ENHANCING LACOME TO CONSIDER PRIVACY AND SECURITY ISSUES

by

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DEDICATION PAGE

This thesis is dedicated to my late grandfather, S. Ajaib Singh Dhillon who always encouraged me for scintific research.

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ABSTRACT

LACOME, the Large Collaborative Meeting Environment, is a collaboration system that allows multiple users to simultaneously publish their computer desktops (workspace) and/or windows on a large shared display via a network connection. Once published, windows or even full desktops can be moved, resized, and iconified; optionally, users can even interact with the content of other users. LACOME was originally designed and developed at The University of British Columbia; we extend the system to consider privacy and security concerns. We conducted a series of focus groups to obtain feedback on the initial design of the system. Based on our findings, we developed high level design requirements for future iterations of LACOME; these include the need for addressing privacy and security concerns when moving from the use of LACOME in a co-located setting to the overarching goal of its use in a mixed presence environment. We implemented new features that provide enhanced awareness of users' shared workspaces and the interactions of others with them. We also developed an access control framework in the system that allows users to assign permissions on an ad-hoc basis. We undertook an initial evaluation of the LACOME system to evaluate the overall system and the changes that we made to it.

LIST OF ABBREVIATIONS USED

CHI	Computer Human Interaction
CSCW	Computer Supported Collaborative Work
EMS	Electronic Meeting Systems
LACOME	LArge COllaborative Meeting Environment
LSO	Large Screen Optimized
MDE	Multi-Display Environment
MPG	Mixed Presence Groupware
SDG	Single Display Groupware
VNC	Virtual Network Computing

GLOSSARY OF TERMS

Controller

The term *Controller* refers to a user who can interact with the content of another user's workspace**.**

Manipulator

The term *Manipulator* refers to a user who may move, resize, iconify, or deiconify windows, or interact with onscreen widgets.

Navigator

The term *Navigator* refers to a machine that forwards its mouse and keyboard events to the shared display to interact with the workspace of others.

Publisher

The term *Publisher* refers to a user machine that shares its workspace to be viewed and accessed by others on the shared display.

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CHAPTER 1 INTRODUCTION

Large displays have been used in meeting and workspace environments over the last couple of decades. Traditionally, meetings have operated in a one-operator-per-display paradigm where a single user physically connects his/her computer to the large screen display to make it visible to other meeting participants. While this approach works well for some types of meetings (e.g., presentations with a single presenter), a more flexible system is required to support a wider variety of collaboration patterns. In particular, current tools offer poor support for meetings with multiple presenters. LACOME aims to solve this problem by providing a better ad hoc collaborative meeting environment. LACOME, the Large Collaborative Meeting Environment, was initially developed at UBC (see [1, 2] for details of its development history and architecture). LACOME is a collaborative system that can be used in a meeting environment with a large screen. LACOME was initially designed for use in a co-located meeting environment; however, our research goal is to expand its use to mixed presence settings. This extension is deserved to meet the distributed characteristics of meetings. Distributed meetings have become common and can offer more flexibilities and functionalities to the users [23].

LACOME provides a cross-platform, light-weight, setup-free client for the end users to easily get involved in collaborative interaction with the shared display. The LACOME system supports two types of interaction through a Lacome client: (1) window management tasks on the shared display such as move, resize, iconify, and deiconify and (2) interaction at the application level through virtual network computing (VNC) servers. VNC server is an industry-standard tool for controlling a computer remotely. Users of LACOME are free to use any standard VNC server of their choice. LACOME provides input redirections by using client-server architecture. Users run the LACOME Client on their machines; it captures their mouse and keyboard and forwards them to the LACOME Server. While interacting with the shared display, the system cursor on a user's own machine becomes locked and a virtual cursor appears on the server screen to interact.

1.1 Research Challenges

There are three main aspects of the LACOME system: large screen display surface, support for multi-user collaboration, and use in distributed environments. The current research challenges

addressed in this thesis as we continue to refine and develop LACOME can be divided into three sub-sections; mixed presence challenges, privacy issues with a large shared display, and access control in a collaborative environment.

1.1.1 Mixed Presence

Mixed presence collaboration combines distributed and collocated collaboration. The LACOME system was originally designed for collocated collaboration, but it can also be used in a mixed presence scenario with the addition of conferencing (audio, video) support to provide the necessary verbal communication. The old system only supported one way communication to remote collaborators as they could only connect to the LACOME Server from their remote locations to share their desktop, but could not view the LACOME shared surface or interact with content. The only way to do that would be to run a VNC viewer at remote locations. However, performance issues and limited display surfaces make this hard. We are, therefore, considering this current system to provide equal opportunities for mixed presence collaboration. Therefore, it will face all challenges typical of distributive environments.

Workspace awareness has been studied in both collocated and distributed settings. Gutwin defined workspace awareness as the up-to-the-minutes update about another's interaction with the workspace, which enables users to work more effectively. When collaboration moves from a face to face setting to distributed groupware environments, many elements/attributes change in this process that makes it harder for people to maintain equality in their collaboration. We considered two attributes: environmental shrink and communication because these two play an important role and affect collaboration.

1.1.1.1 Environmental Shrink

In collocated collaboration with large wall displays (the environment LACOME has been designed to support), people generally have a good visibility of the actual physical workspace. Meanwhile, the workspace drastically shrinks for viewing on a small computer screen in distributed environments. Although, we assume many distributed users of LACOME would have access to a large screen, it is not practical to have large screens available at all distributed locations.

1.1.1.2 Communication

Communication is one of the main mechanics of collaboration for the shared-workspace groupware where the small-scale actions and interactions that group members must perform in

order to get a task done in a collaborative environment [16]. Collocated collaborators can use hand gestures to uniquely communicate significant information [39], which may be missed by remote users. One disadvantage for remote collaborators is that the collocated participants have the ability to control (i.e., stop or minimize) another individual's actions while interacting with the system through verbal communication, gestures, etc., while remote users have limited control when collaborating with the system. Co-located participants use hand gestures to put ideas in practice, to draw the attention of the group during collaboration, and to reference objects on the work surface; these cannot be obtained as easily for remote collaborators who may be limited to just a mouse cursor in remote case [19]. Although, verbal communication can be achieved through audio/video conferencing, gestural communication remains as a challenge in remote collaboration.

1.1.2 Privacy Issues in Large Shared Display

Privacy concerns arise when people share personal information on a large shared display. Visual privacy issues can increase in a large screen sharing environment where the information is more visible. In collocated meetings, privacy issues can be mitigated by social norms [18]. However, with the inclusion of remote participants, these concerns can increase. When using large screens to share information, there is a greater possibility of disclosure of confidential information to others that may cause privacy concerns. These privacy concerns are justified with empirical studies. For example, for a given visual angle and similar legibility, individuals are more likely to read text on a large screen than on a small screen [38]. There are very few frameworks that support users in preserving their privacy while sharing information on a large screen. There were no explicit privacy controls implemented in the old LACOME system; instead it relies on the social privacy norms inherent in face-to-face collaboration to allow its user to manage their privacy. As we move to implement privacy and security controls more formally, we are guided by the Social Translucence design principles [14] of providing visibility, awareness, and accountability in the system.

1.1.3 Access Control

Since computer systems have been used for multiple applications and by multiple users, data security issues among the users have occurred. In the early days of computer use, access control mechanisms were based on the access matrix model (Lampson, 1971). These mechanisms were

suitable for centralized computer systems where each user could create his/her objects and assign access rights. These mechanisms do not meet the needs of today's decentralized dynamic computing environment.

Access control is an indispensable part of any information sharing system. Collaborative environments introduce new requirements for access control, which cannot be met by using existing models developed for non-collaborative domains. Recently, there has been much research done in facilitating collaboration work among distributed groups. However, there has been little work done in controlling access to the collaboration. In fact most collaborative systems expect access to be controlled by social norms [13]. This works to some extent for collocated collaboration but is more difficult in mixed presence meeting environments. Access controls and trust management are the two key requirements for systems intended to support dynamic collaboration [34]. In the previous LACOME system, access control mechanisms were not implemented.

1.2 Contribution

This thesis builds upon the research completed by Zhangbo Liu [25] and Russell Mackenzie [26] in the course of completing their master's theses at the University of British Columbia. In this report, we introduce unique version numbers, LACOME (v 1.0) and LACOME (v 2.0) for Liu [25] and Mackenzie [26] respectively to eliminate any confusion while referring to LACOME. Although, this research continues where Mackenzie (v 2.0) left off, we refer Liu's (v 1.0) work where needed to get more information about the LACOME project. Our versions of LACOME are (v 2.1) and (v 3.0). The LACOME (v 2.1) is the LACOME system with the implementation of awareness features while LACOME (v 3.0) is the final version with access control features. More information about these features can be found in chapter 5.

We made three major contributions in this research, in addition to some minor changes. The first contribution is that we analysed security and privacy needs in large collaborative meeting environments. For this purpose, we conducted a series of focus groups with various potential LACOME user groups to better understand the requirements of design and obtain feedback on the initial design of the system. We also presented the LACOME system as a reception demo in the Computer Supported Cooperative Work (CSCW) Conference in 2012 [27]. Attendees showed their interest by asking us many questions regarding existing design and provided us

with valuable feedback to improve the system. Moreover, we presented a position paper [8] in the Distributed User Interface workshop in the CHI 2012 Conference and a research note [7] in the GRAND conference about research challenges in existing system and future design of the LACOME system. The feedback received in these venues also shaped our design ideas.

The second contribution is the development side of the system; it includes enhancements to the LACOME client and server. Based on our focus group analysis, feedback from the research community, and related work, we implemented a number of controls in the original LACOME system. We added more awareness features in the LACOME client (i.e., provided more information and controls) to increase the easiness and effectiveness of collaboration. In this improved LACOME system (v 2.1), cursors and shared content can now be easily identified, and access to the shared content can be controlled by its publisher. Additionally, by running a VNC viewer, the LACOME Server can be imported anywhere and users can collaborate with shared content from remote locations.

Third, we undertook an initial evaluation of the LACOME system. It had not been formally evaluated as a whole until now, although a study of its window management technique was conducted [26]. As we have implemented controls and made enhancement in the existing system, we believed that the system was robust enough to run a field evaluation. We conducted a field study to evaluate the effectiveness of the system. While the study was limited in scope and could not validate all features, those features that were measured, such as effectiveness, ease of accessing information during meetings, ease of interaction with other group members' material, workspace awareness, usability, and user satisfaction with newly implemented features during collaboration, showed positive results in qualitative responses from participants.

1.3 Overview of the Thesis

This dissertation is divided into seven chapters. Chapter 1, Introduction, provides a brief description of the LACOME system and talks about the key LACOME terminologies that will be required to understand the discussions in subsequent chapters. The last section of the chapter talks about the contribution of this work and research problems in the old LACOME system. This chapter is intended to raise awareness about research problems in the existing field.

Chapter 2, Background, briefly revisits the LACOME background discussed by Mackenzie [26] and explains LACOME's basic features and how to use the system during a meeting. The motive

of this chapter is to provide the reader a strong understanding of the operation of the LACOME system.

Chapter 3, Related Work, addresses distributed user interfaces systems and electronic meeting software. The primary motive of this chapter is to explain how LACOME relates to other systems and to examine the privacy and security issues exist in collaborative meetings for this class of systems.

Chapter 4, Design requirements, presents the user study that was conducted to better understand the design requirements of the existing system. We were mainly interested in obtaining feedback on the initial design of LACOME and privacy and security issues. This chapter provides both qualitative and quantitative data that were used to measure the privacy and security concerns. Moreover, this chapter includes the information and feedback that were used in further development of the LACOME system.

Chapter 5, Improvements in LACOME system, discusses the design and implementation of the enhancements we made in the LACOME Server and client. This includes low level bugs in some LACOME features and implementation of some new features based on the feedback and prior research. These new features are divided into two major sections: the first section is enhanced awareness features, which include cursor identification, screen identification, and short cut keys and other controls for awareness. The second section is the use of access control mechanisms, which is how users can assign permissions to other users during meetings. It also explains how LACOME system can be used in a mixed presence scenario that allows LACOME Server information to be sent to remote users.

Chapter 6, Field evaluation of LACOME system, describes the field study that was conducted to evaluate the overall usability and effectiveness of the improved LACOME system. We evaluated the LACOME system in terms of effectiveness, awareness, usability, user satisfaction, and the newly implemented privacy/security features.

Chapter 7 provides conclusions and discusses the limitations of this research. The last part of this chapter includes a number of key research and design issues that need future work.

CHAPTER 2 LACOME BACKGROUND

LACOME, the Large Collaborative Meeting Environment, was initially developed at UBC (see [25, 26] for further details of its architecture and implementation). It makes use of a client/server architecture to allow meeting participants (clients) to connect to the LACOME Server and publish their desktops on a large screen via one or more VNC (Virtual Network Computing) servers (see figure 1). Once published, windows or even full desktops can be moved, resized, and iconified. The LACOME Server is responsible for running the shared display and creating multiple VNC sessions simultaneously whenever requested by the LACOME clients. It allows other users to interact with the displayed information at a variety of semantic levels.

LACOME uses the Large Screen Optimized (LSO) technique which allows window manipulations to take place anywhere in the window, including within the content pane. In the LSO technique, windows are divided into nine regions: four edges, four corners, and the remaining centre region. This technique introduces a mode-switch to distinguish between the actions of manipulating windows and interacting with window contents. Having a mode-switch allows the entire area of a window to be used for manipulation, providing much larger interaction handles. More information about, the LSO technique can be found in chapter 4 of Mackenzie's dissertation [26].

The motive of this chapter is to provide a strong understanding of the operation of the LACOME system and to explain its basic features and how to use the LACOME system during a meeting.

2.1 LACOME Mechanism

LACOME is a set of software tools that allow multiple users to simultaneously publish their personal computer displays onto a large shared display using any VNC server. VNC is a remote-control client/server application that allows a local client computer to connect and share the desktop to a remote server computer over a network. Keyboard and mouse inputs are sent from the local computer to the remote computer, and screen output is sent from the remote computer to the local computer. The LACOME Server serves as middleware and functions like a VNC client; it may connect to multiple VNC servers at once. The keyboard and mouse inputs are sent twice within the LACOME system. The first stage of input redirection in LACOME, from the

user's machine to the LACOME Server, is achieved through the LACOME Client running on the client's machine. The second stage of input redirection takes place when the LACOME Server redirects the inputs to the VNC server. The display output then flows in reverse order of the input.

2.2 LACOME Modes of Operation

A LACOME client can be connected to the server either as a publisher or a navigator or as both. The definition of these terms is given below [25].

Publisher: The term *Publisher* refers to a user machine that shares its workspace to be viewed and accessed by others on the shared display via a VNC server. The user can publish his/her workspace directly by running one of the VNC servers or it can also be done through the LACOME Client. In this mode, the user behaves like a passive user as he/she would not have any control.

Navigator: The term *Navigator* refers to a machine that forwards its mouse and keyboard events to the shared display to interact with the workspace of others. A user can connect into navigation mode only by running the LACOME Client on his/her machine. By pressing the "Toggle Nav" button on the LACOME Client interface, the user redirects their mouse and keyboard input to the shared display. In this mode the user's system cursor will be locked in the yellow region (see figure 2) of the LACOME client. Navigation can take place in one of the two states: Manipulator or Controller. Manipulators may move, resize, and iconify windows while controllers can interact with the content of another user's workspace. More information on navigation is presented below in section 2.6.

2.3 LACOME Architecture

In figure 1, three computer systems are interacting with LACOME. The first client is connected as a navigator, while the second one is connected as a publisher by VNC connections. The third client is connected both as a publisher and a navigator. There are two types of VNC connections shown in the diagram, a regular VNC connection is initiated by the LACOME Server, while a reverse VNC connection is started by VNC server. The navigators communicate over LACOME connections, while publishers communicate over VNC connections [26].

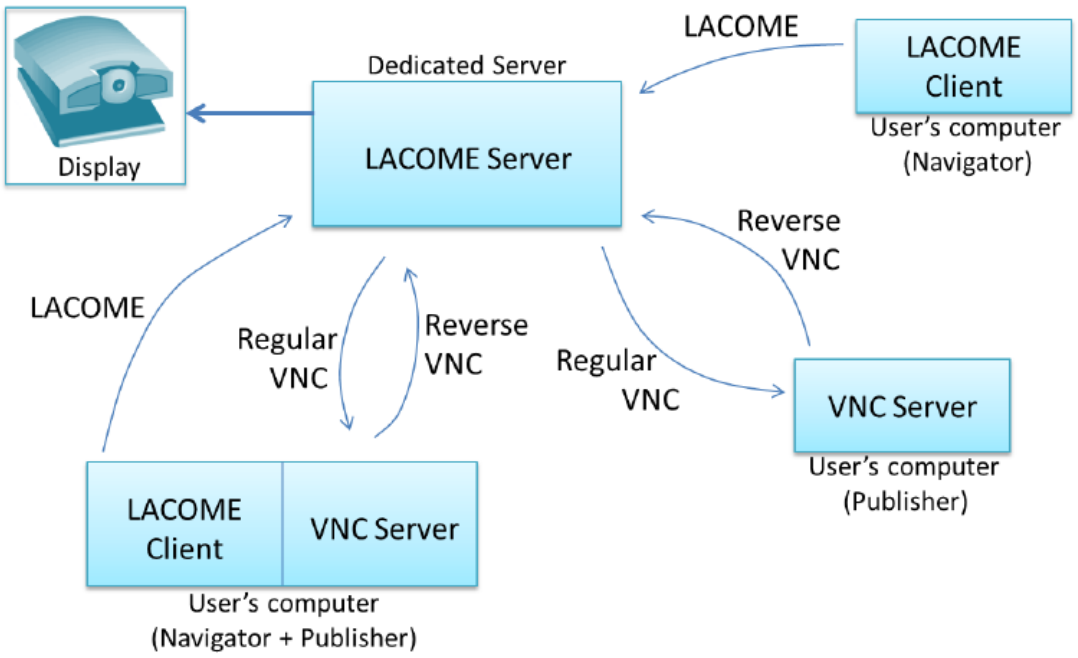


Figure1 A typical LACOME configuration showing the three types of clients and the server. Arrows indicate the direction socket requests are made (from requestor to receiver). Clients with VNC can optionally use reverse connections [diagram modified from [26]].

2.4 Connecting to LACOME

In order to connect a LACOME Client to the LACOME Server, a user needs to enter the IP address of LACOME Server into the text field at the top of the LACOME Client and then presses the "Connect" button. As soon as the Connect button is pressed, the LACOME Client attempts to connect to the LACOME Server on port 2001. Immediately upon connection, the user's nick name can be send by using the "Send Nick" option on the LACOME Client. Once connected, a user by default is a Navigator (see section 2.6 for detail) and can optionally publish (see section 2.5). Users who wish to share their computer desktops on the shared display are required to run a VNC server. Any standard VNC server can be used for this purpose and a user can publish multiple desktops (any computer that shares network connectivity with the LACOME Server) by using three different fields for publishing on LACOME Client interface (see figure 2). Once content has been published on the LACOME Server, any navigator may move, resize, iconify, or deiconify the windows, or may interact with onscreen content.

