UNIVERSITI PUTRA MALAYSIA

A JAVA BASED MULTIMEDIA DISTRIBUTED COLLABORATIVE ENVIRONMENT OVER THE INTERNET

CHEE BOON KOK

A JAVA BASED MULTIMEDIA DISTRIBUTED COLLABORATIVE ENVIRONMENT OVER THE INTERNET

By

CHEE BOON KOK

Thesis Submitted in Fulfilment of the Requirements for the Degree of
Master of Science in Faculty of Engineering
Universiti Putra Malaysia

June 1999

To God and my parents……

ACKNOWLEDGEMENTS

I am indebted to several people who have directly or indirectly contributed to this dissertation work. The knowledge and experiences I have gained with them cannot be measured in words. Neither can the appreciation I have for them. The following list, by no means exhaustive, is an attempt to acknowledge at least a few of these people.

First and foremost, I have been very fortunate to have Prof. Malay Raj Mukerjee as my supervisor and mentor. His guidance and encouragement throughout my research have been indispensable. In technical matters as well as intricacies of academic and daily life, his knowledge and willingness to help are unsurpassed. His incredible interest and in-depth knowledge, which cover topics from politics to sports, from movies to musics and from philosophy to religion have caused many thought-provoking and absorbing discussions.

It is my pleasure to express my deepest gratitude and appreciation to Assoc. Prof. Dr. Borhanuddin Mohd. Ali, the chairman of my supervisory committee for his guidance and inspiration during the research period. I would also like to express my sincere thanks to my second co-supervisor Dr. Abdul Rahman Ramli for his kind supervision and suggestions to carry out my works properly.

I also wish to take this opportunity to express my sincere gratitude to all my fellow friends in ATM & Broadband Research Group for their helps, friendships and insightful discussions. Not to forget also all my friends who are always with me when I was upset or emotionally down. Their unconditional supports and

encouragement have enabled me to go through many hard times in life. I am particularly indebted to Chen Soong Der, Low Wai Yan, Lim Kean Meng, Ali Mohd. Abdelrahman and Tan Buan Tong.

Above all, I owe my humble achievements, to my family back home. My parent deserves the credit for my degree. They have provided mental support and encouragement for my higher studies and taught me to take pride in my work. Finally, I would like to thanks God for His blessing.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

API	-	Application Programmer Interface
ATM	-	Asynchronous Transfer Mode
AWT	-	Abstract Window Toolkit
CORBA	-	Common Object Request Broker Architecture
CSCW	-	Computer Supported Collaborative Work
DCE	-	Distributed Collaborative Environment
DCOM	-	Distributed Component Object Model
FDDI	-	Fiber Distributed Data Interface
HTML	-	Hyper Text Markup Language
HTTP	-	Hyper Text Transfer Protocol
IP	-	Internet Protocol
IRC	-	Internet Relay Chat
JOS	-	Java Object Serialization
JVM	-	Java Virtual Machine
LAN	-	Local Area Network
MPEG	-	Motion Picture Expert Group
NNTP	-	Network News Transfer Protocol
OOD	-	Object-Oriented Design
OODBMS	-	Object-Oriented Database Management System
OQL	-	Object Query Language
ORB	-	Object Request Broker

QoS	-	Quality of Service
RMI	-	Remote Method Invocation
SMTP	-	Simple Mail Transfer Protocol
TCP	-	Transport Control Protocol
UDP	-	User Data Protocol
UI	-	User Interface
UML	-	Universal Modeling Language
VRML	-	Virtual Reality Markup Language
WAN	-	Wide Area Network
WWW	-	World Wide Web

GLOSSARY

Community – Several clients who are connecting to a server make up a community. Anyone who successfully logs into the system automatically becomes a member of the community. There may be several different sessions that different group of users in the community are participating in. A user can choose to participate in as many session as he/she likes.

Session - This term refers to a period of time when a group of users are actively involved in collaboration activity. A session normally involves those users that have the same interest or goal. Any action of a session's member is immediately broadcast to every other member in the same session. Each session has a set of applications that is available to all the session members.

Application - This refers to the applications that are used by the participants to complete their task or work. These are the special software built with collaboration awareness features to help in the collaborative activities.

Lock - This refers to the shared object lock that enables or disables the access to the particular object. Each object that is shared must be assigned a lock. This lock avoids the inconsistency of the shared-object data caused when two or more users trying to modify the content of the object at the same time. This lock maintains the synchronization of the shared-object data.

