IMPROVING THE COMMUNICATION PERFORMANCE IN SYNCHRONOUS COLLABORATIVE APPLICATION

JAYESH M PATEL MAGANLAL

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Science (Computer Science)

Faculty of Computer Science and Information System
Universiti Teknologi Malaysia

FEBRUARY 2005

To my beloved parents

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Associate Professor Dr. Shamsul Sahibuddin, for his encouragement, guidance, critics and friendship. I am also very thankful to all members of the Spread research group. Without their continued support and interest, this thesis would not have been the same as presented here.

I am also indebted to University Teknologi Malaysia for funding my M.Sc study. My fellow postgraduate students should also be recognized for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family members and loved ones.

ABSTRACT

Point to point communication models and protocols such as TCP, were designed merely for the use in client-server applications. As the demand for collaborative applications increases, communication involving multi point and proper network bandwidth utilization arises as an issue. The main purpose of this research was to investigate the communication layer in synchronous collaborative systems and introduce an alternative communication model to improve the performance of the system in the context of bandwidth utilization. Reliable multicasting is implemented to provide reliable communication between multicast groups and clients within those groups. Multicasting enables multiparty communication across a wide area to sparsely distributed groups by minimizing the network load but the issue of reliability remains a problem. This research focused on the reliable multicast service that is provided by Spread, in order to handle the bandwidth more efficiently, to provide reliable service and to meet future requirements. This research also looked into alternative means of communication by implementing collaboration on wired and wireless networking. Results obtained from the performance experiment contribute towards improving the performance of communication in synchronous collaborative environment.

ABSTRAK

Model-model dan protokol-protokol komunikasi berbentuk titik ke titik seperti TCP telah direkabentuk khususnya untuk penggunaan dalam aplikasi pelayan pelanggan. Memandangkan permintaan bagi aplikasi kolaboratif kian meningkat, isu-isu seperti komunikasi pelbagai titik dan penggunaan lebar jalur rangkaian dengan sempurna mula timbul. Tujuan utama kajian ini adalah mengkaji lapisan komunikasi dalam sistem kolaborasi segerak dan memperkenalkan suatu model komunikasi alternatif bagi meningkatkan prestasi sistem kolaborasi dalam konteks penggunaan lebar jalur. Komunikasi berbilang kait yang boleh dipercayai digunakan sebagai implementasi untuk membolehkan penghantaran maklumat yang boleh dipercayai antara pengguna-pengguna dan kumpulan-kumpulan berbilang kait. Komunikasi berbilang kait membolehkan komunikasi antara parti berbilang menyeberangi suatu kawasan luas ke kumpulan-kumpulan yang teragih dengan kemampuan untuk mengurangkan penggunaan lebar jalur tetapi masalah kebolehpercayaan masih wujud. Kajian ini telah fokus kepada perkhidmatan komunikasi berbilang kait yang boleh dipercayai yang dibekalkan oleh *Spread*, untuk pengurusan lebar jalur supaya ianya lebih efisyen, untuk memberikan perkhidmatan yang boleh dipercayai dan untuk keperluan masa kelak. Kajian ini juga telah mengkaji talian komunikasi alternatif dengan mengimplementasi kolaborasi atas rangkaian wayar dan tanpa wayar. Akhir sekali, keputusan daripada eksperimen prestasi menjadi sumbangan dalam meningkatkan prestasi komunikasi dalam persekitaran kolaborasi segerak.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

ABBREVIATION		FULLNAME
ACK	-	Positive Acknowledgement
CSCW	-	Computer Supported Cooperative Work
FIFO	-	First In First Out
IEEE	-	Institute of Electrical and Electronics Engineers
LAN	-	Local Area Network
NACK	-	Negative Acknowledgement
OS	-	Operating System
TCP	-	Transmission Control Protocol
UDP	-	User Datagram Protocol
WAN	-	Wide Area Network
WiFi	-	Wireless Fidelity
WLAN	-	Wireless Local Area Network
WYSIWIS	-	What You See Is What I See