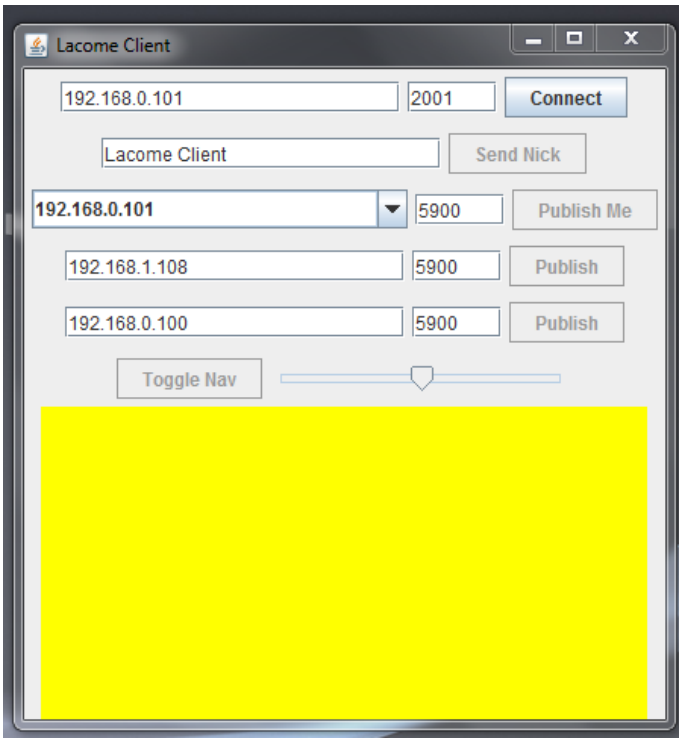


Figure 2 LACOME client

2.5 Publishing displays

Users who wish to share their computer desktops on the shared display are required to run a VNC Server. Any standard VNC server may be used for this purpose, and there are several options available for each of the major operating systems. Our terminology for the act of sharing a computer desktop is "publishing," and the shared computer is termed as a "Publisher". A single user may publish multiple desktops, which may be from his or her own computer or from any computer that shares network connectivity with the LACOME Server. When a LACOME Client disconnects from the LACOME Server, the VNC sessions associated with it are also disconnected. Two different methods may be used to publish a desktop: regular VNC connections and reverse VNC connections. For a regular connection, the network socket is initiated by the VNC client which is the LACOME Server. The network socket for a reverse connection is initiated by the VNC server. For more information about regular and reverse VNC connections see Mackenzie's dissertation [26].

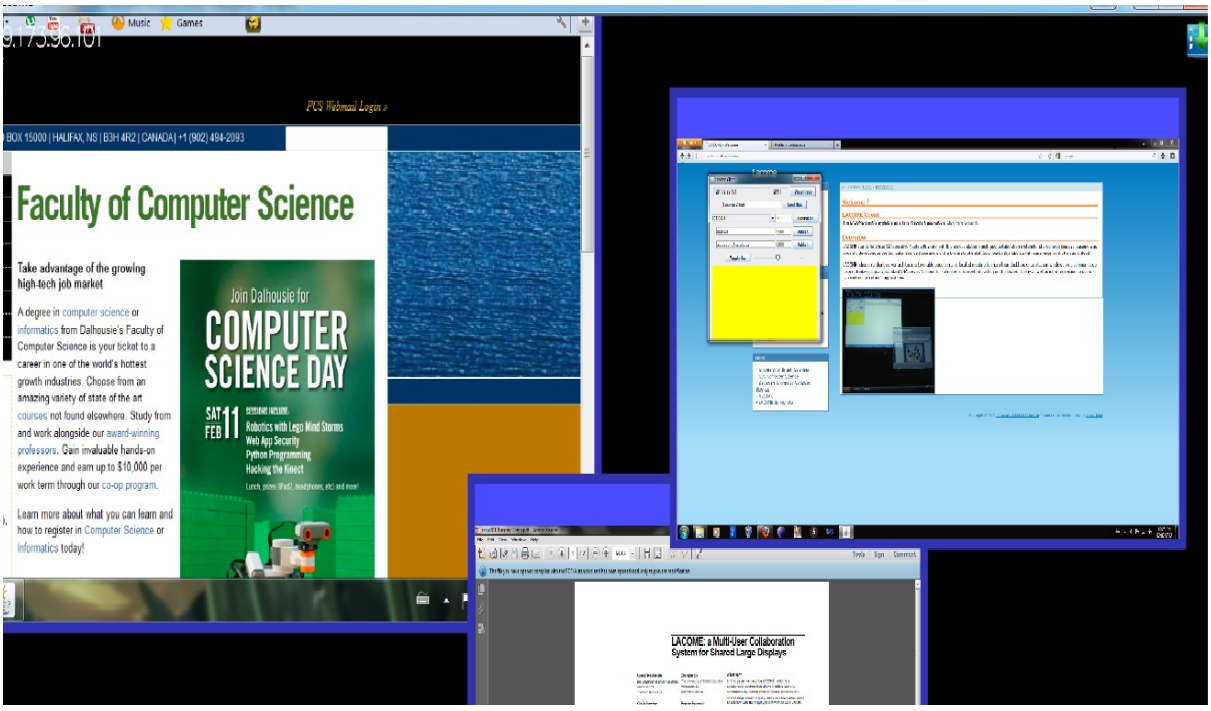


Figure 3 Screenshot of LACOME system showing three shared displays on a large screen.

2.6 Navigation

As mentioned in section 2.2, Navigation can take place in one of the two states: Manipulator or Controller. When a LACOME Client begins navigating, its default state is known as "Manipulator." A manipulator may move, resize, iconify, or deiconify windows, or interact with onscreen widgets. The LSO technique as discussed previously is the default window manipulation technique in LACOME.

A navigator may take complete control of a shared desktop. In this state, the navigator is known as a "controller". To interact with the contents of a shared desktop, a second level of input redirection must take place. The first level of indirection is when the LACOME Client captures the users' mouse movements and forwards them to the LACOME Server. The LACOME Server can then forward those movements again to a VNC server to which it is connected [26]. When a user clicks their middle mouse button on a window, the Navigator undergoes a mode-switch from "Manipulator" to "Controller." When controlling a window, the cursor is constrained to remain within the bounds of that window. Any mouse or keyboard events are forwarded a second time, from the LACOME Server to the target machine. Only one user may control a window at one time because almost all operating systems support only a single cursor [26]. More

information on different key combinations in manipulator and controller mode can be found in Appendix C.

CHAPTER 3 RELATED WORK

Single-user computing, where every user has a dedicated computer and display, and interacts with applications on that display, is not always sufficient. The research area of Single Display Groupware (SDG) strives to allow multiple collocated users to interact effectively with a shared display. Groupware is a generic name for the software or systems that support group work. Groupware includes electronic mail, bulletin boards, asynchronous conferencing, group schedulers, group decision support systems, screen sharing software, whiteboards, teleconferencing, etc. [22]. Computer supported cooperative work (CSCW) is the scientific discipline that motivates and validates groupware design [12].

A large amount of the related work, including tabular comparison of Single Display Groupware (SDG), Multi-Display Environment (MDE) systems, and Multi-Cursor Window Management was identified by Zhangbo Liu and then Russell Mackenzie in their theses [1, 2]. In section 3.1-3.3, briefly introduce characteristics of these systems again and discuss how the LACOME system fits in these classes of systems. More information about other systems which belong to these classes can be found in Mackenzie's thesis [26].

As our research focus was to consider use of the LACOME system in a mixed presence meeting environment, the main focus of this related work is on distributed collaborative and electronic meeting systems. In section 3.4 and 3.5, we identify some distributed collaborative and meeting systems and we discuss their similarities and dissimilarities with the LACOME system in detail.

3.1 LACOME as a Single Display Groupware (SDG)

The growing interest in software applications requires systems for simultaneous interaction in collocated as well as remote environments. The Multi-Device Multi-User Multi- Editor (MMM) project is an early implementation of single display groupware. MMM enables multiple co-present users to interact with multiple editors on the same computer display by providing each user with an independent input device [3]. The system was never made available to the research community.

In 1999, Stewart et al. [36] first introduced the single display groupware model (SDG) to support collaborative work among people who are physically close to each other. CoLab [35] is

designed for small working groups of two to six persons using personal computers connected over a local area network. As in LACOME, each user of CoLab interacts with a dedicated personal computer which provides more fluid access to user content. The LACOME system is based on the SDG model as all users (clients) are publishing or interacting with LACOME on a single large screen attached to the LACOME Server. Therefore, the LACOME system supports multiple simultaneous users to interact in a mixed presence meeting environment on a single large shared display with multiple input-devices.

3.2 LACOME as a Multi-User Multi-Display Environment (MDE) System

In recent years, the typical computer workspace has experienced a significant transformation, from a single desktop computer with a single attached display, to an MDE with multiple connected devices and displays. The large available displayable area provides the ability to display content at a resolution. Additionally, multi display environments with different views provide different levels of privacy in personalization of collaborative meeting environment scenarios. Grudin [14] demonstrated that rather than treating multiple monitors as a single large display space, a user tends to treat multi-monitor systems as ways to partition their desktop space, with each display eventually assuming a particular role.

In section 3.1, LACOME is listed as a single display groupware system. However, the LACOME system can also be considered as a multi-display environment system because on its single display large display users may publish multiple small personal displays.

3.3 LACOME as a Multi-Cursor Window Management System

When multiple users collaborate using computing systems, they must either share an input device or use multiple devices. A number of studies have examined techniques for using multiple cursors and found that the vast majority of extant software supports only a single cursor. LACOME, however, does not rely on workarounds such as time-sharing the system cursor; in fact, the system cursor is not used at all. All cursors are virtual and contained within the LACOME window, which typically occupies the entire screen. Each published desktop within LACOME supports only one cursor, which is a limitation imposed by VNC.

3.4 LACOME as a Distributed Group Support System

Distributive Group Supports System allows communication anywhere/anytime to support group discussion and decision making. Distributed user interfaces provide enhanced interaction capabilities to users by distributing user interface elements across users, platforms, environments and different contexts [9]. The LACOME system is an example of a distributed user interface system as it includes the following dimensions of distributed systems:

- Multiple users: The LACOME is a multiuser system as any number of users can collaborate at the same time.
- Multiple computing environments: The LACOME system can be used in mixed presence collaboration (collocated and remote).
- Multiple domains and tasks: As each user is interacting with his/her personal machine, users have the flexibility of performing independent tasks and can publish their workspace for others when they deem it appropriate.
- Multiple platforms of usage: Users collaborate with different machines (laptop/desktop), hence different computing powers and platforms (operating systems).

We have identified some of these distributed systems which are closely related to the functionality of the LACOME system. These systems are discussed below; Table 1 provides a tabular comparison of these systems with LACOME for the dimensions of restricted access, remote collaboration, large screen display, and multi-pointer support.

Liveboard [10] is a large interactive display system that supports group meetings, presentations, and remote collaboration. It is a directly interactive, stylus based, large area display for meeting environments. It is fully network supported and can be used in a shared mode between remote locations. Liveboard incorporates an accurate cordless pen that allows participants to interact directly with the display which provides a natural point of focus for meetings. The key issue with the system is the positional inaccuracy of the pen.

The Argo system [11] was designed to allow medium-sized groups of users to collaborate remotely from their desktops. The main purpose of this system is to provide effective collaboration to remote users, modeling face to face meetings as closely as possible. In order to support remote collaboration, Argo provides three basic types of functionalities: real time digital audio and video support, general sharing of arbitrary single-user applications and groupware, and telepointing/telepainting tools for gesture and annotation in any shared window. Like the Argo system, unrestricted access in the LACOME system would be a great challenge in distributed meeting environments.

The DISCIPLE [28] (Distributive System for Collaborative Information Processing and Learning) project developed a set of methods and tools for versatile presentation, manipulation, and analysis of multimedia objects in shared environment. The architectural modules of the DISCIPLE system include: a client, which consists primarily of a document editor and data analysis modules organized into public and private workspace; a server, which coordinates the work of clients and maintain a database; and some expert system components for resource management and decision making. Both LACOME and DISCIPLE are distributed systems which use client/server architectures. DISCIPLE is used more for information processing while LACOME is mainly used for screen sharing and interaction with shared content.

ConnectBoard [37] is a remote collaboration system that supports natural interaction among multiple users. Moreover, it supports gaze awareness interaction by using a camera behind the screen where the remote user is virtually located. Thus, it resolves the limitations of conventional video communication systems by capturing natural user interactions. The system is based on the "ClearBoard" idea of Ishii and Kobayashi [20] where the shared media is presented as though on a sheet of glass between the local and distributed participants.

Wallshare [41] is a collaborative system for portable devices. It is a multi-pointer system based on a client/server architecture that allows collaboration for face-to-face meetings and working groups [41]. Therefore, connected participants can upload and download various resources to and from the shared zone. Users can collaborate through the shared zone via their mobile devices, and to use the shared zone, users have their own cursors that allow them to share any type of files, such as images, or documents. A usability evaluation showed positive outcomes in terms of effectiveness, productivity, task efficiency and task time. LACOME and Wallshare have a

number of similarities: both are distributed user interface systems and have similar functionality (i.e., client-server architecture, large display sharing, and support multi-user interaction).

Dynamo [21] is another large publicly accessible multiuser interactive surface. It allows cooperative sharing and exchange of media remotely. It also supports shoulder to shoulder (collocated) collaboration by allowing multiple users to interact simultaneously on a large shared display [21]. Users can attach multiple USB mice and keyboards to the surface and manage it as a communal resource by claiming areas of the interactive surface for use. Both Dynamo and WallShare [41] are mainly designed for displaying and exchanging information in collaborative environments, while LACOME was mainly developed to support large collaborative meetings by screen sharing and eliminate the need to sequentially display and interact with information on a large shared display.

3.5 LACOME as a Meeting Support System

The common meeting is an integral part of group work. However, due to scheduling conflicts or other constraints, people are often not able to attend all the meetings in person. Teleconferencing and recording of meetings can address this problem.

During meetings, groups communicate, share information, generate ideas, and collaborate on the writing of reports. Electronic meeting systems (EMS) strived to make group meetings more productive in the early nineties. GroupSystems [29], by the EMS research group at the University of Arizona in 1991, is an early example of a system developed to support electronic meetings. The GroupSystems architecture was built on three basic concepts: an EMS meeting room, meeting facilitation, and a software toolkit. Although, meetings are often distributed in terms of space and time, the EMS research was focused on project oriented work groups interacting in a single room at the same time.

Distributed Meetings (DM) [5] is a meeting support system that enables high quality broadcasting and recording of meetings, as well as rich browsing of archived meetings. The main difference with LACOME is that LACOME is designed to support remote collaboration and viewing of meetings as they occur, while the Distributed Meetings system broadcasts multimedia meeting streams to remote participants, who use the public telephone system for voice communication and record meetings to be viewed on demand [5].

PING (Pervasive Information Networking for Groups) [42] is a distributive meeting system that supports real time audio-visual communication and data collaboration. It was mainly designed to support Group-to-individual (G2I) distributed meetings where a group is situated in a meeting room and an individual is in his/her office. The PING system resolved two challenges of G2I distributed meetings: the remote participant is often ignored by local participants, and the remote participant has an inferior technology experience (audio, video) compare to the local participants [42]. The current LACOME system does not provide audio and video support but may be considered including it in the future.

3.6 Access Control Requirements for Collaborative Systems

In the early days of computer use, access control mechanisms were based on the access matrix model [24]. These mechanisms were suitable for centralized computer systems where each user would create his/her objects and assign access rights. These mechanisms do not meet the needs of today's decentralized dynamic computing environment.

Role based access control (RBAC) allows access permission to information based on responsibilities or roles. Role based access control is required in collaborative systems, especially in company's internal meetings where different people require different level of access according to their job functions and responsibilities. RBAC models can be used to limit the access of processes. With RBAC, role-permission relationships can be predefined, which makes it simple to assign users to the predefined roles. RBAC offers a key benefit through its ability to modify access control according to change in organizational needs. Team Based Access Control (TMAC) is an approach of applying role based access control in collaborative environments where an activity is best accomplished through organized teams [40]. TMAC can be considered an active model because permissions can be assigned on run time environment.

Many access control mechanisms are deployed at the group level. A main difference between groups and roles is that groups are typically treated as a collection of users while role is both a collection of users and a collection of permissions. With RBAC, role-permission relationships can be predefined i.e. permissions can be assigned to a role because permissions assigned to a role do not tend to change as frequently as users change to a role [34]. Without RBAC it will also not be possible to determine what permissions have been assigned to which users.

Discretionary Access Control (DAC) models are based on the idea that the owner of an object has the control over the object permissions. The author is authorized to allow or withdraw permissions for this object to others users. Access rights of collaborative application may not be known until runtime, so DAC models are necessary to enable a user or application to limit access rights.

Access control model for collaborative environments should support Role based access control, dynamic change in access with roles, access should be assigned to roles and then role should be assigned to the users of the system [31]. As we move to design access control policy in LACOME, It should be light weight and provide a flexible framework for sharing.

3.7 Summary

We now briefly summarize the related work described above, in a tabular format. We use a short system name chosen by the designer of each system and provide the reference number for each paper in the reference list. Additionally, the year of publication is provided for each system. The table then identifies which of the following aspects a system utilizes or affords: restricted access, remote collaboration, large screen display and Multipointer support. A system that supports particular feature is shown by [✓], otherwise [✗] symbol is used. Whenever it is not clear from publications whether a system supports a particular feature we represented the uncertainty with a [?] mark.

Table 1 Tabular summary of related work

.System	Year	Restricted Access	Remote collaboration	Large screen display	Multipointer Support
Liveboard [10]	1992	?	✓	✓	✓
Argo [11]	1994	×	✓	✓	×
Disciple [28]	1996	×	✓	✓	?
DM [5]	2000	?	✓	✓	×
Dynamo [21]	2003	×	✓	✓	✓
PING [42]	2006	?	✓	✓	×
Old LACOME [25]	2008	×	×	✓	✓
Connect [37] Board	2009	×	✓	✓	×
WallShare [41]	2010	×	✓	✓	✓
New LACOME	2012	✓	✓	✓	✓

CHAPTER 4 DESIGN REQUIREMENTS FOR LACOME 3.0

The LACOME system was developed for collocated collaboration but was not formally used by groups or evaluated for these settings. We therefore had no user feedback on which to base our implementations to the system. We conducted a series of focus group to obtain feedback on the initial design of the LACOME system in order to understand the design requirements before further developing the system. In this chapter, we present our user study design, which had as a primary focus obtaining feedback on the initial design and on privacy and security issues. We report the results, including both qualitative and quantitative data. Based on these results, we wrote a set of guidelines that were used to further develop the LACOME system.

4.1 Research Objective

The LACOME system was initially developed to support screen-sharing and interaction with shared documents during collocated meetings. However, meetings often require the inclusion of remote participants. No explicit privacy and security controls had been implemented in LACOME (v1 and v2), as privacy issues were being managed through social norms. When we began to consider extending LACOME for use in mixed presence (collocated and remote) environments, it was essential to implement security and privacy controls in the existing system in order to protect confidential information from non-authorized users. We were also aware, through our own casual use of LACOME, that there were areas for improvement with respect to its usability. Our research objective was to conduct a series of focus groups to better understand the requirements of design and obtain feedback on the initial design of the system.

4.2 Study Design

We decided to conduct a series of focus groups in order to get feedback on the existing system. LACOME is a collaborative system where multiple users can share their desktop screen and interact with it. We believe that focus groups study design is appropriate to obtain feedback on the system where groups can use the system and share their experience with the system. The information about the study, participants, and nature of the task is provided below in subsequent sections.

4.2.1 Study protocol

The participants signed a consent form at the beginning of the session. Afterwards, the researcher provided an introductory demo of LACOME and instructions on how to use the system during the exploratory activity phase. Then the participants used the LACOME system and performed independent activities such as connecting to the LACOME Server, sharing desktop contents on a large screen by using the VNC server, dragging and resizing windows, interacting with (e.g., editing) contents of others. The researchers were there to answer any questions that participants might have while performing the study. After completing the activities, participants were asked to fill out a post-activity questionnaire to provide their feedback and opinions. In the last part of the study, the participants were asked to discuss their experience with others.

The focus group discussion portions of the sessions were intended to last about 25 minutes. Many of the questions about the perceived security and privacy issues were re-iterated. However, in the group setting, we expected that the participants would learn from each other, inspire one another, and provide richer detail in discussion. This discussion also helped the researcher to better understand the benefits and requirements of the LACOME system being examined in the study. We used this setting to brainstorm ideas for possible improvements to the usability of the system.