Abstract of the thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

A JAVA BASED MULTIMEDIA DISTRIBUTED COLLABORATIVE ENVIRONMENT OVER THE INTERNET

By

CHEE BOON KOK

June 1999

Chairman : Associate Professor Borhanuddin Mohd. Ali, Ph.D.

Faculty : Engineering

Computer Supported Collaborative Work (CSCW) and distributed computing have been termed as the next paradigm of computing which allow users to interact and collaborate with each other seamlessly over the network. As a result, many collaborative distributed systems have been developed. Most of them have been implemented on proprietary systems instead of the Internet. Some may not provide necessary awareness for collaboration, while the rest still lack the real-world collaborative tools that are needed by the users. Therefore, there is a critical need for evaluating some of the proposed and existing systems to develop an effective collaborative distributed system that provides superior performance, simplicity and functionality.

In this thesis, efforts have been focused on creating a Distributed Collaborative Environment (DCE) for efficient collaborative editing and interaction among the participating users. Firstly, the comparison and analysis of various existing collaborative systems are presented. Advantages and drawbacks of various

systems are highlighted. Next, an alternative collaboration system has been developed which integrates most of the superior features of other systems while trying to avoid their drawbacks. The object-oriented design methodology is described together with the newly designed collaborative access protocol, SICAP. Finally, the implementation of the protocol on a client-server system is described.

The resulting Java Distributed Collaborative Environment (JDCE) is a platform-independent collaborative system which has been developed using Java. It runs on the Internet and provides both asynchronous and synchronous collaboration. This environment has been built on top of an object-oriented layering architecture framework to achieve maximum extensibility and robustness. The system provides various services for state management, message routing and session control. No installations are required to access the system since the client application is built as a Java applet.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia untuk memenuhi keperluan ijazah Master Sains.

SATU PERSEKITARAN BEKERJASAMA MULTIMEDIA DI INTERNET BERDASARKAN JAVA

Oleh

CHEE BOON KOK

Jun 1999

Pengerusi : Profesor Madya Borhanuddin Mohd. Ali, Ph.D.

Fakulti : Kejuruteraan

Cara Bekerjasama Bantuan Komputer dan Komputer Tertabur telah diperakui sebagai paradigma masa depan di mana ianya membolehkan pengguna-pengguna komputer yang jauh berpisah bekerjasama menerusi rangkaian komputer. Justeru itu, pelbagai sistem persekitaran tertabur dan bekerjasama telah diperkembangkan. Akan tetapi, kebanyakan sistem ini telah dimajukan berdasarkan sistem dan rangkaian yang tersendiri dan bukan menerusi Internet. Kebanyakannya, kesedaran bekerjasama yang disediakan adalah tidak mencukupi, manakala yang lain pula kekurangan perkakasan bekerjasama sebenar yang diperlukan oleh pengguna-pengguna. Jadi, adalah penting untuk menjalankan kajian bagi menguji dan menganalisis sistem-sistem semasa dan yang sedang dicadangkan untuk menghasilkan satu sistem tertabur and bekerjasama yang menawarkan kecekapan, keringkasan dan kefungsian.

Dalam tesis ini, usaha telah difokuskan untuk menghasilkan satu persekitaran tertabur dan bekerjasama yang membolehkan kerja menyunting bekerjasama dan

berinteraksi antara pengguna-pengguna komputer dijalankan dengan lancar. Pertamanya, perbandingan dan analisis pelbagai sistem bekerjasama yang sedia-ada ditunjukkan. Kelebihan dan kekurangan masing-masing juga ditonjolkan. Kemudian, satu sistem bekerjasama telah direka dan dimajukan berdasarkan kesemua kebaikan daripada sistem-sistem yang dianalisis, manakala kekurangan pula dielakkan mana yang boleh. Rekabentuk berorientasikan objek dan satu protocol baru, SICAP, turut diterangkan. Akhir sekali, perlaksanaan protocol pengguna-pelayan sistem ini ditunjukkan dengan terperinci.

Hasilnya, Persekitaran Tertabur dan Bekerjasama Java adalah merupakan satu sistem bekerjasama tanpa bergantung kepada mana-mana pelantar, dengan menggunakan teknologi Java. Ianya berfungsi menerusi Internet dan menyediakan cara bekerjasama secara tak segerak dan segerak. Persekitaran ini telah direkabentuk dengan rangka senibina perlapisan berorientasikan objek untuk mencapai perkembangan yang maksimum dan kestabilan. Sistem ini juga menyediakan pelbagai perkhidmatan untuk pengurusan keadaan, penghalaan risalah dan pengawalan sesi. Pengguna tidak memerlukan sebarang pemasangan untuk menggunakannya kerana applikasi-applikasi pengguna adalah dibangunkan sebagai "Java applet".