LIST OF APPENDIX

LIST OF PAPER PUBLISHED

Paper	TITLE
1	"Reliable and Scalable Multicast Communication with IPv6 Support in Real Time Collaborative Systems", InterNet 2002, International Workshop on Internet Technologies and Applications, 6th International Symposium on Parallel Architectures, Algorithms, and Networks (I-SPAN'02), Ateneo de Manila University (Rockwell Campus), Philippines.
2	"Reliable Multicast Service with IPv6 Support: Synchronous Collaborative Applications", SCORED 2002, 2nd Student Conference on Research and Development (SCOReD2002), IEEE Student Chapter, Shah Alam, Malaysia, UiTM, July 16-17, 2002.
3	"Performance Analysis on Synchronous Collaborative Application using Transition Mechanism from IPv4 to IPv6". Malaysian Science and Technology Congress 2002 (MSTC2002), Symposium A: Physical Sciences, Engineering and Technology, Confederation of Scientific and Technological Associations In Malaysia, Johor Bahru, Malaysia.
4	"Reliable & Scalable Multicast Communication In Real Time Collaborative Systems", International Technical Conference on

Circuits/System, Computers and Communications at Phuket Arcadia Hotel & Resort, Phuket (ITCC-CSCC 2002)
16th -19th July 2002, Thailand

5 "Communication and Architectures in Synchronous CSCW Applications", CoGramm, National Conference on Computer Graphics and Multimedia (UTM), Melaka, 7 – 9 October 2002.

6 "Group Communication Using Spread Over Wireless Network", Engineering and Technology Conference 2003 (EnTech2003), Crown Plaza Riverside, Kuching, Sarawak, 30 July – 1st August.

7 "Multicasting In Synchronous Collaborative Application Using SPREAD", 2003 International Technical Conference on Circuits/Sistems, Computers and Communications, Phoenix Park, Kang-Wong Do, Korea, July 7-9.

8 "Collaborating Over Wireless Network Using Group Communication Toolkit", 2003 International Symposium on Information Technology (ITsim 2003), Crown Princess, Kuala Lumpur, Malaysia, September 30th-2nd October 2003.

CHAPTER 1

INTRODUCTION

1.1 General Introduction

The world wide web (WWW) already accounts for more Internet network traffic than any other application, including email and simple file transfer. It is also a collaborative technology in a weak sense of the word - it allows people to share information. Collaboration can range from asynchronous, where an interactive activity is separated by long period of time (e.g. email, discussion groups), to synchronous, where an interactive activity is simultaneous and in real-time (e.g. video conferencing).

Synchronous collaboration is where an interactive activity is simultaneous and in real-time. Synchronous collaborative systems are not as common as asynchronous systems. Computer based synchronous collaborative systems like shared whiteboards and collaborative editor are only beginning to emerge recently. These applications involving more than two users exchanging information, require multi point communication (Keidar, 2001). Multi point communication or better known as multicast communication is a transmission mode that is now supported by a variety of local and wide area networks (Rezende and Fdida, 1999). Multicasting

enables multiparty communication across a wide area to sparsely distributed groups by minimizing the network load (Hewitt, 1997).

Multicasting itself is one of the key technologies in the next generation of the Internet. As the internet networks grow by the day, more and more people are getting connected via wireless environment. This fast developing new technology known as Wireless Fidelity (Wi-Fi), is a concept which is basically a free-network movement, a high-bandwidth wireless connectivity everywhere.

In this thesis, we describe the technical issues in its design and implementation of a prototype; a synchronous collaborative system with minimal tools that allows multiple users to collaborate simultaneously over a wired and wireless environment with reliable data delivery. The thesis also describes various issues from the aspect of communication.

1.2 Problem Background

An important issue in the design of a software application is its overall architecture, that is, the nature of the components of the application and the communication among these components. While there has been much work done in characterizing architectures of single-user software, there has been relatively little research addressing architectures of multi-user or collaborative software (Dewan, 1999). This makes groupware development involves many issues that introduce additional technical problems.

This research describes the synchronous collaborative systems, technical issues in its design and implementation. The synchronous collaborative tools that is looked into is a shared editor that allows multiple users to edit a single document at the same time without any constraints and a shared whiteboard that allows users to

share graphical drawings and images and able to work on it at the same time without any constraint. These issues are further discussed in this thesis.