4.2.2 Recruitment procedures

For the study, the targeted population was Dalhousie University students, faculty and staff, as well as business professionals. We wanted to recruit a broad cross-section of the general community, including both technical and non-technical users. Each focus group included 3 to 5 participants. We believe that the size of the focus groups was sufficient to obtain initial design feedback. Because LACOME is a collaboration system, we preferred to recruit people who were working or had worked on a project together within one group, but this factor was not a necessity for participation.

We asked potential participants to express their interest in participating in the study. We first screened potential participants to identify that they fell under one of the groups that we required for the study. As LACOME is a collaborative system designed for meetings within similar communities, we asked participants if they had any friends/colleagues who were willing to take part in the study. We preferred to recruit participants who were currently working on a project together. After considering all of the applications, we formed six distinct groups.

4.2.3 Pilot study

We ran a pilot session with a student group. There were 5 participants (4 males, 1 female) at the session; four were graduate students and one was an undergraduate student. Three participants had their own laptops and two were provided laptops by the researcher. After signing the consent form, participants were briefly introduced to the LACOME system and its operation. They were then asked to download and install a VNC server and the LACOME client on their machines. We initially thought that it would take an hour to run the whole session, but we noticed that it took significantly more time than we expected. Participants appeared to focus on the interaction techniques, which may in themselves not show privacy concerns. As well, some participants experienced Java issues in their machines and were not able to download the LACOME client, and others were having issues while installing the VNC server. Specifically, they were able to use the system only for a short time and could elaborate the system only at the accessibility level. In other words, they were not able to evaluate the needs of privacy and security concerns.

In the focus group session, the participants did not mention any difficulties they had faced during the installation process. We realised that if we could provide our lab's PCs and personal laptops with the VNC server and LACOME client installed, it would be possible to get useful feedback on the concerned issues. We requested amendments in our original ethics and planned to provide our own laptops for the next groups. Nevertheless, we included their data, as their concerns and comments did not differ greatly from those of the other groups.

4.2.4 Participants

We recruited 24 participants in 6 groups during our study, which ran from June to August, 2012. Information on the primary characteristics of each group, the number of participants, the gender of participants, etc., is given below in Table 2. We also indicate whether participants used their own computers and whether they used the original version of LACOME or the enhanced version that we made based on early feedback during the focus groups (described in detail in the next section).

The first group was our pilot group. These participants used their own laptops or the ones provided by the researchers. We included their data because their concerns and comments did not differ greatly from the other groups. For the remaining groups, we provided laptops with all

Table 2 Participant characteristics table

Group	Primary Characteristics	Participant ID	Gender (M/F)	Personal Computer?	Enhanced Awareness Features?
1	Students	5 (S1- S5)	4/1	Mixed	No
2	Non-technical	5 (NT1- NT5)	3/2	Provided	No
3	Technical	5 (T1- T5)	3/2	Provided	No
4	Business Professionals	3 (BP1- BP3)	2/1	Provided	No
5	HCI Researchers	3(H1- H3)	0/3	Provided	Yes
6	Diverse	3(D1- D3)	2/1	Provided	Yes

necessary software (Java, LACOME client and VNC) already installed. The first four groups used the original LACOME system. We found that some basic awareness features were lacking, which led some participants to shift their focus from privacy concerns. Participants were not easily able to identify others' cursors and workspaces. Basically, they had difficulty determining who was accessing which computer and which workspace belonged to which participant. From their confusion, we realized that their attention was more focused on the awareness side of the system rather than on the primary goal of considering privacy and security concerns. We therefore decided to implement enhanced awareness features before conducting the study with further groups.

In Figures 4 and 5, the cursor and title pane of the window are shown after implementation of the enhanced awareness features. We noticed that, after implementing awareness features, participants provided more feedback about security and privacy in their discussion rather than about awareness.

Figure 4 Screen showing labeled cursor

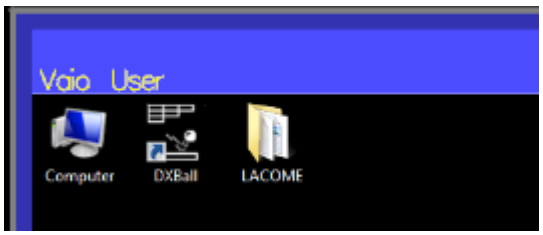


Figure 5 User's name in the window title pane

4.3 Results

As discussed previously, participants were asked to fill a post-meeting questionnaire after experiencing LACOME (see Appendix E). The participants rated their privacy concerns for different scenarios and answered general questions about the LACOME system such as what technology they use for meetings, privacy and security concerns when considering LACOME in a meeting environment with remote and collocated participants. The results are divided in two sections, the first quantitative analysis of privacy ratings in different scenarios and the second discussion of participants and feedback through questionnaire.

4.3.1 Privacy Ratings (Questionnaire)

As shown in Table 3, participants were asked to rate their privacy concerns on a scale of 1 to 5 (1= low privacy concerns, 5= high privacy concerns) for eight different scenarios that varied according to location of meeting members (collocated vs. remote), their relationship with the meetings member (friend vs. stranger), and confidentiality of information being shared (confidential vs. non-confidential). We used the Friedman test to determine whether there was an overall statistically significant difference between the mean ranks of related groups. Results of the Friedman test reveal that there is a statistical difference between the mean ranks of all possible different combination of these factors ($\chi 2$ (7) = 94.166, P = .0001).

A post-hoc analysis with Wilcoxon Signed Rank Tests was conducted to find where these differences lie. We compared 12 pairs with Wilcoxon pairwise comparison for three factors (Location, Relation, and Information type), with four different combinations for each factor. To analyse the results of Wilcoxon rank tests, we did a Bonferroni adjustment, changing the significance level to .004 (.05/12).

We found that there was a significant difference in privacy concerns for two factors: information type and relationship. When we compared privacy concerns for Information Type under all four combinations (FCNC vs. FCC P=.001, FRNC vs. FRC P=.000, SCNC vs. SCC P= .001 and SRNC vs. SRC= P= .003) and Relationship of participants to meeting members (SCC vs. FCC P=.001, SCNC vs. FCNC P=.000, SRC vs. FRC P= .002 and SRNC vs. FRNC P=.000),

Table 3 Showing visual privacy concerns for eight different scenarios

Relationship Viewing Scenario	**Location Viewing Scenario**	**Information Type Viewing Scenario**	**Acronyms**	**Privacy Concerns median**	**Privacy Concerns mean**
Friends	Collocated	Confidential	FCC	4	3.5
Friends	Collocated	Non- confidential	FCNC	2	2.04
Friends	Remote	Confidential	FRC	4	3.92
Friends	Remote	Non- confidential	FRNC	3	2.62
Strangers	Collocated	Confidential	SCC	5	4.71
Strangers	Collocated	Non- confidential	SCNC	4	3.79
Strangers	Remote	Confidential	SRC	5	4.75
Strangers	Remote	Non- confidential	SRNC	4	4

we obtained a less than significant value of .004. The above results indicate that privacy concerns of the participants varied according to the relation of the members and the type of digital information being shared among the group. However, there was no significant statistical difference for privacy concerns that varied with changes in location under all four combinations: (FRC vs. FCC P=0.106, FRNC vs. FCNC P= 0.029, SRC vs. SCC P= 0.792, SRNC vs. SCNC P=0.212).

We plotted a line graph to further understand the privacy concerns and to ascertain how these varied with location. As shown in Figure 6, privacy concerns are shown on the Y-axis and

locations (collocated and remote) are plotted on the X-axis. The graph is drawn for all four possible scenarios to see how it varies with changes in participant location.

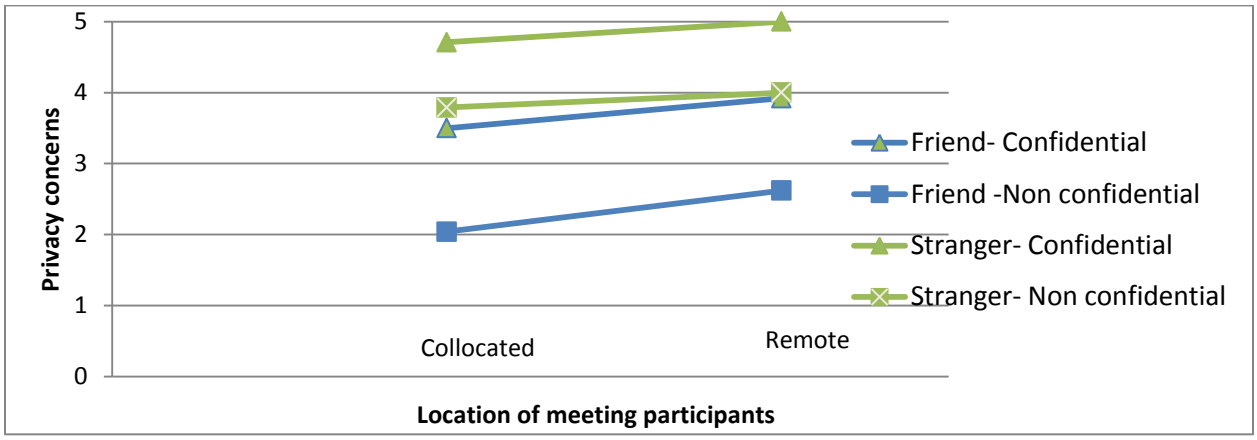


Figure 6 Variation in privacy concerns, with location plotted on the X-axis and privacy concerns on the Y-axis

The starting point of a line indicates the privacy concerns for collocated participants, while the end point reflects privacy concerns for remote participants. As can be seen, all four lines are nearly horizontal, which indicates that privacy concerns do not vary significantly with location. The blue lines on the graph indicate privacy concerns when sharing information with friends, and the green lines show privacy concerns if information is shared with strangers. As is clear from the above graph, the blue line falls under the green line, which indicates that participants have fewer privacy concerns with friends than with strangers. Similarly, the squares and triangles represent privacy concerns for non-confidential and confidential information, respectively, showing that privacy concerns for non-confidential information is relatively low.

4.3.2 Privacy and Security Concerns

We asked participants to provide feedback on the LACOME system and privacy and security concerns in both collocated and remote collaboration. Participant responses on individual questionnaires and in focus group discussions are presented in this section.

4.3.2.1 Collocated security and privacy concerns

In the individual questionnaire, we asked participants to specify "What privacy and security concerns would you have if you were using LACOME in a collocated meeting environment?" Only three participants (S4, T1 and D1) said they would have little or no privacy concerns due to

the intended nature of public display. As D1 noted, “It is a sharing system, like a projector. People in the same room would be able to see anyway. I don’t think there is any privacy issue.”

Two participants (NT5 and NT4) expressed the need for audience familiarity in a meeting environment. As NT5 stated, “people should be familiar, otherwise it may threaten the privacy”, while NT4 suggested that “privacy concerns would be higher if any stranger is accessing my screen.” When we asked these participants in detail during the discussion, their main concern was how their information might be used, as they do not know the identity of strangers.

Four participants were concerned about the general awareness while using LACOME system in their meetings. Two of these (BP3 and T4) stated the need for enhanced active session awareness. As BP3 asked, “Who is controlling what?” Members of student group (G1) stated that because all screens are shared, it is not possible to identify which screen belongs to whom. They also noticed the need for some mechanism to identify mouse cursors and windows on the large screen. Members of non-technical group (G2) suggested displaying information on the header and to have the name of the person on the respective cursor. Members of technical group (G3) also elaborated on the need for awareness. Participant T1 stated that even we are not able to identify our own screen on the large display. When we asked the third group what information should be on the header to identify the workspace, they supported the idea of just the name because too much information about users for a larger group would make it more complicated to identify.

Two participants (T4 and H3) were concerned about post-session awareness. As T4 said, “I need to know which files or folders have been accessed. Also, I would like to see session history.” H3 added, “I would like to know if someone changes something on my machine.”

Five participants (S3, NT3, T5, BP1 and H2) were concerned about public viewing and sharing of personal information. As S3 said, “People may open the stuff that I don’t want to share.” Members of non-technical group (G2) suggested that it might be better to have shared folder to save files, which would restrict access to all other information. NT3 stated, “People seeing my work, plagiarism perhaps being judged on a document that is in draft mode.” When we asked in detail during the discussion, she admitted that she is a “control freak”: “If I’m working on a project with a team and other people are editing it, I would like to check it for grammatical mistakes and plagiarism.” T5 said, “There might be personal files or folders which another person can open in front of other people”. BP1 said, “Personal or client data can be accessed

even by mistake by another user and everyone can see it." She also mentioned, in discussion, that she works in a highly confidential environment and that disclosure of clients' personal data, even by mistake, can cause serious damage. H2 stated, "Someone could take over my machine and share all my personal files to everyone in the meeting." Member of technical group (G3) elaborated on screen sharing mechanism in discussion and pointed out that rather than sharing the whole desktop, it might be better if there were an option to select documents that needed to be shared. These could be put in LACOME client or somewhere else, and only those documents could be viewed by other people. The bad outcomes of sharing information in public can be an embarrassment, and sharing of confidential data by mistake might lead to plagiarism if the content is copied.

Six participants (S2, NT1, NT4, T2, H1 and H2) had issues with the control mechanism of the current LACOME system in terms of granting, maintaining and taking back the control of their own machine. As S2 stated, "Others can modify and view my laptop screen as soon as they gain access, I can't prevent them from doing so." Members of diverse group (G6) discussed providing more control to the owner of the workspace. They suggested that the owner should be able to release connection when unauthorised user gets control of it. NT1 said, "At a time, only one can operate this system. If others try to open this, it doesn't have access for others." NT4 commented, "If anyone is accessing my screen, I am not able to access my computer." H2 stated, "Someone might share my files with everyone in the meeting with no method to stop the interrupter."

Four participants (S2, T2, BP2 and D3) were concerned about what other people might do if they gained control of their system and what would happen to their confidential data. As S2 said, "Other people can view and modify my data". As T2 added, "There is no access control to confidential stuff". BP2 was concerned about the confidentiality of the information that needs to be shared with other users, while D3 was concerned about the safety of his personal confidential data.

Seven participants expressed a desire for access control and the ability to limit the sharing of personal information. Two of these (H1, D1) were concerned about the access of personal information by others. As H1 said, "Someone can access my desktop, entire computer and files". However, one of the participants (BP1) from business professional group pointed out during the discussion that, "If I share my stuff on screen, I would be only worried about what I have and

how it is secured. If I know that my personal documents and files are saved in my document folder, it is my responsibility to have that password-protected so no one can access it, even if it is on public display". All other group members agreed with this. Two of the participants (T5 and D2) expressed the need for some sort of permission mechanism through access control. As T5 said, "Anyone can access my files without my permission". While D2 stated, "The only privacy concern is that someone can access my files without permission". Three out of seven (S5, T1 and H3) voiced a desire for some mechanism to limit the sharing of information. S5 said, "I need restricted access for personal control of my laptop". And H3 added, "I would like to always be able to control my own computer. It is hard to control what is shared because everything is shared."

Three participants (S1, NT2, and T3) provided some solutions to dealing with these challenges. S1 suggested, "It would be good to secure privacy by passwords between users because you need to restrict other users." NT2 said, "Only the group leader should have the higher priority to access other people's computer." T3 suggested, "There should be blank labelled window instead of an actual window in sharing until permission granted to access." One participant (D3) raised the issue of eavesdropping of information if the system is used over a wireless connection.

In figure 7, all different types of privacy and security concerns are shown in a column chart. As we can see the major concerns are related to access control, awareness, public viewing of personal information, user control mechanisms and disclosure of confidential information.

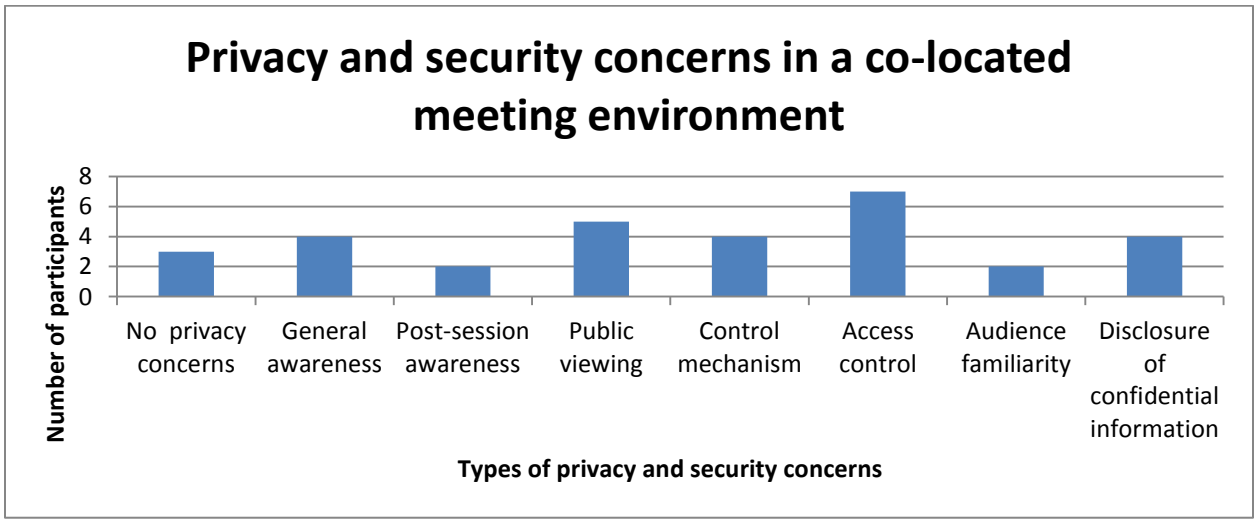


Figure 7 Types of Privacy and security concerns

4.3.2.2 Remote security and privacy concerns

In the individual questionnaire, we asked: "What privacy and security concerns would you have if you were using LACOME with inclusion of remote participants?" We found that their concerns were shifted with inclusion of remote people, even when there was not a significant difference in their privacy ratings. The participants are more concerned about trust, identity, and network security information of remote users and overlooked the other general issues such as access control, general awareness and control mechanism issues. Five participants (NT4, T2, T3, H1 and D3) said they would not have any different concerns than they would have in collocated settings.

We noticed that, in collocated settings, people are primarily concerned with personal and confidential data, but with the inclusion of remote participants, they also worried about their software and programs. As T1 said, "As long as I am in the room, my concerns are limited. But, suppose I am the remote user? I would not share my computer using LACOME because even my C drive is shared." We are unsure about this, as the C drive is shared with collocated people as well. People are more concerned about privacy when sharing information in a distributive environment. This suggests that people are not only worried about revealing their personal information but are also afraid of sharing their software, operating system files and installed programs.

In remote settings, we noticed that people are more worried about hacking, security and network protocol/topologies used by other remote people. As T4 stated, "I would be concerned in their connection type, whether it is secured or not." People are also concerned about networking and wireless aspects of the system, which was not a concern in collocated settings. As participant S1 said, "A system should be shared without using an IP address. It can be hacked."

One third of the participants showed high privacy and security concerns regarding remote meeting environment and sought more information about remote collaborators. Two of the participants (S4 and NT5) said their privacy and security concerns would be high with remote participants due to the lack of information about remote users. Five participants suggested the need for some technique to identify remote users. As NT2 said, "I need [at least] basic information about the remote user." One participant (D2) raised privacy concerns due to lack of trust. As he said, "There might be some trust issues, as I am not sure what to share with others if

they are not physically present there." H3 said, "I would like to know who the remote people were."

There was one participant, H2, who completely denied this system in remote collaboration, stating "I would not use it in the presence of remote people."

4.3.2.3 How do you typically share information in your meetings?

On individual questionnaires, we asked participants how they shared information in their meetings. Our intent was to understand their information-sharing behaviour. As can be seen in Table 4, most people were using large screens (most commonly, a projector), email and software to share information during meetings. The LACOME system includes all of these attributes/features, and thus best fits in their meeting environment perceptions and expectations.

