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CSS 434

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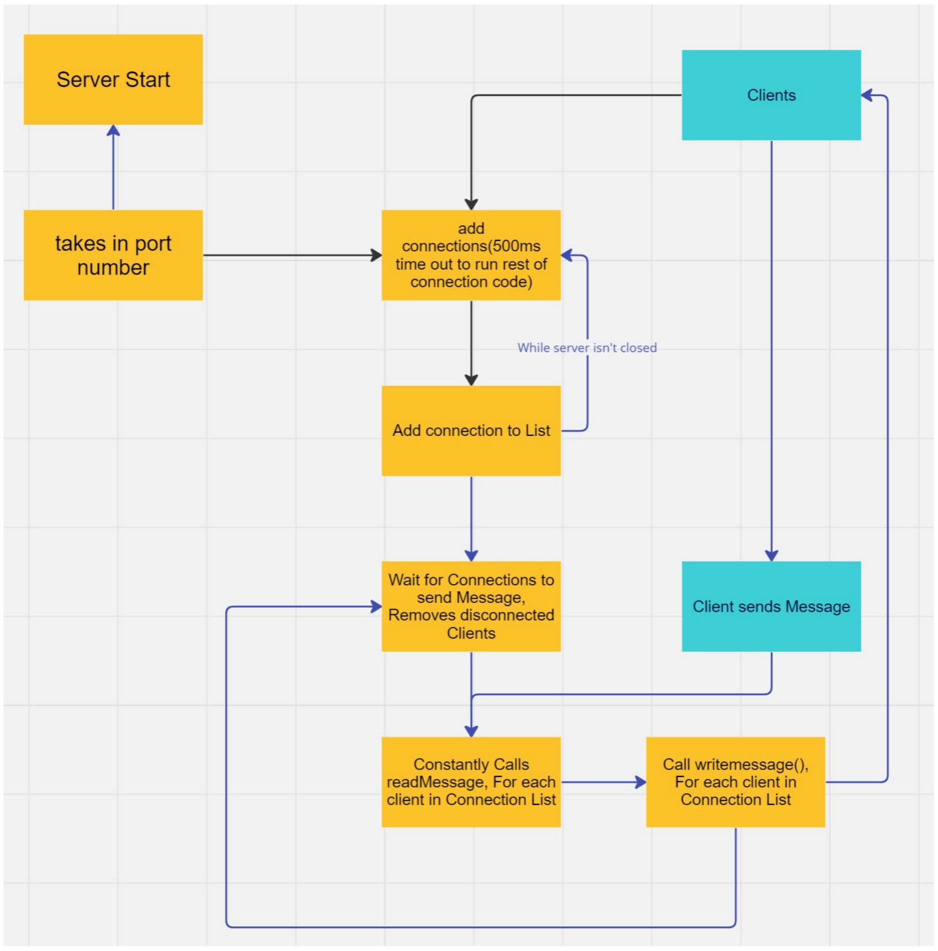
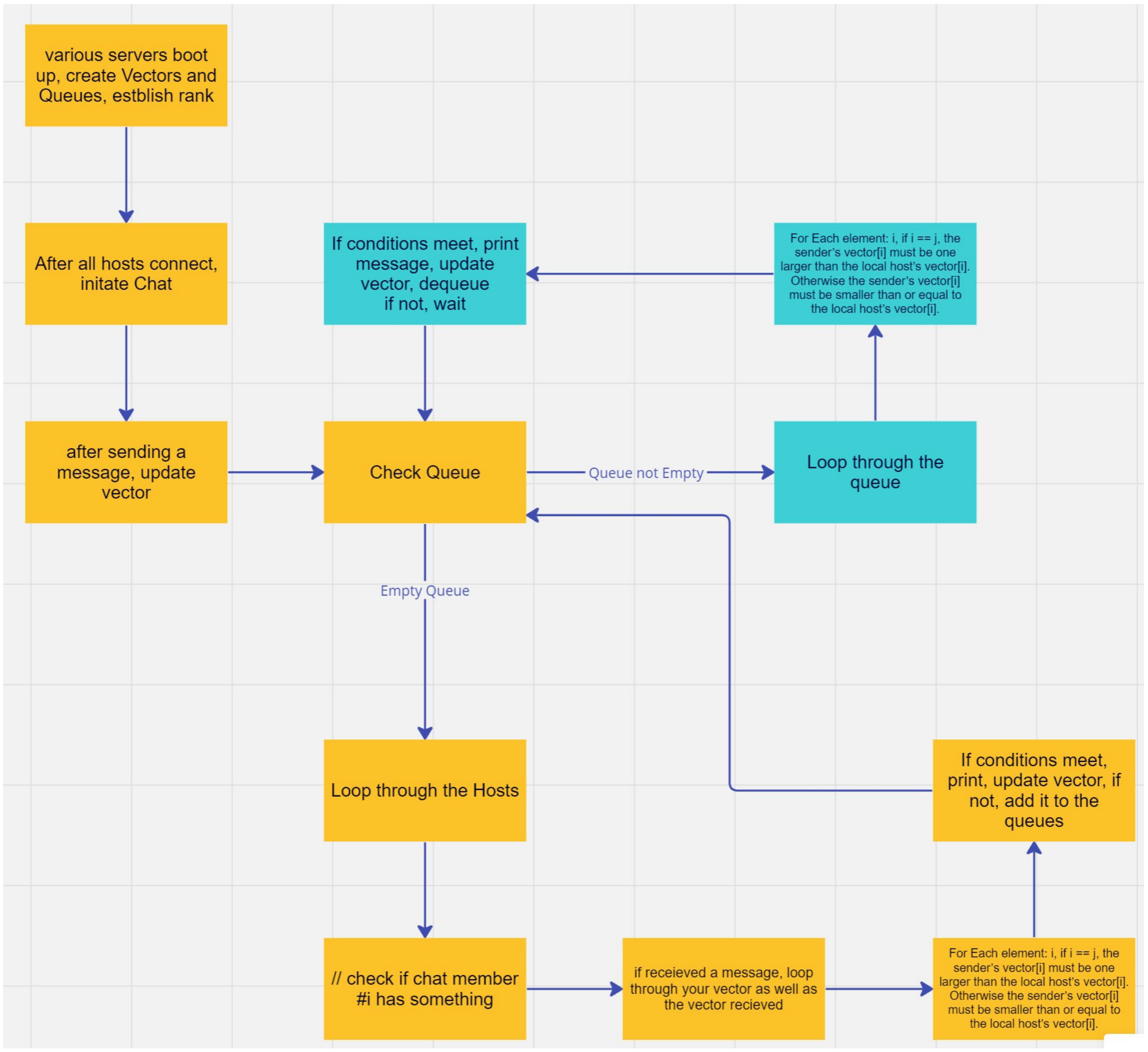
1. Documentation including explanations and illustrations