As the Internet continues to grow, new approaches are needed to provide large number of users with efficient, concurrent, on-demand access to information. In current approaches, like the client-server model used in the World-Wide-Web (WWW), information services are centralized and become bottlenecks under high demand (Callahan *et al*., 1996). Centralized systems suffer this problem and the performance of the system is affected due to this bottleneck. Bottleneck is an important issue in the design of a centralized collaborative application since it influences the performance (Dewan, 1999).

Different multicast applications require many different levels of reliability and ordering guarantees in the face of transient network failures such as dropped packets (Callahan *et al*., 1996). Although multicasting has an enormous potential to reduce application bandwidth requirements, its lack of reliability remains a problem and how multicasting system handles lost packets becomes an issue (Kosiur, 1998). A synchronous collaborative system requires reliable packet delivery to ensure data consistency. Data must be sent error-free to ensure that the images and text send are correct and latency requirements remain low, as extreme delay greatly reduces the utility of a real-time data application in a collaborative environment (Miller, 1998).

Most applications running above Transport Control Protocol/Internet Protocol (TCP/IP) use Transport Control Protocol (TCP) as the Transport layer for the rich services it provides. TCP, however, provides only point-to-point (unicast) services. Thus all multicast applications must run on top of User Datagram Protocol (UDP) (Miller, 1998). UDP on the other hand is unreliable and if UDP detects an error in the received packet, it silently drops it (Forouzan, 2000). Lost packet has to be retransmitted again and bandwidth utilization increases.

As the demand grows in internetworking, future networks will require better services and better scalability from the current wired network that we have now. The availability of wireless networking and wireless LANs can extend the freedom of a network user, solve various problems associated with hard-wired networks and even

reduce network deployment costs in some cases. Wireless LANs allows users to collaborate without having the trouble to look for a place to plug in.

This thesis also addresses several other issues relating to the architecture of the synchronous collaborative systems such as centralized and replicated systems, concurrency and floor control, scalability of the system and wireless connectivity.

1.3 Problem Statement

Based on the problem background, we can summarize the main research question as:

"What can be done to improve the performance in synchronous collaborative systems, how to ensure reliability and scalability in synchronous collaborative systems and can synchronous collaborative systems be supported with future networks?"

This research will develop a prototype of two synchronous tools which is a collaborative editor and a shared whiteboard with support of a reliable multicast service to ensure reliability and scalability of the system, efficient utilization of bandwidth and ready for the next generation of wireless internetworking. This research will also examine the features of some synchronous collaborative systems such as concurrency control and consistency management to allow and support proper handling of users during collaboration.

1.4 Research Objectives

The research has four objectives:

- to identify current communication model and features in synchronous collaborative systems.
- to investigate how to provide reliable communication in synchronous collaborative systems to ensure proper bandwidth utilization.
- to design and develop new communication approaches without having to change the underlying network in the implementation of synchronous collaborative systems.
- to experiment and evaluate the implementation of reliable multicast communication in synchronous collaborative systems.

1.5 Purpose of Research

The purpose of this research is to choose the appropriate technique to resolve the bandwidth utilization issue in synchronous collaborative applications. Types of reliable multicasting protocols is studied and based on the findings, appropriate protocol is implemented into the prototype. The research evaluates the use of this protocol in a collaborative environment. Collaboration over wired and wireless network is examined and implemented. Lastly, testing is done on this prototype with minimal functionalities to understand its proper usage, implementation and results obtained will be analyzed as a contribution towards this research.

1.6 Research Scopes and Limitations

The scopes of this research includes that this project is implemented as a prototype to execute the testing scenario. The prototype is with minimal functionalities such as shared whiteboard and editor. This system is implemented and will be tested in a wired and wireless LAN network. The end user of the prototype would be a software developer and someone who understands the basic concept behind groupware systems. The final product of this research is a prototype to improve the communication in current synchronous collaboration systems. Although the tools developed in our prototype may lack of certain functionalities but the purpose of this research is to show the output result from the reliable communication process. User interface, workspace awareness and security is not the subject of investigation. In this research, prototype is developed on WIN32 platform using Java with Spread Java API libraries. Although Java is a platform-independent programming language, the prototype may have some problems in other platforms, which are not examined. Testing of the systems prototype is done and results obtained is analysed and discussed to show its effectiveness. The testing phase will consist of two separate parts. Firstly will be the testing of current implementation and our prototype and second part will be the study of the network performance based on the systems network usage. Finally, some of the open issues are left to future research.