Table 4 Sharing methods used by participants

Information Sharing Method	**Number of Participants**	**Percentage**
Share on large display	18	75%
Email	10	41.6%
Paper	9	37.5%
Software	9	37.5%
Gather around a PC	6	25%
Others	3	12.5%

4.3.2.4 Would you use LACOME in your meetings?

We asked participants if they would consider using LACOME in their workspace meetings. We got a mixed response: 13 participants answered that they would not use LACOME at this point, while the rest of the participants showed some interest in using it, with some minor improvements. When we asked participants to elaborate on their responses, they suggested that design improvements were needed, along with general awareness, security and privacy management in the current system. People who would not use LACOME had the same privacy and security concerns as those mentioned in relation to collocated and remote collaboration. As NT4 said, "There is a lack of security, so it is not advisable to use it right now. After

improvements, we can use it". BP1 stated, "Not at this time. I'm working in a highly confidential environment and the possibility of someone else controlling my information is too high." T3 said, "For now, it is not a sophisticated version system. When it is fully developed, I will be concerned". S4 added, "It may not be useful until it has full functionality. Full functionality means all users should be able to access it at the same time". And T5 said, in halting English, "Messy environment because didn't get notification of who is in controller mode at a time, can't able to recognise my screen."

Six out of 11 participants who showed an interest in using the LACOME system requested improvements in the system. As NT3 stated, "I feel it needs some fine tuning." BP2 agreed, "With some modifications, such as identification of screen, [I would use it]." Five participants stated they would use this system because of its unique functionality. As S1 said, "If we need to do a cooperative work, it would be great to work together". S2 mentioned it was better than "gathering people to see one laptop screen then switching to another screen". NT1 elaborated: "It is really helpful that if some manager gives a presentation, everyone can see it and collaborate through the system".

4.3.2.5 Focus group discussion

In this section, we present the detail focus group discussion to provide the sense of each group and how the discussion went among the group members.

Student group

S1 stated during focus group discussion that it was hard to identify the person who was controlling my computer, if we get something to identify mouse that would be great. He also noticed that when a user was controlling second user's computer at that time second user was not able to access computer of other people. Then S3 added in the discussion that multiple screens were shared, it was not possible to identify which screen belongs to whom. S2 agreed with both S1 and S3 and added that the system needs some mechanism to identify who is controlling my laptop. S5 brought new point into discussion that in collocated setting it was easy to know who was controlling my computer because I can ask or people can tell me but with the inclusion of remote participants it is hard to know who is accessing your system.

When we asked the group about the access control requirements for the LACOME system, S3 stated that access control is certainly required before someone gets access of my computer. He further added that every meeting should have access control for every new session and access

permission should be assigned for read/write and it should be assigned in the beginning of a meeting. When we asked him whether the access control should only be for controlling a computer or it should be for navigating as well. He said this should depend on the task and the type of information to be shared in a meeting. S4 jumped into discussion and clarified it more with an example; he said if it is a picture other people can only view so there is no problem but if it is a document other people can edit or change it. All group members agreed on assigning permission for each session.

When we asked the group about security and privacy concerns with the inclusion of remote participants, S2 said that the level of trust would be low with remote people and it also depend on the familiarity of remote person for example if I know that person for a long time in that case I do not mind sharing information even if he is remote. S5 raised different concerns he added that in collocated setting we can see how people are accessing our information but in the case of remote we would not be able to see what they will be doing with that information. S1 stated that it will make more sense to have visual notification when someone does something with your machine.

Non -Technical group

NT1 suggested about the access control mechanism that there should be a disable and an enable option to disconnect someone from accessing the system. While NT2 added that users should be prioritized in controlling the workspace of others because only one person can control at one time. These priorities should depend on the designation of the person. He further added that like in gotomeeting, organizer is the one who invites people for the meeting and he can assign permissions. While talking on access control NT5 stated that the system should have a shared folder to access the information or it should be limited to access only the desktop icons. NT4 suggested that there should be a password before connecting to the LACOME system because only the IP address would not be secure for confidential meetings.

NT4 suggested improving the usability of the system by providing information on the header of the window so user can identify other people in the meeting. NT2 agreed and added that it would be better to put the name of the person on the window header within one community meeting and put organizations name for meeting with various communities or companies.

Technical Group

About concerns and requirements to implement the system for remote participant, T1 discussed the need of addition of a voice system in to the system for communication during the meeting. T4 suggested the system could be improved if users would able to get notification about the current state of the system. T5 was concerned about the full accessibility of the system and discussed that people should not be able to access the C drive of the computer because it stores operating system files and other softwares. He added that it would be idle to have an option to choose what to share or partial sharing. T2 further added in the discussion that rather than sharing the whole desktop if there is an option to select, for example put the documents that you want to share in LACOME Client or in a shared folder and only those documents should be accessible to other people.

The group also raised the awareness concerns in identifying the cursor and workspace of other like previous groups. T3 suggested that system should show some information about the users on the cursor so it would be easy to identify. When we asked what kind of information should be there he added that just the name would be enough because too much information about the users for a larger group would make it more complicated. While T4 suggested that system should store some more information about the user and should be hidden if somebody needs to know more about a person, so it can be viewed. It will give more comfort that when are sharing information with others. When we asked about the access control requirements, T2 stated that permission should be granted by a moderator, otherwise it can cause to silent dispute because if one user gave permission to user X and denied for Y. T1 was agreed and added that if the permission are assigned at the run time it would interrupt the speaker.

Business Professional group

When we asked the group about the privacy and security concerns while sharing information with group members, BP1 stated that if she has shared her personal stuff on the large screen she would only be worried about what she has and how it is secured. She said that, “If I know that my all personal documents and files are saved in my document folder and it is my responsibility to have that password protected so no one can access even it is on public display”. She said that it is completely user responsibility to protect confidential information. She further included that There can be two type of scenarios for access control requirements: the First, if someone start controlling her computer that will bother her but suppose that she needs some help and she asked

someone to take control of her machine so that would not bother her because she initiated the connection. In further discussion on access control BP1 suggested that moderator can decide permission in the beginning and then user can assign permission at run time. BP2 agreed with BP1 and added that there should be a password before connecting to LAOCME because it depends on the environment and physical location of the meeting. He said that the department where he works, it is externally secured so nobody can come from outside and peep your IP address of the server and steel information. BP3 did not agree with BP1and she stated that in her company there is no problem with the environment because doors are locked.

The group did not find any problem in identifying the cursor and workspace of other group members. One reason could be the small size of the group. BP1 suggested that it is good to know about other people by putting more information the screen but it would not reduce trust issues.

BP2 commented on this said that the trust issues will be a more concern for people who are remote not me because they cannot see the full workspace. He further added that if the remote people can see everything then his concerns will be same as collocated.

HCI Researcher group

When we asked about the usability of the system, H1 stated that she is control freak, and do not think there is a need to control someone else computer. Once you open a computer of other people you can open email, picture and other personal document. She said it was not easy to figure it out her desktop on the large screen but it may be easy with her own computer because of familiar desktop background. She further included that it should allow sharing only certain things such as word documents but not the browser and other confidential stuff. She said this was not her computer, she feet deeply uncomfortable when other members were controlling her computer. H2 jumped into discussion and said that she does not want to give control to anyone; even we are working together on a project but never felt a need to access others' computer. She said that you need something collaborative but it seems too much, invasive. The big concern is that the user lost control of his computer. H3 commented on the client interface buttons and said that the "Toggle Nav" and "send nick" is not ideal name. She added that she was confused with zoom and resize. Resize is fine but zoom does not do what it supposed to do. She said about the privacy that her concerns are way more than privacy and security, security is something that can be achieved by having a password but privacy is the bigger concerns. H1 raised different type of privacy concern and suggested that the system should not show the bottom taskbar when desktop

is shared. She said suppose that she is in a work meeting and open some personal content such as Facebook or something at the same time. She does not want anyone to see what other programs are running. H1 said that allowing other to access the computer, this concept works well in help desk scenario but does not required for a meeting scenario. H2 further added and said the multiple cursors on a large screen are a good idea to point something on one document; it does not need necessarily to interact with the content.

Diverse Group

D1 commented on the concept of access control mechanism of the system and said that the sharing desktop with others is good but only the person who has shared should be able to interact with it, so only the user should be able to publish and interact with it. He further added that the interaction should be in a controlled manner, it will not help if everyone moving the display. D3 commented and said that the system is good for knowledge sharing and several people can work in a collaborative environment but people might be able to see confidential project, pictures, and emails. Moreover, people can see browsing history that is most dangerous.

In discussion about the access control requirement D2 stated that in the start of the session users have the purpose of meeting, based on that a user can decide what level of sharing is required during the meeting and can provide access to people accordingly.

4.4 Requirements to Enhance Privacy and Security in LACOME (2.0)

Based on our findings, we generated several requirements for LACOME to not only enhance its usability for co-located users but to also expand the privacy and security features as remote user are considered.

4.4.1 Enhanced awareness of person controlling cursor

LACOME does not rely on workarounds such as time-sharing the system cursor. Each published desktop within LACOME supports one cursor to interact and control shared workspace. Although these cursors are colour-coded for each user in the old LACOME system, other users will not know who the cursor belongs to. This can be resolved by having a list of all users and associated cursors on one side of a large screen. Our first four groups used the LACOME system without using enhanced awareness features. One student group said that all screens are shared and it is not possible to identify which screen belongs to whom. They noted the extensive need for some mechanism to identify mouse cursors. This similar question was raised by following

groups as well. As BP3 said, “Who is controlling what?” After running the first four groups, we realised that participants are focused more on awareness features rather than on privacy concerns.

4.4.2 Enhanced awareness of the owner of the workspace

A large number of windows appear on a large screen, depending on the users of LACOME. Each window contains a published computer desktop for each user. The virtual cursor may be used to manipulate windows through such actions as moving, resizing, and iconifying. A user may take control of a window in order to interact with its contents. It was not easy to identify the workspace of other people when more than two users were sharing their desktops on a large screen.

4.4.3 Enhanced awareness to cease navigation of shared display

There is a “return to desktop” icon on the top right side of the server screen to exit navigation and get control back by user. In the old LACOME system, when this icon is pressed, the virtual cursor on the shared display is released but the system cursor is not. Despite distributing instruction sheets on how to use LACOME and key combinations during the study, we were asked this question multiple times. Because getting control back is an important activity, we then decided to have instructions on client interface to exit navigation and release cursor.

4.4.4 Post-session awareness

Participants seek post-session awareness to know if anything has been changed in their system during the meeting. One of the participants (T2) from the third group said, “The system should save session history so I’d know if someone open or accessed my document. I should be able to identify this later.” This concern was also raised by other participants during group discussions.

4.4.5 Access control

There is an access control framework to connect to LACOME. It authenticates users and establishes secure connections, but once the connection is established, there is no control on access. A user can interact with any workspace and make changes, and the owner of the associated workspace will have no control to stop it other than to unpublish the display. We posed the question to all discussion groups regarding whether they want to assign access permission at the start of the meeting or at run time. The first group suggested that, at the start of

the session, you state the purpose of the meeting. Then, based on that, a decision can be made as to what level of sharing is required during the meeting and permission can be assigned accordingly. Permission should be assigned for each new session, and access control requirements for navigation or controller should depend on the task/information and type of meeting scenario. Meanwhile, the second group concluded in discussion that there should be disable and enable options for some to control your machine. The users should be prioritized to control other users' machine because only one person can control at one time. These priorities should depend on designation/organizer. Like in gotomeeting, the organizer is the one who invites people for the meeting and he can assign priorities and permissions. One participant from group four said "there can be two types of scenarios for access control: First, if someone starts controlling my computer, that will bother me. But suppose that I need some help. I asked someone to take control of my machine, so that would be a different scenario because connection is initiated by the user." In order to provide more security before connecting to LACOME, the same participants from group four pointed out that it depends on the environment/location of the meeting: "The department where I work, it is externally secured, so nobody can come from outside and peep at the IP address of your server", and other group members agreed on this. The third group recommended in discussion that permission should be granted by a moderator. Otherwise, it can cause a dispute if a user gave permission to one but denied it for another. Permission can be assigned at run time as well, but assigning permission at run time may interrupt the speaker.

4.4.6 Client interface (Keys names and their functionalities)

Users interact with LACOME client interface, so there should be sufficient information on the client interface. We found, during our study, that participants were having learnability issues even after using this interface for a while. As H1 said, "Learnability was a bit hard and I am still confused how to use it." The other issue with client interface is that some keys do not represent their functions clearly. As H2 noted, some keys like 'Send Nick' and 'Toggle Nav' do not clearly indicate their associated functions.

4.4.7 User idle

As explained in chapter 2, a user can interact with the content of other users in controller mode. Once the user gets the access in controller mode, other people cannot get the access of that

workspace. There may be a scenario when the user leaves the meeting room while controlling one's workspace. The owner of the workspace and other people would not be able to interact with it. Future design of LACOME may include a feature that will sign out the user from the system if a user is idle for a certain time.

4.4.8 Communication channel

A user in a collocated meeting can communicate a significant amount of information through gestures, such as to ask if it is permissible to move or resize the user's window, they may simply gesture or whisper to each other. In a distributed meeting, they must use a separate communication channel shared between all meeting participants typically a telephone conference call or video conferencing call.

Our technical group mentioned that it would be helpful to add a voice system for remote participants so that they could communicate. Our HCI researcher group also supports the idea of having a second channel to communicate with remote people. This communication must happen over the phone or other secondary source.

4.5 Limitations of focus group study

While these focus groups study of LACOME were effective at getting initial feedback about the existing design of the LACOME system, it has limitations. The small size of groups is not a representative sample and does not explore the privacy and security concerns and usage environments of all potential users. Furthermore, the participants did not use their own laptop; the privacy concerns will not be known until participants use their personal computers.

The LACOME system was developed for collocated collaboration but was not formally used by groups or evaluated for these settings. So we did not consider including remote participants in our focus groups study; we believe participants would not be able to provide genuine feedback about remote participants' privacy concerns until they have the experience working with remote participants.

4.6 Summary

In this section, we briefly summarized the design requirements described above in tabular format. We divided these design requirements into three categories: Awareness, Privacy and Security, and Usability. The table below provides information on the actual source of particular

design requirements and whether they were implemented or not. Finally, the table's last column briefly explains how these requirements are implemented. More information about the implementation of the design requirements can be found in the next chapter, from sections 5.1 to 5.4.

Table 5 Design requirements in tabular form

S. No.	Design requirements	Category	Source
1	Enhance awareness of the owner of the screen	Awareness	Focus groups
2	Enhance awareness of person controlling cursor	Awareness	Focus groups
3	Exit navigation	Awareness	Focus groups
4	Post session awareness	Awareness	Technical focus group
5	Access control	Privacy and security	Focus groups
6	Keys names and their functionalities	Usability	Focus groups
7	User idle	Usability	CSCW 2012 Conference
8	Communication channel	Usability	HCI Researcher focus group

CHAPTER 5 THE IMPROVED LACOME SYSTEM

The LACOME Client is software (Java web-start application) that runs on each user's computer, capturing user input and relaying it to the LACOME Server. This chapter describes the continued development of the LACOME Client along with several new features that have been implemented in the LACOME system.

5.1 Robustness

Although the previous version of the LACOME Client (v 2.0) [26] was functional, it had some usability issues that needed to be addressed. The LACOME system was previously used only at the University of British Columbia, and we experienced several issues transferring it for use at Dalhousie University. One major problem was that there is no step-by-step documentation to run this system on different platforms. We are grateful to Russell Mackenzie for his assistance in this matter. We have now created step-by-step guidelines to run the LACOME Server and LACOME Client (see appendix D).

Once we got LACOME up and running, there were two main concerns with the system. Firstly, there was a noticeable lag in the cursor movement on the LACOME screen, which rendered it nearly unusable. The second issue was related to the SSL connection. The Server and the Client had to be in the same state (i.e., both had to use SSL or not). This was somewhat of an issue for the Client to have to know the current state of the Server and then connect to the appropriate state. We fixed both of these issues, as explained below in sections 5.1.1 and 5.2.2.

5.1.1 Lag in redrawing texture

The most troublesome problem that had to be addressed was that the original version of the LACOME Client (2.0) had a noticeable lag in mouse movement when in Navigation mode. In this mode, mouse movements and button clicks are redirected from the user's own computer to the LACOME Server running on the shared screen. When the mouse is moved, the LACOME Client sends a message to the LACOME Server.

Awareness of buffering issues is particularly important in socket programming because buffering, while designed to enhance performance, can interfere with the interactive feel that

some programs require [1]. The data will not be sent to the other end of the connection immediately, instead, it will wait until the buffer is full.

Under a strategy called The Nagle Algorithm, output sends on TCP sockets are subject to buffering at the operating system level. When a packet of data has been sent but is not acknowledged, additional to-be-sent data is queued and sent as soon as another complete packet's worth is collected or the outstanding acknowledgment is received. By default, all current Microsoft operating systems have Nagle's Algorithm enabled [1]. In the LACOME system, there was a noticeable delay in mouse events both on the client and server side, which happened due to OS-level buffering when mouse events are being sent to a windowing system. Nagle Algorithm can be disabled with the TCP_NODELAY socket option. In the connection constructor for client protocol, when the socket was created and before the output stream is obtained, the TCP_NODELAY socket option was used to turn off the OS-level TCP buffering.

5.1.2 SSL issue

Securing Java applications with an SSL certificate can be extremely important. An SSL certificate serves two essential purposes: distributing the public key and verifying the identity of the server so that users know they are not sending their information to the wrong server. The secure transmission of VNC passwords is supported using SSL in LACOME instead of relying on default passwords. We used a self-signed certificate, which, as its name implies, is a certificate signed by itself rather than by a trusted authority. Since any attacker can create a self-signed certificate and launch man-in-the-middle attacks, using LACOME with untrusted users in a public domain is not recommended at this point. If the client is using SSL and the server is not, (or vice versa), the server will not establish a connection with client. In order to enable or disable SSL on both server and client, some VM arguments need to be configured (see Appendix D for required VM arguments). Hence, it becomes extremely important to know whether or not the server is configured with SSL in order to establish a connection. In our new concept, SSL can be turned off and on easily. As shown in Figure 8, when a client tries to connect to the LACOME Server, a socket is opened by first attempting SSL; if that fails, the server will attempt to establish a plain connection (Non-SSL).

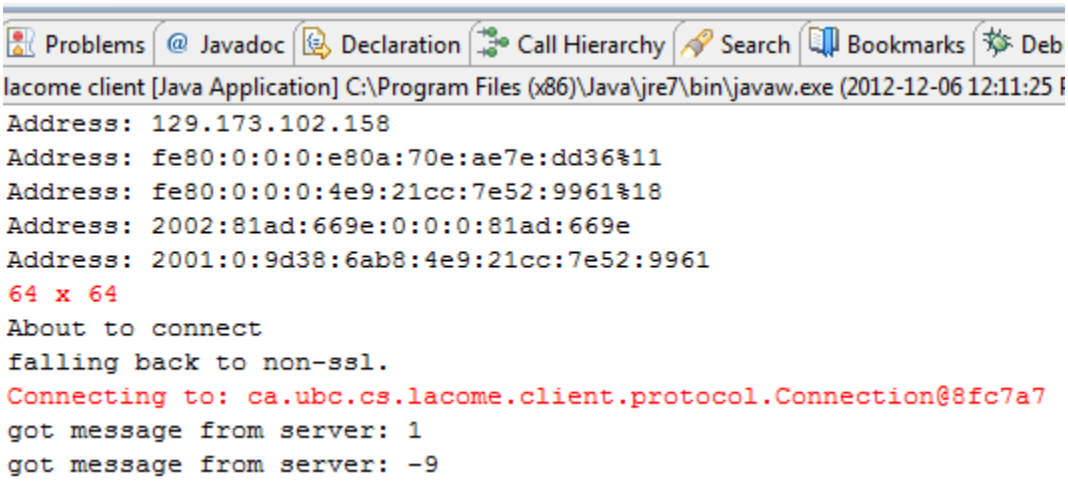


Figure 8 Lacome Server and Client establishing a connection without SSL

5.2 The Improved LACOME Client GUI

We rebuilt the LACOME Client interface by using the river layout which is a simple and flexible Java Layout Manager. We made the client interface simple and it includes information in four fields. As shown in figure 9, the new LACOME Client (v 3.0) looks almost same as the previous one (v2.0). The only difference is that some unnecessary fields have been removed (VNC fields to publish more than one display), the space has been utilized more wisely and the buttons aligned to look more attractive. We kept only four fields on the interface; each line has a different role, which will be explained briefly in the following subsections.