CHAPTER I

INTRODUCTION

Computer Supported Collaborative Work (CSCW)

CSCW is the study of how people working together using computer technology to facilitate human interactions for problem solving. Typical applications include email, decision-making support systems, awareness and notification systems, videoconferencing, chat systems, multi-player games, real-time shared applications (such as collaborative writing or drawing) etc. CSCW is also concerned with the behavioral aspect of the group working together. It looks at the way people interact and collaborate with each other, and attempts to suggest guidelines for developing technology to assist in the communication process.

Computer technology has gone through a remarkable and astonishing progress since its introduction only a few decades ago. The number of tasks that can be performed by the computer have increased significantly over the past few years as hardware and software technologies have improved exponentially. Networking technology, especially, has changed the way people work and thus changed the computer from an isolated island to a networkable entity which enables sharing of data through communication. Internet, as a global network which links more than thousands of computers, affects not just the way people work, but how they live,

think and perceive the world they live in. People can now communicate, interact, search or send information with just a simple mouse click.

The secret of success lies in recognizing and responding to a series of changing demands. In order to do this, people need to be able to acquire and analyze information instantly, respond innovatively and collaborate productively. Small teams of experts, drawn from all areas of the organization are now believed to be most effective. So people now find themselves working on short-term projects, being drawn into teams as and when they are needed and accessing information via computers. They might work with people they do not know well, and, with the increase in multinational companies, they might even be working with people who do not speak the same language. This is true to every facet of the industries, which require collaboration of diverse skills in creating more sophisticated products.

This trend might be extended to a flexible-working trend in the future. In contrast to the traditional working style (with employees actually clocking in and off of shifts controlled by factory klaxons), future employees might come and go within certain hours, and would be free to organize their time as long as they meet deadlines. In another scenario, employees might just work from their home, eliminate the need to commute to the office and meet their colleagues face to face.

CSCW systems play an important role in the success of teamwork and flexible-working concepts. CSCW systems will assist groups in communicating, collaborating and coordinating their activities. While the idea of supporting these activities is not new, the realization of any form of computer support has been more difficult than most would have anticipated. This is because of the diverse nature of

tasks undertaken by groups, different styles of group working, and a host of behavioral factors which are difficult to overcome. The challenge to the CSCW designer will be to come out with a solution to solve different problem domains of a workgroup environment.

The present project, Java Distributed Collaborative Environment (JDCE), is an attempt to give an alternative solution. JDCE offers an opportunity for the users to collaborate actively and effectively through the Internet. This is achieved through various distributed collaborative services and applications. JDCE has been designed and built using Object-Oriented Design (OOD) Methodology for extensibility and robustness. A high level protocol called System Independent Collaborative Access Protocol (SICAP) has been implemented and utilized for message passing and collaborative access to the server resources. Java Language has been chosen as the implementation language for this project. An important feature is that the client of JDCE has been built as a Java applet so that it is accessible from the Web without any installation at the client machine.

Distributed Computing

The rise of networked workstations and the fall of the centralized mainframe has been the most dramatic change in the last two decades of information technology. This shift has put more processing power in the hands of the end-user and distributed hardware resources throughout the enterprise. The challenge is to develop the software infrastructure for CSCW system by making use of these distributed resources. The significant advancement of the object-oriented technology

also makes distributed system a viable and affordable solution for collaborative environment.

Distributed Computing is a computing paradigm that allows objects to be distributed across a heterogeneous network, and allows each of the components to inter-operate as a unified entity. These objects may be distributed on different computers throughout a network, living within their own address space or dynamic library outside of an application, and yet appear as though they were local to an application. The object interaction is enabled through well-defined interfaces. The transmissions of messages between objects are facilitated through a middleware or broker. This approach extends traditional programming practice by enabling the distribution of functions and processes into various distributed resources in the network. Several advantages offered by this distributed environment are:

a. Access to the legacy assets can be leveraged. This is particularly important for large corporations which have huge collections of legacy applications and database that need to be maintained and linked to the network at the same time.

b. Programmers enjoy the freedom to distribute components of an application to computers that best fit the task of each component without having to change the rest of the application using these components.

c. The object interface becomes the gateway for object interactions such that changes to an object implementation will not affect other objects as long as the interface remains the same.

d. Since objects appear to be local to their clients, a client does not know what machine or even what kind of machine the objects reside on.