1.7 Research Assumptions

In this research, several assumptions have been identified. Focus of this research is on the communication of the collaborative system and user interface is negligible. Testing and evaluating the prototype is done with the number of users is assumed to be sufficient to conclude our research objectives and same end users are used for both pre and post experiments of the prototype. The end users of the

prototype are assumed to be familiar with collaborative applications and are assumed to be software developers themselves. To show the real effectiveness of this prototype, a shared editor is used to show the consistency of the characters that are being inserted into the shared area. Many functions of a synchronous collaborative system are assumed to exist such as workspace awareness in current implementation. Availability of numerous network facilities to support collaborative working environment is also taken under assumption. Wireless networking standards, 802.11b, are assumed to be the same for all running prototype. All wireless devices are assumed to have good band signal within the assigned radius. Lastly, all running Spread daemons will be of the same version and having the same configuration settings.

1.8 Research Significance

Communication model is a critical part of a collaborative editor and to other collaborative applications. The model not only will determine the performance of a certain collaborative application but it will make the overall system more efficient and reliable. As the result of this research, knowledge on how to provide reliable multicast service within collaborative applications and in a wireless environment will continue to contribute for future research.

For collaborative application based on centralized architecture the communication model plays a role in issues such as bottleneck. Thus, scalability of a system indirectly is determined by the communication model. System prototype that has been built will resolve this bottleneck problem and can be used as a reference for future development or research. The core engine of this prototype can be reused to develop a complete system. The prototype also will resolve the bandwidth issue using different approach such as reliable multicasting provided by Spread and implemented on a wireless environment with hope for performance almost on par to wired network.

Results obtained from the testing of the systems prototype would be the main contribution towards this research. This thesis also will allow researchers and developers to get better knowledge and understanding about how multicasting works in a synchronous collaborative environment, how to provide reliability and scalability to synchronous collaborative applications, and how wireless networking can perform as good as wired networking.

Finally, this research will play an essential role on the issues of providing reliable multicast service to synchronous collaborative applications.

1.9 Thesis Organization

This thesis is our research findings for a better communication model to provide better communication in synchronous collaboration. There are eight chapters in this thesis.

We start by discussing the literature review on related systems and other research done in Chapter 2. We conduct the study by looking at the general topic which is CSCW. From there we concentrate into synchronous collaborative applications and look into the communication layer of that application. We discuss on types of communication available and discuss in detail about our findings and our possible solution to this research problem.

Chapter 3 describes the research framework. It also discusses about the technologies and requirements that are used to develop our prototype. We also discuss on types of testing that we will conduct in the second major phase of this thesis which is the testing phase.

Chapter 4 describes the architecture and system design of the prototype. In this chapter, we describe the interaction between its various components. We also

explain our aim for the research prototype and finally explain how each part of the architecture works.

In Chapter 5, we show and discuss the user interface of our prototype and how each component of the design in Chapter 4 is implemented. We explain the process and part of the coding in this chapter to show how certain functions were implemented.

Chapter 6 describes the second half of this research, the testing phase. It gives an overview of the testing that will be conducted. This chapter will outline the testing phase on how it was conducted, the tools that were used and the procedure for collecting the data and the testing environment.

The outcome from the testing phase is discussed in detail in Chapter 7. Chapter 7 discusses on the findings of the experiment and gives an analysis based on the results obtained.

Finally, in Chapter 8, we draw conclusions from the work described, our contribution towards this research and present future research ideas.

REFERENCES

Amir, Y. and Stanton, J., (1998). *The Spread Wide Area Group Communication System*. Technical Report 98-4, Johns Hopkins University, Center of Networking and Distributed Systems.

Amir, Y., Danilov, C. and Stanton, J., (2000). *A Low Latency, Loss Tolerant Architecture and Protocol for Wide Area Group Communication*. Published in International Conference on Dependable Systems and Networks (FTCS-30, DCCA-8), New York.