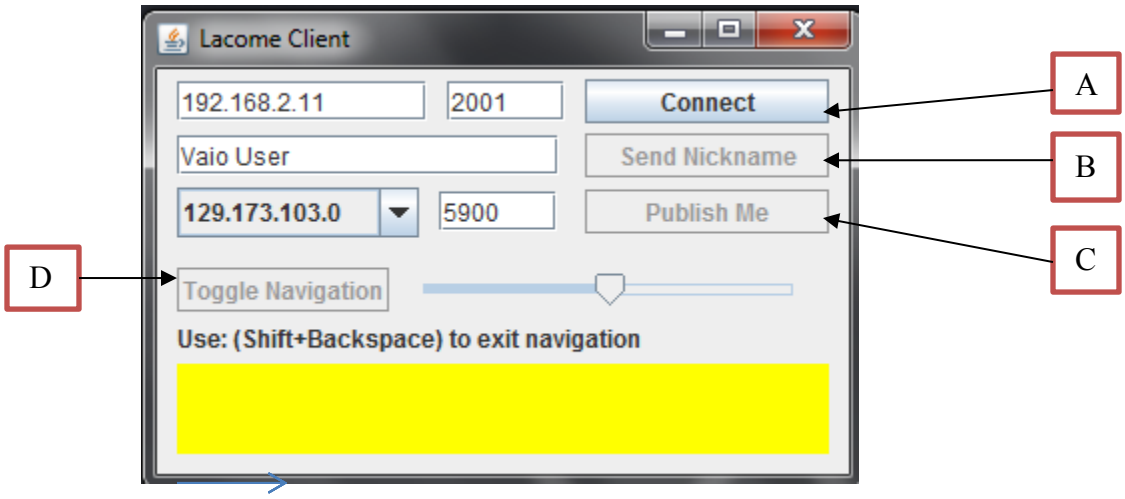


Figure 9 The new LACOME Client (v 3.0)

5.2.1 Connection

The first field in the Client interface (Figure 9 A) is required so that users connect to the LACOME Server. It has an IP field that needs the server's IP address in order to connect. The connection is essential for using any other features in LACOME Client, as without a connection, all other fields are inaccessible. Once the proper connection is established, the user can then choose any of the following three features in any order.

5.2.2 Send user information

The second field in the LACOME Client (Figure 9 B) is used to provide awareness about the user. This field was also on the original LACOME Client (Figure 2) but it was not visible on the screen. In the new Client, this information will appear on the LACOME display on the title bar of that user's screen and also on user's cursors.

5.2.3 Publish

The third field in the LACOME Client (Figure 9 C) is used to publish desktop content to the LACOME Server, if required. This is possible with the incorporation of a VNC server in the LACOME Client. The Publish Me feature allows a user to easily initiate a connection from the LACOME Server to a VNC server running on his or her desktop. When started, the LACOME Client determines the hostname and various IP addresses associated with the computer on which it is run.

5.2.4 Interaction

The last field in the LACOME Client (Figure 9 D) is used to interact with the shared content on the LACOME Server. It sends mouse and keyboard inputs to the LACOME Server and a virtual cursor appears on the server screen to interact with shared content.

5.3 New Features

Several new features were added to the LACOME Client, intended to make the software easier to use. Users are now provided with more information through tooltips, enhanced awareness of the users controlling cursor and screen. We also disabled extra VNC panels to remove any confusion. Finally, we deployed access control to provide more security and privacy into the existing system.

5.3.1 Tooltips and renaming buttons

One of the main things that came up during the focus group study was that the participants were not able to understand the roles and functions of the various fields and buttons. For example, the second field in LACOME Client (Figure 9 B) is used by the client to send his or her nickname. In previous versions of LACOME Client (v 2.0), this button was named as "Send Nick", which is not clear to users unless explained to them. Our G5 in the focus group (i.e., the HCI researcher group) suggested a strong need to change it to something more logical that can describe its functionality better. The same problem occurred with the "Toggle Nav" button, which is used to switch to navigation mode. We changed the names for these buttons to "Send Nickname" and "Toggle Navigation", respectively.

There was also some confusion regarding IP addresses; participants were not able to identify which IP address was required to connect to LACOME Server and which one was required to publish their display. One question that repeatedly arose throughout the focus group study was about the function of each button.

We used tooltips to provide a simple solution to this problem .The advantage of this approach is that it does not take any space and provide enough information about each field and button. A tooltip is a small label or text that appears next to a tool/control when the user pauses over it. The tooltip is typically short text which describes what the control/view is. Tooltips are handy when a user has multiple tabs in the application. The user scrolls through these tabs using left and right arrow keys.

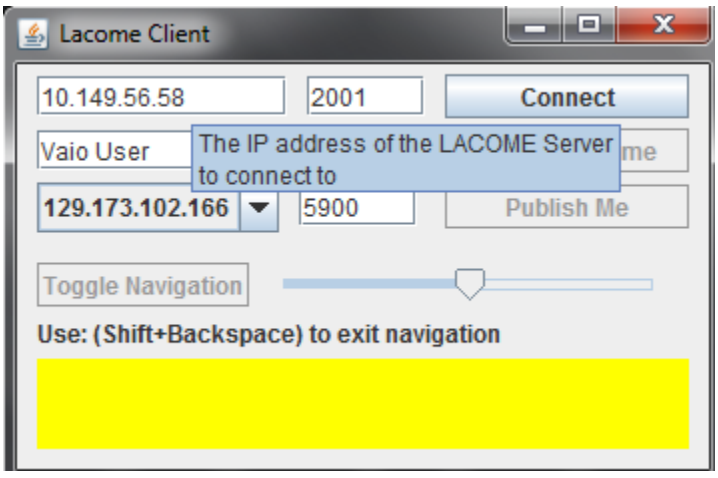


Figure 10 The screen showing information about first field as a tool tip

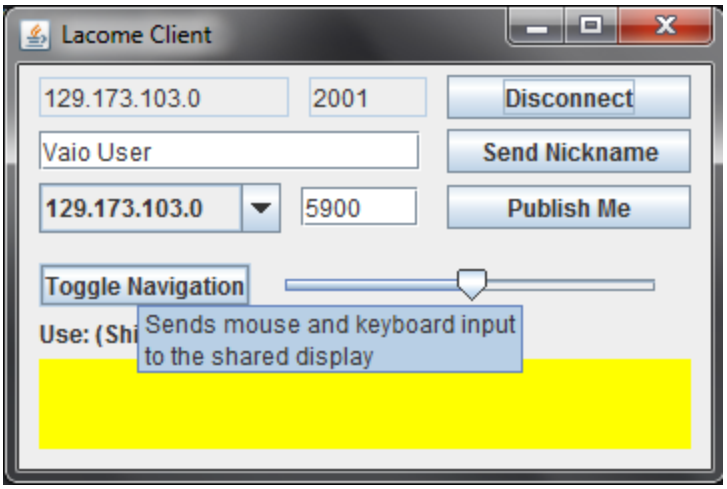


Figure 11The screen showing information about one of the buttons as a tool tip

In figure 10, the tool tip shows information on the first field of LACOME Client, which is to enter the IP address of LACOME Server to connect to the system. In Figure 11, the tool tip shows the function of "Toggle Navigation" button, which is to send mouse and keyboard input to the shared display.

5.3.2 Disabled extra VNC panels

A single computer may have multiple network interfaces and can be attached to multiple networks simultaneously. For example, the machine shown in Figure 12 has multiple network interfaces, and each interface has IPv4 and/or IPv6 address. To successfully publish a VNC server, a user must know which address will be visible to the LACOME Server. Most users are expected to only attach to one network at a time. Hence, a user can publish with just this field by using appropriate interface.

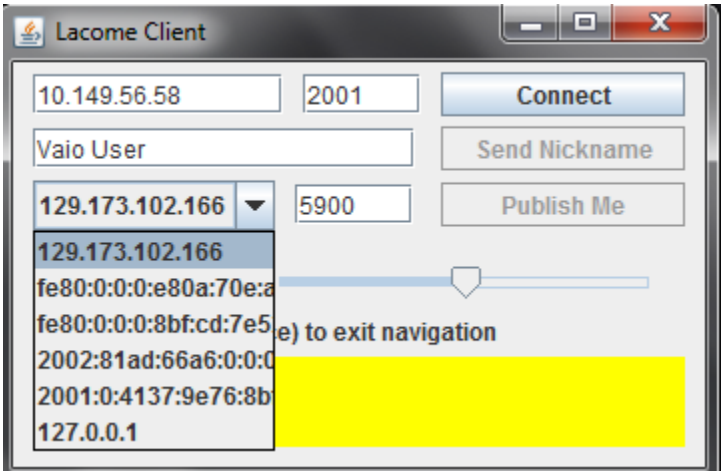
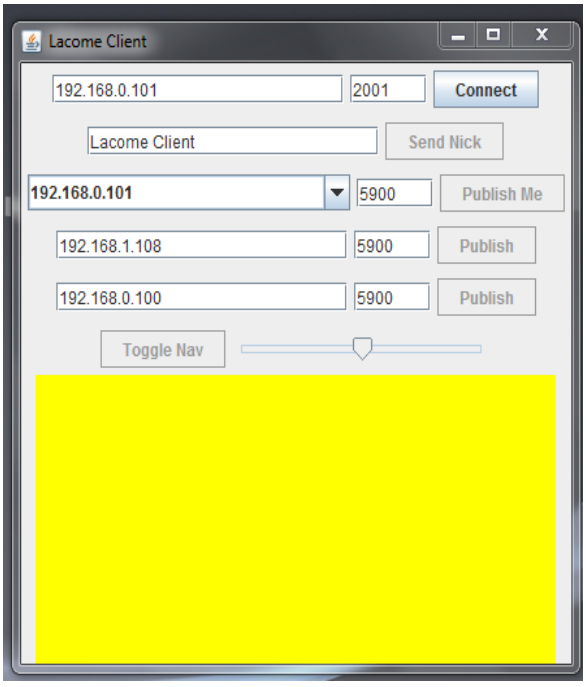


Figure 12 LACOME Client with multiple network interfaces

In the previous LACOME Client (v 2.0), there were two more VNC fields after the "publish me" field, as shown in Figure 13 (compare with Figure 14). The purpose for having these extra VNC panels is to publish someone else's display, but in practice users are not likely to use this feature in a meeting scenario because they were sharing their screens on their own. In fact, participants were confused by these two additional fields. Therefore, the NUM_VNC_PANEL value was set to 0 in order to disable the additional VNC panels. If a meeting scenario did require users to publish more than one computer, this feature can be easily enabled just by changing the value of static NUM_VNC_PANEL.



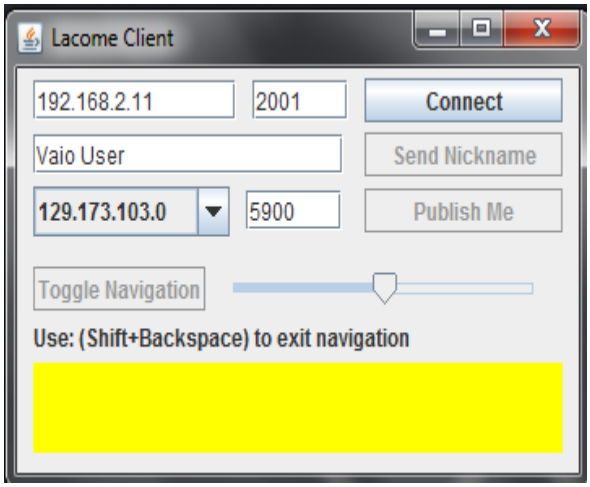


Figure14 The new LACOME client (v 3.0)

Figure 13 The LACOME client (v 2.0)

5.3.3 Adding user name to title bar

Many windows can appear on the large screen, if multiple users publish LACOME; each window contains a published computer desktop for each user. The virtual cursor may be used to manipulate windows through such actions as moving, resizing, and iconifying. A user may take control of a window in order to interact with its content. It was not easy to identify the workspace of other people when more than two users were sharing their desktops on a large

screen. As we mentioned in section 4.2.1, participants were not able to identify the cursors and workspaces of others. Basically, they could not figure out who was accessing which computer and which workspace belonged to whom. We realized that their attention was more focused on the awareness side of the system rather than on the primary goal of considering privacy and security concerns. We therefore decided to implement enhanced awareness features before conducting study with further groups.

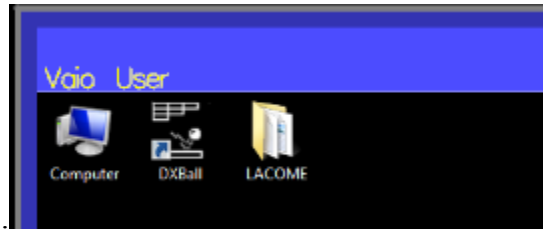


Figure 15 Workspace showing user name in window title pane

When a LACOME Client first connects to a LACOME Server, it is termed an empty client because it is not associated with any VNC publishers. In FrameWindow.render (GL g, Boolean translucent), a section was added that draws a title in the sub-window in yellow. It gets its title from the abstract method getTitleText (), which was added to the new version. We also added an implementation of the abstract method in the derived class VNCDisplay to return either the name from the parent or the empty string. This was possible with a new method, VNCClient.getName (), where, to get the name of the parent of a VNCDisplay, it returns either no nickname or the name of the Lacome Client. As shown in Figure 15, the shared window is shows the user name on the left corner of the screen. This name is chosen by the user and can be sent through the "Send Nickname" field.

If a user double-clicks the left mouse button anywhere on a window that is not currently being controlled or manipulated, the window becomes iconified. First, the window's current size and position are stored. Next, the window is shrunk to a small size and placed in the bottom-left corner of the display. The window continues to receive frame buffer updates while it is iconified [26]. If multiple windows are iconified, they are placed in a line along the bottom edge of the display (see figure 16). Iconified windows cannot be moved or resized, and we found that text overlaps if a user name is more than 12 characters long while iconified.

Figure 16 Screen showing only first 10 characters when window is iconified

To make the icon text stop spill over the edge of the icon area, we limited the text to 10 characters. Since the font is fixed-width, there will not be a narrower or wider text string. The changes went in the rendering for Frame Window, just above where the title text was rendered. If the state is an icon and the text is too long, it simply gets truncated after 10 characters, as shown in Figure 16.

5.3.4 Adding a label to the mouse cursor

In our focus group user study, participants suggested the need for awareness features. Each LACOME user has one cursor to interact with and control the shared workspaces. Thus, multiple mouse cursors appear on the large screen at any given time. Although cursors are colour-coded for each user in the original LACOME system (v 2.0), the owner of the cursor is not clear. This can be resolved by having a list of all users and associated cursors on one side of the large screen. This technique may work well with a few users. However, if there is a large number of users, there will be a long list, which makes is harder for users to see who is controlling or moving their shared window.

During focus group discussions one suggestion was to put the information on the cursor. Wallshare [41] is a collaborative system for portable devices based on client/server architecture that allows collaboration for face-to-face meetings and work groups. When the user gets connected to WallShare, a pointer representing the user is drawn on to the screen. In Figure 17, three pointers are shown on a Wallshare shared zone with different users' names on them.

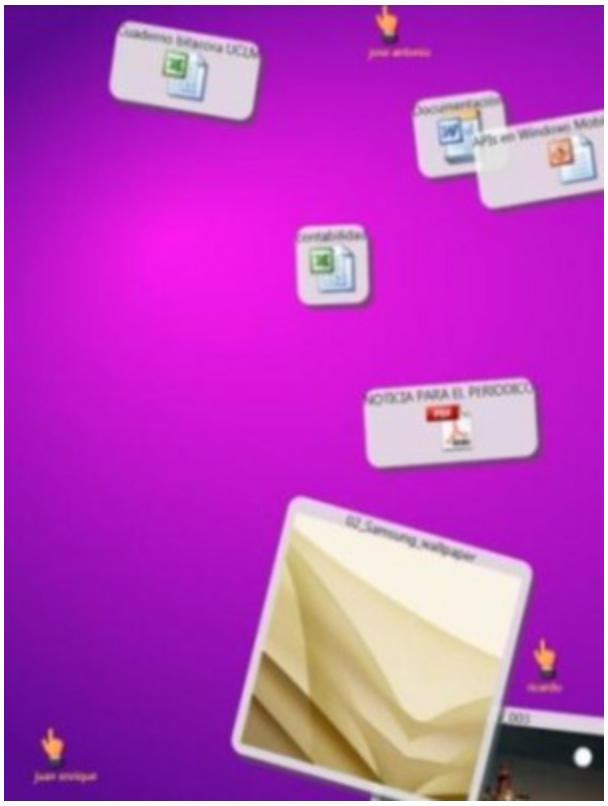


Figure 17 WallShare shared zone [41]

We used a similar concept to label the cursors in order to differentiate multiple cursors as shown in figure 18. As LACOME Client was already sending the nick-names to the server, we made use of it and labelled the cursors with nick-names.

Figure 18 Screen showing LACOME cursor labelled with user name

Since users are free to send a nick-name of any length, we chose that only the first five characters would appear on a cursor as a label. Screen shots of LACOME mouse cursors are shown in Figure 18 with labels on them. Once a user connects to the LACOME system, he/she can send his or her user name through the “Send Nickname” field in LACOME Client. The first

10 characters of the user name will be sent as a window title and the first five characters of the user name will appear as a label on cursor.

5.3.5 Exit Navigation

When users click the "Toggle Navigation" button in LACOME Client, their mouse becomes trapped in the yellow navigation region. A cursor associated with them appears on the shared display, and mouse and keyboard input is redirected to the shared screen. In the original LACOME system (v 1.0), a special keyboard sequence was used as an escape command to end navigation and return control to the user's own display. The sequence Shift+Backspace was chosen because it is not in common use in other software applications [26]. This shortcut is, however, difficult to remember, and not easily discoverable by new users.

Despite being provided with an instruction sheet showing short cut keys to use in the LACOME system, users were confused as to how to get control back on their machine. We added this shortcut key on the LACOME Client user interface to exit Navigation, so that user do not need to remember the shortcut.

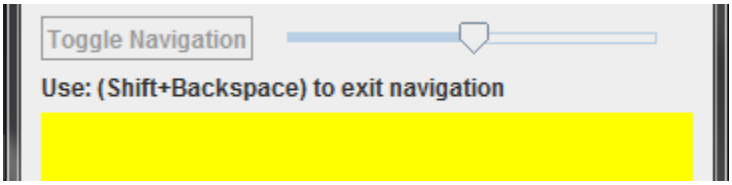


Figure 19 Screen showing client interface with enhanced awareness

5.4 Access Control

As mentioned throughout this report, users can interact in two modes: navigator and controller mode. As discussed in Chapter 3, participants are more concerned about privacy and security in relation to someone gaining access to use their personal computer. In controller mode, access to someone's computer can be obtained without permission. Thus, the access control mechanism was developed for the controller mode, as participants said the potential risk in navigator mode was low. This is because one can only resize the screen, iconify or de-iconify it in that mode. More information regarding design requirements of access control and participants concerns during focus group discussion can be found in Chapter 4.

Our focus was to provide users with controls to assign permission to access their computer. This can be done at the beginning of the meeting or at runtime. We felt that it is extremely important

to include both mechanisms. The first mechanism is important because users can assign permission at the beginning of a meeting, which will reduce overhead during the meeting; if they are not sure in the start of the meeting, they can assign an odd in-between the meeting. While the second mechanism is important (in case users do not know at the beginning of the meeting who would need to get control their machine), this reflects a need for runtime permission so that a user would be able to send an access request to obtain permission. Messages used in access control conversations include three parts: user name, IP address and port number. The user name is sent by each user to the LACOME Server and is mainly used to identify users during a meeting. The IP address and port numbers are used mainly to provide enhanced information.

