticipated in a collaborative authoring system. It also demonstrates some of the patterns in collaborative authoring efforts that may be explored and augmented in future efforts. Finally, the study has suggested a number of ways in which such systems might be structured to improve performance of collaborative authoring over a network.

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Appendix 1: Activity by Week by Group by Subject

		Week										
Group	Sub	1	2	3	4	5	6	7	8	9	10	Total
Group L2	1	72	169	4	137	88	17	37				524
	2				21			11				32
	3	7	147	11		1795	1	15				1976
	4		27	97		12						136
	5	65		2	93			56				216
	6	29			740	24		174		13		980
	7				19	165		50				234
L2 Total		173	343	114	1010	2084	18	343		13		4098
Group L3	8				21	50	6	97			8	182
	9				27	2		48	56			133
	10				57	27	16	12	6			118
	11				12	182		6				200
	12			192	43	30	191	39	65			560
	13			12	105	72						189
	14				40	75	31	42	4			192
	15				109	28	215	89	46			487
	16				27	44	76	36		8		191
	17				4	63	61					128
	18				6	106	20					132
L3 Total				204	451	679	616	369	177	8	8	2512
Group L4	19					19						19
	20				6	65	5					76
	21				81							81
	22				108							108
	23		34			48						82
	24	6				41						47
	25				47	213	5					265
	26				20							20
L4 Total		6	34		262	386	10					698

		Week										
Group	Sub	1	2	3	4	5	6	7	8	9	10	Total
Group L6	27				68		33					101
	28		3		222	2084	4					2313
	29				43					24		67
	30				37			2				39
	31	15	7		66							88
	32			4	655	2	53		2			716
	33				578	141	14					733
	34				28		60					88
	35				53			28				81
	36				24	27						51
L6 Total		15	10	4	1774	2254	164	30	2	24		4277
Group L9	37		25		39							64
	38								40			40
	39				49				19			68
	40		9			100		109				218
	41			93		163	53		41			350
	42				48	3	1	33				85
	43							104				104
	44	22			145	8	30	54			5	264
	45					49			6			55
	46						47	9	16			72
	47						30					30
	48				10			49				59
	49				59	31			8			98
L9 Total		22	34	93	350	354	161	358	130		5	1507
Grand Total		216	421	415	3847	5757	969	1100	309	45	13	13092