Armstrong, S., Freier, A. and Marzullo, K., (1992). *RFC 1301: Multicast Transport Protocol* : http://www.faqs.org/rfcs/rfc1301.html, November 2001.

Baecker, E.E, (1993). *A Survey of Experiences of Collaborative Writing*. In M. Sharples, editor, Computer Supported Collaborative Writing. Springer Verlag, Berlin. 87-112.

Baecker, R.M., Nastos, D., Posner, I.R., and Mawby, K.L., (1993). *The User-centred Iterative Design of Collaborative Writing Software*. Proceedings of InterCHI'93, ACM. 399-405.

Baecker, R. M., Grundin, J. and George, W. A. S., (1995). *Readings in Human – Computer Interaction: Towards Year 2000*. Morgan Kaufmann Publication. 743

Bormann, C., Ott, J. and Seifert, N., (1996). *MTP-2 Protocol Description*. MTP/SO: Self-Organizing Multicast : http://user.cs.tu-berlin.de/~nilss/som/mtp-prot.htm, October 2001.

Brink, T., (1999). *CSCW and Groupware*. School of Information, University of Michigan : http://www.crew.umich.edu/~brinck/cscw.html, September 2001.

Callahan, J., Montgomery, T. and Whetten, B., (1996). *High Performance, Reliable Multicasting: Foundations for Future Internet Groupware Applications*. NASA/West Virginia University Software IV & V Facility.

Chabert, A., Grossman, E., Jackson L. S., Pietrowiz, S. R. and Seguin, C., (1998). *Java object-sharing in Habanero*. Communications of the ACM. 41(6): 69-76.

Breen, J., (1998). *CSE5803 Multicasting*. School of Computer Science and Software Engineering, Monash University

Deering, S. E. and Cheriton, D. R., (1990). *Multicast Routing in Datagram Internetworks and Extended LAN'S*. ACM Transactions on Computer Systems. 8(2): 85-110.

Dewan, P., (1996). *Multiuser Architecture*. Proceedings of IFIP WG2.7 Working Conference on Engineering for Human-Computer Communication.

Dewan, P., (1999). *Architectures for Collaborative Applications*. In Beaudouin-Lafon, M. (Ed.), Computer Supported Cooperative Work, Trends in Software Series 7, John Wiley and Sons Ltd.

Dix, A., Finlay, J., Abowd, G. and Beak, R., (1998). *Human Computer Interaction*(Second Edition), Prentice Hall.

Ellis, C. A. and Gibbs, S. J., (1989). *Concurrency Control in Groupware Systems.* Proceedings of the ACM SIG-MOD Conference on Management of Data.

Ellis, C. A., Gibbs, S. J. and Rein, G. L., (1990). *Design and Use of a Group Editor*. Engineering for Human Computer Interaction. G. Cockton, editor. North-Holland, Amsterdam. 13-25.

Ellis, C.A., Gibbs, S.J., and Rein, G.L., (1991). *Groupware: Some Issues and Experiences*. CACM, Readings in Groupware and Computer-supported Cooperative Work: Facilitating Human-Human Collaboration, Morgan Kaufmann Publishing.

Forouzan, B. A., (2000). *TCP/IP Protocol Suite.* McGraw Hill.

Fout. T, (2001). *Wireless LAN Technologies and Windows XP*. Microsoft Corporation.

Garfinkel, D., Welti, B. and Yip, T., (1994). *Shared x: A tool for real-time collaboration.* Hewlett-Packard Journal. 23-24.

Glicksman, J. and Kumar, V., (1992). *A SHAREd collaborative environment for mechanical engineers*. Groupware '93. D. D. Coleman, editor. Morgan Kaufmann Publishing. 335–347.

Greenberg, S. and Roseman, M., (1999). *Groupware Toolkits for Synchronous Work*. In Beaudouin-Lafon, M. (Ed.), Computer Supported Cooperative Work, Trends in Software Series 7, John Wiley and Sons Ltd.