5.4.1 Assigning permission at the start of a meeting

We next provide a scenario to illustrate the assigning of permissions at the start of the meeting. In this scenario, two users – Main Computer and Vaio User – are connected with the LACOME system. When a third user – Gvlab – connects through LACOME Client, a message appears which allows the new user (Gvlab) to grant access at the beginning of the session for the other users (Main Computer and Vaio User) to interact with his display. The user can chose "Grant Access" to allow the other users to access the system or "Deny for Now" to select it later.

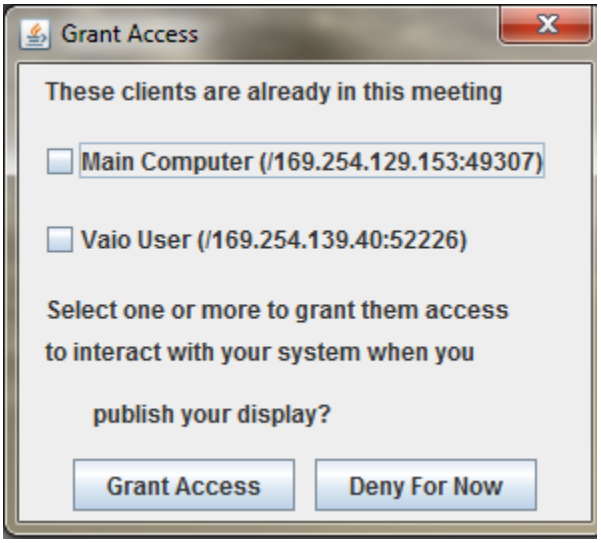


Figure 20 Screen prompting to allow access at the beginning of the session

5.4.2 Assigning permission at run time

Permission can also be assigned at runtime. If a user wants to access another user's computer, a request will be sent to ask for permission. If the requested user allows "grant access", then the requester can take control of the requested computer. Otherwise, a message will come back to the requester stating that the requested user did not allow access the system.

In this scenario, Gvlab requests access from Vaio User by clicking Vaio's desktop. Two different messages will appear on the requested (Vaio User) and requestor (Gvlab) users' systems. In Figure 21, a message appears on the requester's screen with the requested user name, IP address and port number.

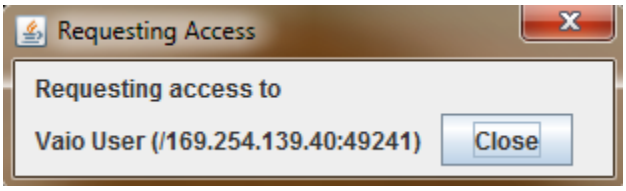


Figure 21 Requesting access from a user

At the same time, as shown in Figure 22, Vaio User gets a message stating that Gvlab wants to access his/her system and is provided with the options to grant access or deny the request. If Vaio User presses "Grant Access", then Gvlab will be able to gain access. Otherwise, as shown in Figure 23, a message will goes back to Gvlab stating that Vaio User did not allow access to the system and will halt the communication. If a user wants to access it again, a new communication will start from the beginning.

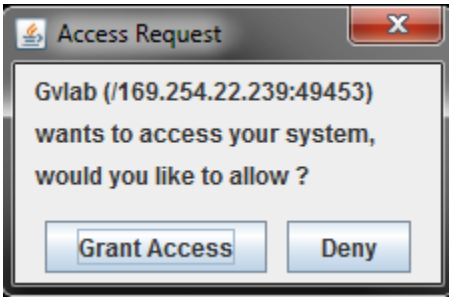


Figure 22 Requested for access by other user

If a user grants access to another user, the LACOME Server will save it for that particular session, which means that even if the user disconnects while the other user is still connected, the next time the user connects during that same session, he/she will not need to ask for permission again.

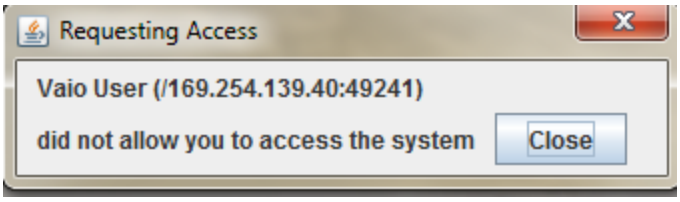


Figure 23 Notification to requester if access is denied

5.5 SUMMARY

In this chapter, we discussed newly implemented features in detail. We summarized this in table 6, it shows that the design requirements that we identified in chapter 4; how these design requirement are implemented. It has a column stating at what stage of our research these are improved or implemented.

Table 6 Table showing design requirements

S. No.	Design Requirements	Category	Implemented?	How	When
1	SSL issue	Security/Usability	✓	Automatic turn on and off of SSL	Before running focus groups user study
2	Lag in redrawing textures	Usability	✓	Turn off TCP delay	Before running focus groups user study
3	Exit navigation	Awareness	✓	Provided information at client's interface	After running first focus group
4	Enhance awareness of person controlling cursor	Awareness	✓	Labelled cursor with user name	After running first four focus groups
5	Enhance awareness of the owner of the screen	Awareness	✓	Added user name on title pane of window	After running first four focus groups
6	Key names and their functionalities	Usability	✓	Used tooltips	After finishing focus groups study
7	Access control	Privacy and security	✓	Ask for permission before allowing access to system	After finishing focus groups study
8.	User idle	Usability	×	n/a	n/a
9	Communication channel	Usability	×	n/a	n/a
10	Post-session awareness	Awareness	×	n/a	n/a

CHAPTER 6 FIELD EVALUATION OF THE LACOME SYSTEM

Field studies are a good way to evaluate collaborative technology are done best through field studies because they can be used to assess social psychological and anthropological effects of the technology [15]. We conducted a field study to evaluate the overall LACOME system and including the changes that we made. In this chapter, we present the qualitative and quantitative results of our study, which includes participants' privacy and security concerns, overall impressions of the LACOME system, the overall usability of the system and the practicality of our design solutions.

6.1 Research Objective

As described in chapter 4, we conducted a preliminary study to gather design requirements and gain initial feedback of LACOME. Based on this feedback, we implemented enhanced awareness features and access controls for the system. To enhance awareness, each shared window and cursor displays the name of the associated user, which makes it easier to identify who is interacting with which window on the large screen. To restrict access, our new control mechanism allows users to assign permission before giving access to others. Our research goal for this field study was to evaluate the LACOME system in terms of effectiveness, workspace awareness, usability, and user satisfaction and to observe the usability of these newly implemented features during collaboration. This study is intended as a formative evaluation to find out how security and privacy issues will affect the users, what they will do in this situation, and whether people's sharing behaviours differ with the type of meetings (e.g., student projects vs. professional).

6.2 Study Design

We wanted to study meeting groups with a variety of characteristics (students vs. professionals, smaller groups vs. larger groups) and observe the groups during their natural meetings, both with and without using LACOME. The entire formative evaluation study was divided into four phases: the initial meeting session, the software installation phase, meeting sessions and the semi-structured interview.

6.2.1 Initial meeting session

We conducted an initial session with all groups at different times. At these sessions, we briefly explained the study process, after which the participants signed the consent form to take part in the study. In the sessions, we did not introduce any new technology. The purpose for doing this was to observe participants in their normal meeting environment and understand their meeting behaviour and characteristics. We observed them and made note of their use of technology and information sharing practices observed during the meeting. At the end of this session, we asked group members to fill out a demographic questionnaire.

6.2.2 Software installation phase

We asked each group to come for a half-hour session prior to their next scheduled meeting. There, we provided an introduction to the LACOME system and also provided instructions on how to use the LACOME system. Each group member needed to install the necessary software (Java, LACOME Client and VNC server) on any of their computers which would use LACOME in a meeting.

6.2.3 Meeting sessions

This phase included at least two group meetings by each of the groups using the LACOME system during their scheduled meetings. We collected at least three hours of data during the meetings. After each meeting, group members were asked to fill out a post-meeting questionnaire. With this questionnaire, we were able to understand particular meeting characteristics, individual and group characteristics and what kind of impact LACOME made on their meetings. The meeting sessions were also audio-recorded to support the accurate reporting of responses without disrupting the flow of the discussion.

6.2.4 Semi-structured interviews

At the end of the study, we conducted a semi-structured interview with individual group members to obtain their feedback about the LACOME system in terms of privacy and security concerns as well as their overall impression about the LACOME system, practical design solution suggestions, overall usability of the system, its effectiveness, etc. (see Appendix F).

6.3 Considerations in a Real World Meeting Setting

Participants were observed in their real-world meeting environment or at the GV lab (HCI lab) in the Mona Campbell Building at Dalhousie University. In consideration of possible privacy concerns (depending on meeting type), we provided a quiet room for the meetings and only researchers and observers were present in the room. Because the use of LACOME is only one mode of communicating in a collaborative meeting environment (e.g., speech, paper document sharing, whiteboard, etc.), participants were free to use the communication mechanism(s) of their choice. We asked participants to incorporate LACOME as an additional tool and to use it when it best fit their needs. We also told participants that if, at any time, the system was not serving their purposes, they were free to revert to their existing practices.

6.4 Recruitment Procedures and Inclusion/Exclusion of Participants

We targeted Dalhousie University students and employees of a leading electronic retail store to take part in our study. We wanted to recruit a broad cross-section of the general community including both expert and non-expert users. We recruited four groups, a total of 17 participants from different technical backgrounds, and each group included a minimum of three participants. We believe that the size of the groups was sufficient to evaluate all of the necessary aspects of the system.

We asked participant groups to express their interests in participating in the study. We recruited groups who were currently working on a project together. After considering all responses, we selected the groups that we felt could best evaluate our system and who provided breadth in participant and meeting characteristics. We recruited only those groups that made use of a large screen during their regular meetings. Meetings had to be at least half an hour in duration and at least one person was required to share digital information. We wanted meeting settings where multiple people were required to interact with the information.

6.5 Results

We evaluated the LACOME system with four different groups. Because each group is different from another in characteristics, we present our results in the form of case studies.

6.5.1 Case study 1: Student technical group (Large)

6.5.1.1 Group description

Participants were recruited from the computer science community. Five people, aged 25-34, took part in the study (4 males and 1 female; see Table 7 for demographic information about the group).

The minimum education level was a Bachelor degree. Specifically, four participants had completed a Bachelor degree and one had a Master degree. All members of the group were considered technical experts. Our measures of technical expertise were on 1-5 rating scale, with 1 being most technical and 5 being least. The last question that we asked in the demographic questionnaire was whether or not the participant would prefer to have a password on his/her computer. All group members chose to have a password on their personal computers (see Appendix F).

Table 7 Characteristics of the case study 1

Participant_ID	**Age Range**	**Gender**	**Education**	**Tech. Expertise 1= most tech. 5= least tech.**	**Personal computer password protected?**
11	25-34	M	Bachelor	2	Y
12	25-34	M	Bachelor	2	Y
13	25-34	M	Bachelor	2	Y
14	25-34	F	Master	2	Y
15	25-34	M	Bachelor	1	Y

6.5.1.2 Meeting description

This group included graduate students from the computer science community who were taking a graduate course at Dalhousie University. The one course requirement was that they had to submit a project with a report and final presentation. There were deadlines for each deliverable and they conducted meetings during all of the phases of the course project. We observed the group in their three meetings. The group booked a graduate study room in Dalhousie University library for all their meetings. This graduate study room was a large room equipped with a projector, a table, two whiteboards and five or six chairs. A brief description of the meetings is as follow:

First meeting (without the LACOME System)

The group already had a few meetings before they participated in our study. In the first meeting, we observed they used a projector to share information with group members, switching the projector back and forth between people in the group. Their discussions surrounded issues such as research papers and topics they wanted to include in their final report.

The group did not share paper documents during the meeting. They did not use a whiteboard for discussion, in fact there was no whiteboard equipped in the room. Except P15 remaining four group members bring their laptop in the meeting. We did not focus on observing meeting content; however we logged participants' activity and action during each meeting. P1 connected his computer to large display by using a projector and opened a research paper. The group discussed the paper for 20 minutes and planned how to implement similar technique in their project.

P3 Connected to large display to show the part of the report and some papers downloaded by him at the same time P4 shared file on google docs with other group member. P3 Stood up and went close to the large display to indicate something. P1 sent report to P5 by email.

Second meeting (with the LACOME System)

The second meeting was the first time that the LACOME system was used. We had installed the necessary software (LACOME Client, VNC server) on participants' computers prior to this session. The agenda of the meeting was to combine the reports prepared by group members and finalize the course project report. P1 connected to LACOME and shared his desktop with project report opened. P2 connected to LACOME but could not publish display due to firewall settings on his computer. P4 connected to the LACOME system but did not publish her screen; she used navigation cursor to manipulate window screens published by P1. P5 connected to LACOME and interacted with display of P1 just to see how manipulation tasks work. P3 published his display; In first 30 minutes of the meeting two participants (P1, P3) published their displays. P2 and P4 navigated on large screen to manipulate the display of P1. P4 and P5 left the meeting early due to some personal work; rest of the participants combined their project report, prepared the first draft of report and shared

Third meeting (with the LACOME System)

This was the second meeting using the LACOME system. It lasted about two hours. The agenda of the meeting was to prepare the presentation and practice. During the first hour, the participants

actively used the LACOME system; during the second hour, they practiced their presentation. P1 and P3 shared their display on the large display, P2 and P5 did not use their laptops in the meeting. P3 connected and published his display at one point he accidently disconnected from the LACOME but his desktop was still published on the LACOME Server display. During the meeting P3 used paper to draw project framework. P1 used controller mode to add few slides in the presentation. P3 unpublished his display from the large screen and took control of P1 to edit in slides. P1 shared the final presentations with other group members via google docs and then for the next hour P2 and P5 practiced to deliver the presentation.

6.5.2 Case study 2: Student technical group (Small)

6.5.2.1 Group description

Our second case study group were also students, but it was a smaller group. Three participants (all male) were recruited from the computer science community at Dalhousie University. Two participants were in the age group 25 to 34, and one participant was in the 18 to 24 age group. See Table 8 for demographic information about this group.

All group members held Bachelor degrees and were graduate students in computer science. The rated their technical expertise as 2 on the scale of 1 to 5, where 1 was the most technical and 5 was the least. All group members had passwords on their personal computer. This group was the smallest of all groups.

Table 8 Characteristics of the case study 2

Participant_ID	**Age Range**	**Gender**	**Education**	**Tech. Expertise 1= most tech. 5= least tech.**	**Personal computer password protected?**
21	18-24	M	Bachelor	2	Y
22	25-34	M	Bachelor	2	Y
23	25-34	M	Bachelor	2	Y

6.5.2.2 Meeting description

This group was formed for the purpose of completing group work for a graduate course at Dalhousie University. The course requirement was to submit a project proposal and then do the project. This course project included a report and a final presentation. We observed the group in

their three meetings. The first meeting took place in one of the meeting rooms at the Mona Campbell building at Dalhousie University, while the other two meetings were conducted in the GV lab. A brief description of the meetings follows.

First meeting (without the LACOME System)

The first meeting without LACOME took place in one of the meeting rooms equipped with a large table, a few comfortable chairs and two whiteboards. We provided a projector with 800*600 resolutions, which projected onto one of the whiteboards. The agenda of the meeting was to prepare a project proposal for the course project. Only one person (P21) shared his laptop with the projector. He opened some research papers, one after the other, on the computer and then discussed using the whiteboard. P22 used whiteboard for 20 minutes while P1 has document opened on his laptop, both P21 and P23 giving suggestion to make final project proposal. Once the meeting was finished, we installed the necessary software (LACOME Client, VNC server) on the participants' computers and explained how to use the system during their next meetings.

Second meeting (with the LACOME System)

In the first meeting using LACOME system, the agenda of the meeting was to make some corrections to the proposal (as suggested by the professor) and to work on the project report (mainly, to decide headings and subheadings), after which the work was divided among group members. This was a short meeting that lasted little over half an hour. P21 and P23 connected to LACOME system and both shared their display on the large screen. P21 opened project proposal (word file) on his computer while P23 opened a research, both shared the large display screen and opened their display side by side. P22 published his desktop to show a video file which is related to the project.

Third meeting (with the LACOME System)

This was the second meeting using the LACOME system. It took place in the GV lab. The agenda of the meeting was to edit the final report and discussed the presentation slides which were created by one participant (P22). P22 first connected to the LACOME system and shared his display on the large screen with PowerPoint slides opened. P21 then connected to the LACOME system but did not publish his display. P22 was drawing the presentation outline on a whiteboard and all the groups discussed points that need to be included in the deliverable presentation. P21 used navigation cursor few times to indicate some text in the presentation. Overall this was a small group not more than two people published their display on the large

screen. The group used the LACOME system as an alternative to connect to the large screen. They were not able to explore all the features of the system in their meeting scenario.

6.5.3 Case study 3: Student non-technical group

6.5.3.1 Group description

Four graduate students (all male), who were taking a course at Dalhousie University, participated in our study. The participants were from different departments (Dentistry, Civil Engineering, etc.) and were not known to each other before this study. This group is considered a non-technical group, as three out of four participants rated their technical expertise as level 4 on a scale of 1-5, where 1 is the most technical and 5 is the least. However, one participant in this group rated himself at level 2. Two group members had passwords for their user accounts on their personal computers and the other two did not have passwords.

Table 9 Characteristics of the case study 3

Participant_ID	**Age Range**	**Gender**	**Education**	**Tech. Expertise 1= most tech. 5= least tech.**	**Personal computer password protected?**
31	18-24	M	Bachelor	2	Y
32	25-34	M	Bachelor	4	N
33	25-34	M	Bachelor	4	N
34	25-34	M	Bachelor	4	Y

6.5.3.2 Meeting description

These students formed a group as part of their coursework which was the same course as group 1 participants. The course requirement was that they had to submit a project with a report and final presentation. We observed the group in their three meetings. All three meetings took place at the GV lab, where we had installed the LACOME system and had two side-by-side large screens to connect to a large display. A brief description of the meetings is as follows:

First meeting (without the LACOME System)

One person (P32) connected his laptop to the large screen and discussed the project guidelines. Most of the information was shared by paper documents among the group. The agenda of the

meeting was to prepare the course project report. The rough draft of the report was prepared on paper by all group members and then transferred to Microsoft word by one participant (P31). The use of technology was minimal in this meeting. The group member brought paper documents and discussed the project proposal.

Second meeting (with LACOME System)

This was the first meeting using the LACOME system. The agenda of the meeting was to edit the project report and discuss outlines for the presentation. One participant (P33) came late in the meeting and did not connect his laptop to the LACOME system. P31 has rough draft of report in his computer and shared it on the large screen connecting via the LACOME system. P32 and P34 were suggesting corrections and P31 was editing the report in Microsoft word document. The group member did not use the control feature of the system in which one person can interact with the content of others.

Third meeting (with LACOME System)

This was the second meeting using the LACOME system. It took place in the GV lab. The agenda of the meeting was to prepare the slides and practice giving the presentation. P33 first shared his display on LACOME screen, and then P31 connected to LACOME but did not share his display on the large screen. P31 was doing manipulation tasks such as moving window, resizing screen. Once the presentation was made, P33 shared with other group members by email. P32 and P34 did not connect to the system in this meeting. The group members did not interact with the content of each other during any of the meetings.

6.5.4 Case study 4: Technical business corporate group

6.5.4.1 Group description

Five participants (3 male, 2 female) were recruited from an electronic retail store. The group included participants from a management team and department supervisors. As shown in Table 10, this group had a very diverse educational background but were still highly educated. The group included highly technical participants, as 4 out of 5 rated their technical expertise a level 1 (always help others to solve technical problems).