Building upon its many advantages mentioned above, distributed computing has created a rush in the industry to come out with different solutions. The most prominent technologies in the market are Microsoft's Distributed Component Object Model (DCOM) (Microsoft, 1998), OMG's Common Object Request Broker Architecture (CORBA) (OMG, 1995), JavaSoft's Java Remote Method Invocation (RMI) (JavaSoft, 1996) and ObjectSpace's Voyager (Object Space, 1997).

Java™

Java was developed and introduced by Sun Microsystems in late 1995. The original name for Java was Oak. Initially, Java was designed for writing programs for embedded systems in consumer electronics appliances, such as microwave ovens, toasters, lucid lamps and television sets. The focus was changed to the World Wide Web when the introduction of graphical web browsers started to offer new challenges. Java is an object-oriented programming language that has many resemblances to C++. The authors of Java wanted to create a language that was more compact and less complex but with the power of object-oriented languages.

Java is not just a programming language, but is a technology and platform as a whole. It is a pure object-oriented language. All variables or methods that are created must be encapsulated inside classes. However, Java differs from other languages in the sense that it is both compiled and interpreted. Java codes are first compiled into an intermediate form called Java bytecodes. This bytecodes, which are

platform independent, are then interpreted by a Java interpreter. Each program is compiled once but interpreted each time the program runs. The interpreter is implemented in the Java Virtual Machine (JVM) that runs on top of the various operating systems. Bytecodes and JVM contribute to the platform neutrality of Java language. Java programs are divided into applications which run within standalone interpreters and applets which are restricted to run within a Web browser.

Java platform is a software platform that runs on top of other hardware-based platforms and operating systems. The two main components of this platform are JVM and Java Application Programming Interface (Java API). Various APIs have been developed and released by Sun Microsystems to assist programmers to write more powerful and advanced applications. Technologies like Java Space (JavaSoft, 1998), Enterprise Java Bean (JavaSoft, 1998), Jini Technology (Sun Microsystems, 1998), Java Media Framework (JavaSoft, 1997) and RMI make Java an ideal solution for building futuristic and advanced application or framework. The strong support to network applications and ease of use of the technology has shortened the development time. "Write once run anywhere" also means that programmer will be released from the hassle of porting applications from one platform to another.

Java has been chosen as the implementation language of this project because of several advantages. First, Java was designed from scratch as a pure object-oriented programming language that stresses on object-oriented concepts. It provides a simple and intuitive classing mechanism that tolerates between dynamic object models and performance and comprehensibility.

Java is also a simple programming language which does not offer many surprise features that add complexity and difficulty. Features offered are based on simple and common object-oriented concepts yet provides powerful solutions when combined and integrated.

Java was designed with security and safety as one of the key design principles. Java programs are not allowed to call global functions and gain access to arbitrary system resources. Java discards the use of "pointers" which can be hacked by virulent programmers. Java checks the codes both during compilation and interpretation. Bugs were detected and removed at the earlier stages of developments. Memory management and exceptional conditions handling enable the programmers to focus more on writing robust and powerful applications. Furthermore, Java implements a strongly typed exception-handling mechanism for writing distributed dynamically extensible programs.

Java was designed to meet the real-world requirement of creating interactive, networked programs that run across the network. Multi-thread capabilities enhance the performance of interactive server applications in client-server environments.

One of the most important advantages of Java is platform independence. All Java programs can run on any platform that has a proper Java VM through Java bytecode. Java programs will run on all systems or platforms without any modifications. This frees the programmer from the hassle of rewriting the code for each different platform.

Java has a built-in Garbage Collector that cleans up the memory automatically. The absence of pointer type also eliminates memory corruptions and

dangling pointers. Furthermore, Java built-in array bounds check can also avoid memory corruptions. Besides, Java support for Unicode provides an easy path for programmers to write software for worldwide distribution with multi-language capability.

Objectives

This thesis is part of a larger project to create a distance learning system over a national broadband network sponsored by IRPA under the TEMAN (Testbed Environment For Malaysian Multimedia Applications and Networking) group. One of the aims of this project is to create a multimedia collaborative environment to run over the national ATM network. Currently, work has been refocused on Ethernet running IP since the complete testbed ATM network is not yet set up.

The objectives of this project are as follows:

- To create a multimedia collaborative environment for effective collaborative workings by utilizing various technologies such as Java and distributed object computing.
- To provide a framework for building platform-independent and easy to use environment that supports synchronous and asynchronous collaboration over the Internet. It uses an applet client which requires no installation and makes it simple and convenient to access the environment.
- To develop various applications for collaboration activities such as Chat system, Document Editor and Graphics Editor.