Hewitt, K. L., (1997). *Desktop Videoconferencing: A Low Cost and Scalable Solution to Distance Education.* MS Thesis, Graduate Faculty of North Carolina State University: http://www2.ncsu.edu/eos/service/ece/project/succeed_info/klhewitt/thesis/title.html, October 2001.

Hoffmann, M., (1996). *Scalable Multicast Communication in the Internet*. ConneXions – The Interoperability Report. 10(10): 24-32.

Hoffmann, M., (1997). *Enabling Group Communication in Global Networks.* Proceedings of ITS/ICCC Global Networking'97, Calgary, Alberta, Canada.

Keidar, I., (2001). *Group Communication*. MIT Laboratory for Computer Science.

Koch, M. and Koch, J., (1997). *Using Component Technology for Group Editors - The Iris Group Editor Environment*. Proceedings of Workshop on Object Oriented Groupware Platforms, Lancaster, UK.

Kosiur, D., (1998). *(multi)casting a Reliable Net*. PC Week, ZDNet : http://www.zdnet.com/zdnn/content/pcwk/1514/302986.html, August 2001.

Leland, M.D.P., Fish, R.S., and Kraut, R.E., (1988). *Collaborative Document Production Using Quilt*. Proceedings of CSCW 88, 206-215.

Li, D. and Murttz, R., (1998). *COCA: Collaborative Objects Coordination Architecture*. ACM CSCW 98 Seattle.

Luoma, J., (1997). *Tik-110.551 Internetworking Seminar: Multicasting in the Internet*. AvantComp Oy, Matti Tella : http://www.tml.hut.fi/opinnot/Tik-110.551/1997/multi.htm, August 2001.

Miller, C. K., (1998). *Multicast Networking and Applications*. Addison Wesley Longman Inc..

Paul, S., Sabnani, S. S., Lin, J. C. and Bhattacharyya, S., (1997). *Reliable Multicast Transport Protocol (RMTP).* IEEE Journal on Selected Areas in Communications, special issue on Network Support for Multipoint Communication, 15(3): 407-421.

Quinn, B., (1999). *Reliable IP Multicast*. Stardust.com Multicast Technical Resource Center : http://www.stardust.com/multicast/whitepapers/ReliableIP_01.htm, August 2001.

Raman, S. and Tung, T. L., (1996). *Mediaboard Using Scalable, Reliable Multicast Toolkit*. Department of Electrical Engineering and Computer Science, University of California, Berkeley : http://www.cs.berkeley.edu/~suchi/mboard /paper/paper.html, October 2001.

Rezende, J. F. and Fdida, S., (1999). *Scalability Issues for Reliable Multicast Protocols*. Lectures Notes on Computer Science, University Prerre et Marie Curie.

Rodden, T., (1992). *A Survey of CSCW Systems.* Interacting with Computers 3(3). Computing Department, Faculty of Applied Sciences, Lancaster University. 319-353.

Satyanarayanan, M., Kistler, J.J., Kumar, P., Okasaki, M.E., Siegel, E.H., Steere, D.C., (1990). *Coda: A Highly Available File System for a Distributed Workstation Environment*. IEEE Transactions on Computers. 39(4): 447-459.

Sorensen, R., (1995). *A Comparison of Software Development Methodologies*. Software Technology Support Center.

Stanton, J., (2002). *A User Guide to Spread Version 0.11*. Johns Hopkins University, Center of Networking and Distributed Systems.

Terzis, S., (1998). *CSCW & Groupware*. Computer Science Department, University of Dublin : http://www.cs.tcd.ie/Sotirios.Terzis/CSCW.html, July 2001.

WLANA (1999). *Introduction to Wireless LANs.* Wireless LAN Association : http://www.wlana.com, July 2002.

WLANA (2002). *Wireless Networking Standards and Organizations*. Wireless LAN Association : http://www.wlana.com, July 2002.

Yang, Y., Chengzheng, S., Yanchun Z. and Xiaohua J., (2000). *Real-Time Cooperative Editing on the Internet*. IEEE Internet Computing. 18-25.

Zafer, A. A., (2001). *NetEdit: A Collaborative* Editor. Department of Computer Science, Virginia Polytechnic Institute and State University: Masters Thesis.