Table 10 Characteristics of the case study 4

Participant_ID	Age Range	Gender	Education	Tech. Expertise 1= most tech. 5= least tech.	Personal computer password protected?
41	18-24	M	College	1	Y
42	25-34	F	Master	3	Y
43	18-24	M	College	1	Y
44	25-34	F	Master	1	Y
45	25-34	M	Bachelor	1	Y

6.5.4.2 Meeting description

The retail store has two management meetings every week where they discuss their business plan, financial growth for the company, training schedule, weekly store budget, inventory report, store performance, etc. We were allowed to observe three group meetings. However, we did not get permission to audio record the meetings due to confidentiality reasons. For the meetings, the group had a special meeting room with a large table and chairs and a 46" TV for presentations. The meetings characteristics were quite different from the other groups, as most of the information was shared through paper documents. A brief description of the meetings follows.

First meeting (without the LACOME System)

There were three presenters in the meetings (p41, 42, 45) who needed to deliver a presentation. Two of them had their personal laptops, while one did not have a laptop. They copied PowerPoint slides to a laptop connected to the large-screen TV. Three participants (P41, P42, and P45) delivered the presentations and discussed about the next meeting. This was not a formal presentation; in fact this was a discussion and sharing numbers (quantitative data) with the group members. The group members have paper documents to discuss after the meeting.

Second meeting (with the LACOME System)

This was the first meeting using the LACOME system. The purpose of this meeting was to discuss the business plan of the month. P41 and P45 had their personal laptops while P42 was

using a workstation. The LACOME system was installed on a laptop and connected to the TV. P41 and P45 shared their displays on the TV by using LACOME system. The TV screen was not big enough so only one user displayed his screen at a time. There was not a need to interact with the content of other people during the meeting but they used this feature to see how it works. We noticed that when a participant tried to interact with the content of other, the mouse cursor becomes small in size compare to the navigation mode which made hard to see the cursor on large screen, especially when a document was with a white background. Participants also found hard to get into controller mode by using the laptop touchpad mouse buttons (need to press both left and right touchpad buttons at the same time).

Third meeting (with the LACOME System)

This was the second meeting using the LACOME system. It was the weekly meeting called for general purposes. The meeting members used the LACOME system for a longer period of time (over an hour). P41 and P45 again shared their screen, but only to display the computer desktop. Both participants (P41, P45) did not edit or prepare any document during the meeting. So they interacted with the system only for navigation and displaying screens. The LACOME system was just used to display the screens as some features of the system were not used as required. The group used all the features of the system but for non-meeting purpose to see how the system works. The common issue we observed among the evaluation groups that they did not use the system for a longer period of time. The system like LACOME needs 2-3 meetings to understand the features and context of use.

6.5.5 Participant feedback through post-meeting questionnaire

Participants were asked to fill out a questionnaire after each meeting. There were two types of questions: rating-based questions and direct questions. In rating-based questions, participants were asked to rate ease of accessing information and ease of interaction with other group members' materials. The other questions were related to the technology used in the meetings and how the information was shared among group members during the meetings (see Appendix F).

6.5.5.1 Information sharing methods used during meetings

In the post-meeting questionnaire, participants were asked about the information sharing resources that were used during each meeting (see Appendix F, Q7). Figure 24 shows how members of each group shared information during meetings.

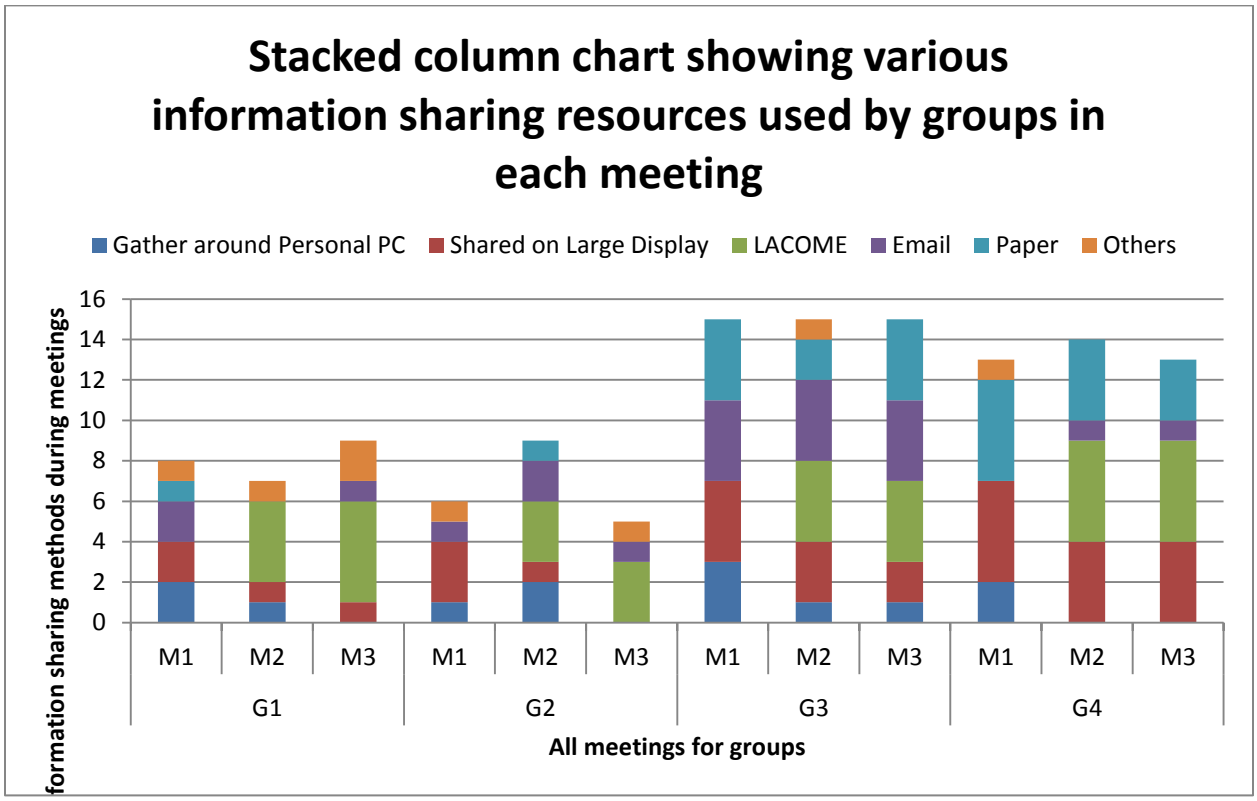


Figure 24 Chart showing various information-sharing resources used by groups

6.5.5.2 Interaction with other group members' materials

In the individual post-meeting questionnaires we asked participants to rate, "How easy was to interact with other group members' material". The participants rated their interaction experience with other group members' material on the scale of 1 to 7, where 1 was the very easy and 7 was the difficult. As we discussed previously there were four groups and we observed three meetings of each group. Table 11 shows means and medians of ease of interaction with other group members' materials for each group in three meetings.

Table 11 Interaction with other group members' materials

Groups	M1(Meeting without LACOME)		M2(First meeting with LACOME)		M3(Second meeting with LACOME)	
	Mean	Median	Mean	Median	Mean	Median
G1	2.8	4	2.6	2	3.2	2
G2	4.6	4	2.3	5	3.6	2
G3	2.5	2	2	3.5	2.5	2
G4	3.4	4	2.8	4	3.2	2

We used the related-samples Wilcoxon signed rank test to find whether there was an overall statistically significant difference in ease of interaction between two meetings. We found that there was not a significant difference for interaction with group members' material as the median of difference between two meetings is zero (Meeting without LACOME vs. First meeting with LACOME P=.163, Meeting without LACOME vs. Second meeting with LACOME P= .338). P value (>.05) indicates that there was not a significant impact of the LACOME system on the interaction of group members' materials. However, participants expressed in interview that the LACOME system provides easy way of interaction during meetings. The detail of participants' feedback is discussed in section 6.6.

6.5.5.3 Accessing information during meetings

We asked participants in the post-meeting questionnaires to rate, "How easy was to access information during the meeting". The participants rated this question on the scale of 1 to 7, where 1 was the very easy and 7 was the difficult. Table 12 shows means and medians of ease of information accessing during the meetings for each group in three meetings. As expected participants found easy to access information during the second meetings with LACOME compare to the first meeting with the LACOME system.

Table 12 Accessing information during meetings

Groups	M1(Meeting without LACOME)		M2(First meeting with LACOME)		M3(Second meeting with LACOME)	
	Mean	Median	Mean	Median	Mean	Median
G1	2.4	2	3.2	3	2.8	2
G2	4.3	5	3.6	4	2	2
G3	3.25	3.5	2.5	2.5	2	2
G4	3.2	4	3.2	3	2.4	2

We used the related-samples Wilcoxon signed rank test to find whether there was an overall statistically significant difference accessing information during a meeting with the use of LACOME system. For this purpose, we compared meeting with and without LACOME. We found that there was not a significant difference in order to access information during a meeting with LACOME and a meeting without LACOME. The median of difference between two meetings is zero (Meeting without LACOME vs. First meeting with LACOME P=.289, Meeting without LACOME vs. Second meeting with LACOME P= .072). P value (>.05) indicates that there was not a significant impact on information accessing with the LACOME system.
Thus statistics test reveals that there was not a significant difference of LACOME on interactions with shared content and accessing information during a meeting. Participants' feedback in semi - structured interview is presented in next section.

6.6 Discussion

We conducted a post-study semi-structured interview with each group member after the completion of the study. The participants were asked questions: did they encounter privacy and security concerns while using the system, did they have any suggestions for practical design solutions to address those concerns, what was their opinion about the overall usability of the system, and would they consider including LACOME in their future meetings. These four major questions and participants' response will be discussed in subsequent sections from 6.6.1 to 6.6.4.

6.6.1 Privacy and security concerns in collaborative meeting environments

The first question that we asked in interview was "What privacy and security concerns did you encounter when you were using LACOME system in collocated/remote meetings". The participants' responses are quoted here in sub-sections. Six participants said that they had privacy and security concerns when using the system in a meeting environments while other eleven said they did not have any privacy concerns with the existing meeting scenarios and the system.

6.6.1.1 Privacy concerns

Six participants raised privacy concerns while using the LACOME system in their meetings. Interestingly, all four participants were from the third group (Non-Technical) and all had similar

concerns. As P31 said, “There is a flaw we can see, as we totally deny or allow the access, there is not something for partial sharing.” P32 stated, “Having access to certain files rather the full system would be a good idea. In the current situation, there is a threat of use of personal information by others.” P33 and P34 expressed similar concerns regarding when a user allows others to access the system, and how there is no way to stop this from happening unless you unpublish or exit from the system. As P33 said, “The main concern is that once you allow people access, they can open anything. There should be a way to limit the sharing.” This was the only group where all participants raised privacy concerns. In the other groups, only a few people expressed privacy concerns, not the whole group. As P14 stated, “Yes, there is fully direct access to the users. I didn’t like it because personally I don’t like that concept. I am concerned about privacy of my documents and system, content of my data. You can provide fully access or deny that but I want there should be provision that we can provide just the limited access to the users and provide little permission to others.” One participant from the business professional group had a concern related to network security. P44 said, “If it is used over the network, anyone can connect to the system, not only someone present in the meeting but from outside as well and can interrupt meeting.”

6.6.1.2 No privacy concerns due to the nature of meeting and group

There were eleven people who were satisfied with the existing access control mechanism and interface and had no privacy concerns when asked this question. P23 stated, “There should not be any privacy concerns because normally such meetings happen in close groups where you have a specific topic to be discussed and all members have equal rights to share and access information. Besides that, there could be an issue of your team members or colleagues accessing your system and then deleting or accessing some confidential information, but those things normally won’t happen because of increased level of trust and group coordination.” P22 said, “I didn’t find any privacy issues except the normal concerns. I don’t believe someone is going to open my personal stuff in my presence or open other files or folder when they don’t need to.” P12 explained, “I am a computer science student so I am not worried about the security thing; I think other people may be worried about their documents. I didn’t publish anything during the meetings so I am not worried. I am not worried even if I did publish something because I saved my confidential private data on an external hard drive, which is in my apartment.” P13 stated, “Normally when we are in a group, it is common project. When we deal in common project, you

have the information that you want to share with group members. I don't think there is an information security issue. Moreover, things are visible in front of you".

Two participants (P14, P45) had no privacy concerns because of trust relationship among the group members. As P14 added, "The only concern is that someone may delete your personal data or use it. But my understanding is that trust is built up in the group and we don't expect this from group members. You are in team because you have trust in people." Some participants said they don't have any concerns with the existing meeting scenarios but it may shift their concerns if meeting scenario or partner would change. As P45 said, "If you are using the LACOME system in an inter-company meeting that is closed off, like here, then it would not be so much of an issue. But if you are making a presentation with untrusted clients, then it's definitely a concern."

There were two participants (P41, P43) who told us that they might have privacy concerns if they would have used this system before the implementation of access control in it. But with the addition of access control permissions has removed these concerns .As P43 shared the following: "Initially, I thought free access to all the files is a scary thought. But having controlled access on the receiving end, I think this will remove all the privacy concerns for me." P41 agreed, saying, "The only privacy concern was being able to access the files, but as you have to allow the person to connect to your computer, it pushes that concern away."

6.6.2 Overall usability of the system

We asked participants' opinion on the overall usability of the system in the interview. We did not specifically ask for any particular features of the system. We break the participants' responses to following subsection.

6.6.2.1 Awareness

We did not explicitly ask any questions regarding the awareness features we implemented in the system, and participants were not told that which new features appeared in this new version of the LACOME system. One participant (P21) found the new implemented awareness features quite useful, saying, "One thing that I did like is when someone puts a cursor on your screen and it tells you who is controlling which screen. You can track what is going on."

6.6.2.2 Learnability

Nine participants commented on the design of the system, information that needs to remember in order to use it and other features of system. Five people (P41, P43, P12, P32 and P45) found the

LACOME system very easy to set up and use. P41 said, “It was very easy to set up, I didn’t find any issue.” P43 stated, “It looks incredibly user-friendly as soon as you are shown it once, you catch on really quick and have no problem learning it.” P12 said, “I believe the current key combinations and other information is small enough to remember.” P45 added, “It was very easy and very user-friendly, from what I found. I didn’t have any real trouble using it once I got the learning curve down.” P32 said, “The system is usable and very easy to adapt by beginners. I used it without having any prior knowledge about the system.”

Two participants (P33 and P11) found it difficult to learn. P33 said, “I don’t know how to define usability, but I think you need to remember a lot of information such as the IP address, and then different modes and keys, and this seems too much for me.” Similar concerns were raised by P11, who said, “I did not found any issues as a computer science student remembering (IP addresses, port number, VNC passwords) and other key controls, but for other people who are not computer scientists, it might be difficult. Instead of using all these… if they could use something like team viewer software where there is only an ID and password, that would be great.”

6.6.2.3 Mode identification

As previously discussed in chapter 2, LACOME may be used in two modes: Navigator and Controller. When a user clicks their middle mouse button on a window, the Navigator undergoes a mode-switch from “Navigator” to “Controller.” Two participants found it hard to differentiate both the states. As P13 said, “I found it slightly confusing when you go on LACOME interface and then you go back to your machine, there is no clear indication.” P23 stated, “Initially, it was slightly difficult to adjust with the system; some improvements can be made in the user interface. I am not sure exactly what needs to be done but I observed there should be a clear indication when you move back and forth in different modes.”

6.6.2.4 Time-efficient

Five participants (P13, P44, P41, P15, and P31) found that using the LACOME system is time-efficient compared to conventional tools such as projectors and online file sharing systems. As P44 stated: “Overall, I think it’s a great idea to share screens and documents while talking at the same time. It’s definitely a time-saving application during meetings.” P41 said, “It saves time and makes collaboration easier.” P13 stated, “Besides this movement of mouse, overall I found it

quite useful. You can share the data, you can view the screen of each person, and everyone can take instant control. It is time- efficient because everyone can instantly modify a document. In a normal mechanism, if I am preparing a document and another person wants to edit anything, I need to send it to the other person and I won't be able to see what he is doing."

LACOME uses the Large Screen Optimized (LSO) technique which allows window manipulations to take place anywhere in the window. One participant found this unique feature of the LACOME system very useful time efficient when interacting with the workspace of others. As P15 said, "I really like the idea of LSO techniques, which provides a large area to interact on the screen."

6.6.3 Practical design solutions

The practical design solutions offered by participants fell into two main themes: one directly related to their privacy and security concerns, and the second as general suggestions to improve the interface. We discuss each separately in the following subsequent sections.

6.6.3.1 To resolve privacy issues

We asked participants in an individual semi-structured interview what practical design solutions can address privacy and security issues and how the system can be improved to resolve privacy concerns.

6.6.3.1.1 Limited access

We implemented access control mechanism to restrict the fluid access of the system. Most participants were happy with the current mechanism, but five people sought more control for the users and supported the idea of limiting sharing to reduce privacy concerns. P11, P14, P21 and P34 suggested that the system should provide limited access to other users. As well, it should have shared folders where users can put files and documents and only that folder should be accessible to others. P42 added, "Maybe you don't want to share all your folders and file with others. It is good if the system has privacy control to share only the required files or documents." With respect to security P44 said, "There are a couple of things that may be done such as have different user names and passwords to add an extra layer of security. Firewalls in the system can be used to block unauthorized users." One participant suggested considering optional second user account to use LACOME in a meeting environment. As P43 said, "To remove privacy concerns in remote setting, the solution would be having another account set up on the computer

as a limited account that people use in meeting only for business. In that way, people still have free access without worrying about the regular account being accessed."

6.6.3.1.2 No access to system

In LACOME, optionally, users can interact with the content of other users. Two participants (P23, P33) out of 17 questioned the concept of allowing access to others' systems. As P33 said, "I would like to use the LACOME system if it is restricted only to screen-sharing. I might be wrong, but I did not feel the need to access other people's computers in the meeting". P23 stated that, "I liked the system, but I didn't understand the idea of other people accessing your computer. Most of the time, user just needs to publish some documents or files. If anyone wants to edit, then the user should be the one who modifies it."

6.6.3.1.3 Group level access control

The current LACOME system allow user to assign access permissions for one to one user. Two participants suggested (P14, P31) considering group level access control for a larger group. As P14 said, "If 100 people are in a meeting, I should be able to select or deselect a group of people." P31 stated, "Some extra checking should be done before assigning permission. If this system is used by many groups, access control should be done at the group level."

6.6.3.2 General suggestions for improvements

Apart from security and privacy design suggestions, three participants also suggested to include some other features which are not directly related to the privacy concerns.

6.6.3.2.1 Tool tips are not good enough

Two participants expressed the need for more help availability in the system. As P15 commented, "The interface can be improved. There is no help option in the system. It would be good for users if they have any problem." As P22 said, "I liked the system, but may be more help options should be included so users can use it without asking for help."

6.6.3.2.2 Interface improvement

As discussed previously in chapter 2, there are few short cut keys that are required to use the LACOME system. Two participants suggested including the short cut keys on the system screen. P13 said he found it hard to remember the shortcut keys; it should always be available on the

screen. P12 said, “The system is designed to publish display. It would be good if all the commands and keys were made available on one side of the screen.”

6.6.4 Consider using LACOME in future meetings

We asked participants in interview whether they consider using LACOME in their future meetings. Eleven participants were agreed to use it in their future meetings for various reasons such as easy to install, multiple user support and remote collaboration. Six participants said they would consider using it with some improvements in the existing system.

6.6.4.1 Conditional use of the LACOME system

Six participants (P11, P32, P45, and P13) were open to using LACOME system, with some improvements in it. As P45 said, “I like it to ask me permission up front. If I go further with it, I would like to limit what I share and give more control to the user to limit what other people can see or do.” P32 stated, “I would like to use it later if security issues are resolved. The main security issues are access to the whole system, which nobody wants. Only some files should be shared through a shared folder.”

6.6.4.2 Easy to install

Two participants (P43, P12) found it easy to install and use. As P43 said, “I would say yes because it is so simple and easy to set up. anybody can jump on the system in a second. I don’t think there would be any concern. I haven’t seen another program that is quite like this.”

6.6.4.3 Can be used without internet

LACOME can be used via a network connection, not necessarily internet. Two participants (P23, P21) said they would like to consider using it because it can be used without an internet connection. P23 stated, “We haven’t used this kind of system before. Normally we use dropbox or google drive to share files or by email. It’s quite useful even in a place where you don’t have an internet connection. You can set a local area network.”

6.6.4.4 Multiple users

Six participants consider using LACOME in their future meetings due to multiuser support of the system. P41 commented, “Yes, I would consider using this because you can have multiple users input on one screen instead of individuals having to switch all the time.” P15 agreed, “Yes, I would use it because multiple people can share their screens and collaborate with it.” P22 said,

"This is definitely a great system. Providing an opportunity to share screens for multiple people is really a great idea." P43 said, "First, I wasn't quite sure. It kind of looks widely available. But after looking at all its features, I do think overall this is a great system. If you are in a business meeting or marketing groups, it is an easy way to share information from all angles." Two participants (P14, P42) preferred to use LACOME because of visual feedback and support for multiple presentations. P14 said, "It is a very useful tool for meetings. You can have many people's ideas and input at one point so that it is not an audio thing. You can get visual feedback from the whole group on one giant screen. The fact is that everyone can interact with an individual screen." P42 said, "I think it is a good system. You can share your screen with other people in the meeting. It helps multiple presenters, like in our meeting, without switching back and forth."

6.6.4.5 Remote collaboration

One participant (P31) considers using LACOME because it provides support for remote collaboration. As he said, "I would like to use it because multiple people can collaborate and it supports remote collaboration. It is very helpful in a corporate environment where a company has their branches at multiple locations."

6.7 Limitations of field experiment

In field evaluation experiment, we collected data through individual post meeting questionnaire and individual semi- structure interview. One of the limitations of questionnaire data is that it relies on participants' ability to accurately report their data. In rating-based questions, participants were asked to rate ease of accessing information and ease of interaction with other group members' materials at the scale of 1 to 7. We noticed that four participants did not share their desktop by using the LACOME system. Their ratings were lower (1-3) in all three meetings because they did not experience the LACOME system.

Three groups out of four are student groups; the groups have some diversity in size and technical expertise but not in their meeting structure and content. The three groups used LACOME for almost similar tasks such as, preparing presentations, project reports and discussion on research papers, while the fourth group used it for more likely presentations and discussion on corporate reports.

6.8 Summary

In this chapter, we present the qualitative and quantitative results of our study, which includes participants' privacy and security concerns, overall impressions of the LACOME system, the overall usability of the system and the practicality of our design solutions. The results reveal that there was not a significant difference of LACOME on interactions with shared content and accessing information during a meeting.

The meetings groups that we used in the evaluation study of the LACOME system were not using any particular meeting software. In fact, the groups were using projectors or large screens to publish an individual's display. We recommend conducting the evaluation of the LACOME system with groups who have used or using some collaborative meeting system. So they can explore the system and provide feedback on the features of the system that support cooperative work.

We implemented access control mechanism to restrict the fluid access of the system by keeping our access control design simple and light weight. We noticed during the evaluation study that participants found it easy to use but at the same time they raised some security and privacy concerns. The common concerns was that once a user get access to another user's system, the access is not limited, hence any files or folders can be opened. We recommend introducing the concept of limited sharing in which only certain folders or a shared folder should be accessible not the whole system.

CHAPTER 7 CONCLUSION AND FUTURE WORK

In this chapter, we identify some future research pathways that are required to further improve and evaluate the LACOME system. We then present some final conclusions.

7.1 Future Work

The current LACOME system provides good support for collocated collaborative meetings. We conducted a user study to evaluate the LACOME system with co-located meeting members; a more diverse population (industry, business professional, and HCI experts) and more diverse meeting types is required for further evaluation of the system. Based on our evaluation study of LACOME, we present suggestions that can be considered in future development of the LACOME system.

7.1.1 Access Control

People involved in collocated meetings may have a variety of relationships. There is a great chance that all of these relationships may not be trusted. For this reason, various levels of access control will be required in some settings. There are a number of different actions that could be restricted. We implemented the access control by keeping the design simple. For instance, access permission can be assigned by the owner of the system both at the beginning of the meeting and during the meeting. However, meetings often include unfamiliar people, making it harder for a user to assign permission to unknown partners.

7.1.1.1 Access control design for moderator

Professional meetings are often organized by a moderator within an organization. Moreover, many meeting groups have a group leader who calls meeting. Thus a moderator or a group leader is a powerful person who can set the permission levels of the other users. As mentioned in section 5.4, users can assign permission, either when they first connect to the system or during the meeting when requested by someone. In the current state of LACOME, access permission cannot be set up until a user connects to the system because LACOME acquires a client's IP address only when the client is connected. Thus, only then can access permission be assigned. In other words, a moderator cannot assign access permission until a user connects to the system.

One solution for this problem is to pre-register the users with their credentials. The main credential in the LACOME system that can be used to authenticate users and assign access

permission is the client's IP address. Pre-registered users with static IP addresses could therefore be assigned permission in advance. Static IP addresses are more reliable for network communication. Another solution would be for the moderator to assign access permission prior to the meeting or to assign a unique user ID to each user. The concept of using user IDs instead of IP addresses will not only enhance security but also remove the burden (especially for non-technical users) of remembering IP addresses in order to establish connection. First-time users of LACOME should be provided with a user ID configured with available access permission, which may be modified prior to each meeting. Users should then be able to assign permission on runtime during the meeting.

7.1.1.2 Access control for single presenter with large audience scenario

Currently, anyone may connect and use an arbitrary nickname, but in the future users might be required to set up an account and use a verified real-world name. If users are not verified like in current system, there is a definite need of adding other layer of security to the system in a large audience scenario. Even if a cursor is not allowed to perform any actions, it may still be used for pointing. The toggle navigation feature may be further used to move, resize and iconify windows. In a very large meeting, such as in a classroom or an orientation setting, a troublemaker could disrupt a meeting through malicious window manipulations, and it would be almost impossible to determine the troublemaker. In future designs, the system could be implemented for two different modes, such as a normal meeting environment and a large audience mode. When the system is used in the second mode, it may ask for permission for window manipulation tasks as well as access; these could be assigned by the presenter.

7.1.1.3 Role-based and team-based access control

We kept our design of access control simple and light weight in our implementation. Of course, one could design many other roles and groups, or even other access control schemes altogether. Role based access control (RBAC) is one the mechanisms that allows access permission to information based on responsibilities or roles. With the implementation of RBAC into the LACOME system, administrators or moderator may create roles according to the job functions to be performed in a particular meeting, grant permissions to those roles, and then assign users to the roles on the basis of their specific job responsibilities and qualifications [33].

Additionally, groups could be defined, and individuals or roles could have group-specific access permission. Multiple groups or organized teams may be considered using LACOME in a meeting. Thomas [38] first introduced the notion of Team-based Access Control as an approach to applying role-based access control in collaborative environments. Thus, LACOME can be used with the implementation of TMAC on the top of RBAC if multiple groups are using the system.

7.1.2 Comparative evaluation

A comparative evaluation is best carried out using appropriate scenarios with representative users in a lab experiment or, if the product is robust enough, via a field study with users in their work environment [6]. The meetings groups that we used in the evaluation study of the LACOME system were not using any particular meeting software. In fact, the groups were using projectors or large screens to publish an individual's display. It would be interesting to observe some meeting groups that are already using a meeting interaction system. Future work may include identifying those meeting groups that are already using some other electronic meeting software and then introduce LACOME in their meeting scenario for comparative evaluation purpose.

Although, the current version of the LACOME (v 3.0) system can allow remote participants to connect and share their workspace, we did not consider evaluating LACOME in a mixed presence meeting because the system was not formally evaluated before. We have evaluated the usability and other aspects of the system. In future, therefore, the evaluation of LACOME can be considered for distributed environments along with comparative evaluation.

7.1.3 Enhance LACOME for distributive environments

LACOME was initially designed to support collocated collaborative meetings. It would be quite realistic to enhance LACOME for distributive environments because the system depends heavily on computer networking. However, a distributed system brings in security and privacy constraints that do not typically apply to collocated systems, network bandwidth and configuration, and delay concerns [26].

For example, in a collocated setting, a user has visual awareness of the workspace and is confident that any content they may place on the shared display is not being recorded or misused by other meeting participants. In a distributed system, a user cannot know if remote users are using audio-visual recording devices to save information.

A distributed use of LACOME may be well suited to some types of meetings, such as between multiple remote offices of the same company or between researchers at different universities and institutions. However, there are many situations where the use of LACOME would not be appropriate, especially when sensitive information is shared among group members. In this regard, the access control issues raised in section 7.1.1 become more important, particularly in this scenario, and suggest the need for a more explicit access-control mechanism.

7.1.4 Communication channel

A user in a collocated meeting can communicate a significant amount of information through gestures, such as to ask if it is permissible to move or resize the user's window, they may simply gesture or whisper to each other. In a distributed meeting, they must use a separate communication channel shared between all meeting participants typically a telephone conference call or video conferencing call.

LACOME currently only supports sharing computer desktops in a collocated meeting environment. Participants can communicate through verbal communication or gestures in these settings. However, with the inclusion of remote participants, a firm communication medium is required to support the sharing of audio streams.

The most important aspect of collaboration is the ability to speak to and hear one another clearly. The audio support is possible in two ways, either incorporated in LACOME Client or through an independent communication channel. The main problem with the first strategy is that once a user gives system control to other users, he or she will not only lose the control of the system but also the audio system associated to it. Thus, a large amount of research is required before the actual implementation of audio supports to the system. A good motivation for this purpose can be the Argo system [11], discussed in section 3.4. The Argo system provides high quality multi-party digital video and full-duplex audio with telepointers for distributed users.

7.1.5 Implementation of Annotation mode

The existing LACOME system navigation can take place in one of two states: Manipulator and Controller. Manipulators may move, resize, or iconify windows, while Controllers may interact with the contents of a window.

There is a possibility of another potential mode, identified by Zhangbo in his original LACOME thesis [25] as "Annotator." In this mode, a user would be able to enter text or create sketches

with simple drawing tools. In Annotator mode, the Navigator would be able to annotate on the shared space. By allowing users to do annotation on the shared display space, LACOME would provide the feature of collaborative painting that is also provided by other collaboration tool kits or systems such as GroupKit [32].

In the current version of LACOME, we have not implemented the Annotator mode. However, it may be efficacious to include it in the future extension of the system for its wide applicability. The Annotator mode may be implemented either on the full screen of the shared display, or on top of display objects with some degree of transparency so that both the underlying content and the annotations can be seen together. Like the Navigator mode, the Annotator may uses mouse and keyboard information from a Navigator as the input, which may be used for a custom drawing or sketching program that supports shared annotation by multiple users. Another approach that could be implemented in LACOME is graphical editors, which allow design teams to work concurrently on their design [4].

7.2 Conclusions

LACOME was originally designed to support collocated collaborative meetings. The system allows users to publish and share their personal computer displays onto a large shared display space. It can be used in a typical meeting room, such as a professional or an academic workplace, and be augmented with a large shared display. We extended the system to consider privacy and security concerns. For this purpose, we conducted a series of focus groups to obtain feedback on the initial design of the system. Based on our findings, we developed high level design requirements for future iterations of LACOME; these include the need for addressing privacy and security concerns when moving from the use of LACOME in a co-located setting to the overarching goal of its use in a mixed presence environment. We implemented new features that provide enhanced awareness of users' shared workspaces and the interactions of others with them. We also developed an access control framework in the system that allows users to assign permissions on an ad-hoc basis. We undertook an initial evaluation of the LACOME system to evaluate the overall system and the changes that we made to it. Future work will further refine the design of LACOME for mixed presence collaboration. With the addition of new access control features, LACOME can be applied to other domains, such as professional and confidential meeting environments.

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Appendix A: Dalhousie Research Ethics Board Certificate of Approval for Focus Groups

DALHOUSIE UNIVERSITY
Inspiring Minds

Social Sciences and Humanities Research Ethics Board
Letter of Approval

Date: May 3,2012.

To: Sukhveer Dhillon , Computer Science
Dr. Kirstie Hawkey , Computer Science

The Social Sciences Research Ethics Board has examined the following application for research involving humans:

Project # 2012-2674 (v2) (R# 1011072)

Title: Enhancing LACOME to Consider Privacy and Trust Issues in a Mixed Presence Meeting Environment

and found the proposed research involving human participants to be in accordance with Dalhousie Guidelines and the Tricouncil Policy Statement on *Ethical Conduct in Research Using Humans.* This approval will be in effect for 12 months from the date indicated below and is subject to the following conditions:

1. Prior to the expiry date of this approval an annual report must be submitted and approved.
2. Any significant changes to either the research methodology, or the consent form used, must be submitted for ethics review and approval *prior to their implementation.*
3. You must also notify Research Ethics when the project is completed or terminated, at which time a final report should be completed.
4. Any adverse events involving study participants are reported immediately to the REB

Effective Date: May 2,2012.
Expiry Date: May 2,2013.

signed [redacted]

IMPORTANT FUNDING INFORMATION - *Do not ignore*

To ensure that funding for this project is available for use, you must provide the following information and FAX this page to RESEARCH SERVICES at 494-1595

Name of grant /contract holder _____ Dept. _____
Signature of grant / contract holder _____
Funding agency _____
Award Number _____ Dal Account # (if known) _____

Appendix B: Dalhousie Research Ethics Board Certificate of Approval for Field Evaluation

Social Sciences & Humanities Research Ethics Board
Letter of Approval

October 22, 2012

Mr. Sukhveer Dhillon
Computer Science\Computer Science

Dear Sukhveer,

REB #: 2012-2783
Project Title: Enhancing LACOME to Consider Privacy and Security Issues in a Mixed Presence Meeting Environment

Effective Date: October 22, 2012
Expiry Date: October 22, 2013

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans.* This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Appendix C: Instruction to Use LACOME and Key Controls

1. To interact, type the IP address of LACOME server (found in the upper left corner of the screen) in the first line of the LACOME client and press connect.
2. Press Toggle Nav to navigate on the shared display. In this mode, the user's computer cursor will be locked in the LACOME client's window and a cursor will appear on large screen.
3. See the following Table for key combinations and associated interaction functionality as you navigate with the published windows and interact with the content in controller mode.

Table: Key combinations and associated functionality

Navigation Mode		**Controller Mode**	
Keys	**Functions**	**Keys**	**Functions**
Left mouse key + dragging (if cursor is in edge or corner snap region, allows easy placement on screen edge)	**Move** window around the shared display	**Double click middle mouse button or both mouse button at the same time**	Enter controller mode to **Interact** with the content of shared display
Right mouse key in snap region + dragging	**Resize** the window on shared display	**Control+ F1**	**Exit controller mode** & return to navigation mode
Right mouse key click in central region + move mouse up (increase size) or down (decrease size)	**Zoom**		
Double click left mouse key	**Iconify** window on the bottom of shared display		
Shift + Backspace	**Exit navigation mode**		

Appendix D: LACOME Installation Instructions (Eclipse)

1. Download source code for LACOME client and server

2. Import source code in to eclipse

3. Install 32 bit JDK/JRE and select in Eclipse

Eclipse> window> preferences> Java> Installed Jre> c:\ Program Files (*86) \java

4. Copy native libraries from server's support library. The libraries are in the folder JavaLacomeServer/support libraries/. The ones you want are gluegen-rt.jar and jogl.jar, and their native counterparts' gluegen-rt.dll, jogl.dll, jogl_awt.dll and jogl_cg.dll.

Project> properties> java build path> native library locations>

5. Arguments

With these arguments server and client can connect to each other using SSL from eclipse by running java code.

Server arguments:

-Djavax.net.ssl.keyStore=certs

-Djavax.net.ssl.keyStorePassword=abcd1234

-Djavax.net.ssl.trustStore=certs

-Djavax.net.ssl.trustStorePassword=abcd1234

-Djava.protocol.handler.pkgs=com.sun.net.ssl.internal.www.protocol -Djavax.net.debug=ssl

Client Argument:

-Xms128m -Xmx1024m

-Djavax.net.ssl.keyStore=certs

-Djavax.net.ssl.keyStorePassword=abcd1234

-Djavax.net.ssl.trustStore=certs

-Djavax.net.ssl.trustStorePassword=abcd1234

-Djava.protocol.handler.pkgs=com.sun.net.ssl.internal.www.protocol -Djavax.net.debug=ssl

Appendix E: Focus Group

Post activity questionnaire

1. What is your age?
□18–24
□25–34
□35–44
□45–54
□55 or over

2. What is your gender?
□ Male
□Female

3. What is the highest level of education you have completed?
□ High School or College
□ Bachelor's Degree
□ Master's Degree
□ Doctoral Degree
□ Professional Degree

4. How would you rate your privacy concerns level for your information while sharing (Visual) under following scenarios?

Participants	Locations	Information Type	Low				High
Only friends	Collocated	Confidential	1	2	3	4	5
Only friends	Collocated	Non- confidential	1	2	3	4	5
Only friends	Remote	Confidential	1	2	3	4	5
Only friends	Remote	Non- confidential	1	2	3	4	5
Strangers	Collocated	Confidential	1	2	3	4	5
Strangers	Collocated	Non- confidential	1	2	3	4	5
Strangers	Remote	Confidential	1	2	3	4	5
Strangers	Remote	Non- confidential	1	2	3	4	5

5. What privacy and security concerns would you have if you were using LACOME system in a collocated meeting environment?

6. What privacy and security concerns would you have if you were using LACOME system with inclusion of remote participants?

7. How do you typically share information in your meetings environment? (Check all that apply)

□ Gather around a personal PC
□ Share on large display
□ Software
□ Email
□ Paper
□ Others

8. Have you used any other collaboration system before?

□Yes (Please provide description)

□No

9. Would you prefer to consider using LACOME in your workspace meetings?

□Yes (Why?)

□No (Why?)

Appendix F: Field Evaluation

Demographics questionnaire

1. What is your age?
□18–24
□25–34
□35–44
□45–54
□55 or over

2. What is your gender?
□ Male
□Female

3. What is the highest level of education you have completed?
□ High School or College
□ Bachelor's Degree
□ Master's Degree
□ Doctoral Degree
□ Professional Degree

4. How would you rate your technical expertise? I am the one who:
□ always helps others
□ sometimes helps others
□ solves issues by own
□ sometimes ask for help
□ always ask for help

5. Do you allow others to use your computer?
□ Never
□ Sometimes
□ Often

6. Do you prefer to have password for user account on your computer?
□ Yes
□ No

Post meeting questionnaire

1. How easy was to interact with other group members' material?

□ Very easy □ Easy □ somewhat easy □ Neutral □ somewhat difficult □ Difficult □ Very difficult

2. How easy was to access information during the meeting?

□ Very easy □ Easy □ somewhat easy □ Neutral □ somewhat difficult □ Difficult □ Very difficult

3. How would you rate the confidentiality of the meeting?

Low			Neutral			High
1	2	3	4	5	6	7

4. What was the purpose/agenda of the meeting?

5. Which technology did you use in meeting?

6. Was there ever anything that you want to share during the meeting but the technology you used didn't allow you?

7. How did you share information in this meeting? (Check all that apply)

□ Gather around a personal PC

□ Share on large display

□ LACOME

□ Email

□ Paper

□ Others

Post study interview

1. What was your overall impression about the LACOME system?

2. What privacy and security concerns did you encounter when you were using LACOME system in collocated/remote meetings?

3. How might these security and privacy issues affect the way you use LACOME?

4. What practical design solutions can address security and privacy issues?

5. How did you find the overall usability of this system?

6. Would you prefer to consider using LACOME in your workspace meetings?

□Yes (Why?)

□No (Why?)

7. Do you have any other comments or concerns about this system?