Part 1: Consistent ordering:


Server Start
Clients
takes in port number
add connections(500ms time out to run rest of connection code)
While server isn't closed
Add connection to List
Wait for Connections to send Message, Removes disconnected Clients
Client sends Message
Constantly Calls readMessage, For each client in Connection List
Call writemessage(), For each client in Connection List

In consistent ordering, the Server listens on a given port, and listens for incoming connections from clients, then add the connections to a list. Where the server would use a for each loop to listen for any messages sent from the clients, and purges any dead clients. If a client writes a message, the server would use a for each loop to write back the messages. This algorithm is very simple and does not require ordering algorithms. However, it does not scale well due to the nested for loops, and will run at O(N^2) time.

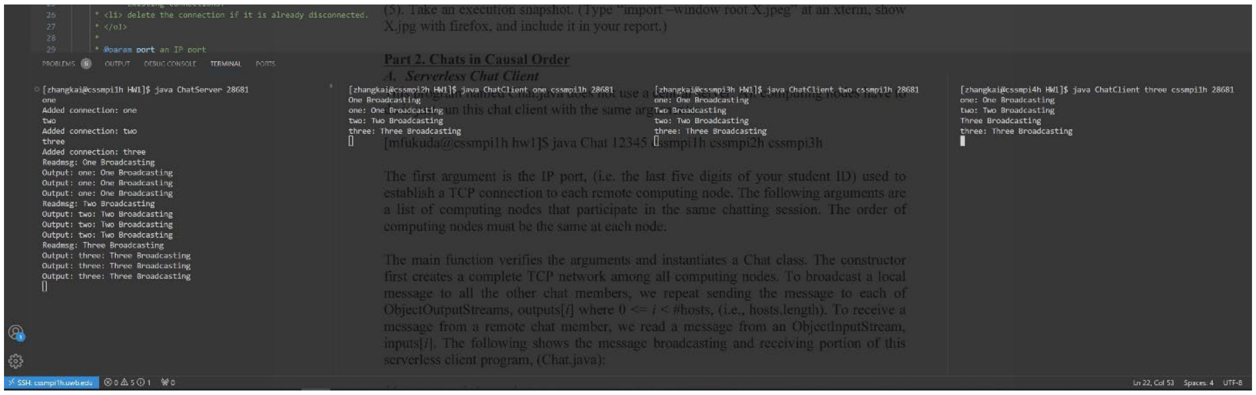
Part 2. Casual ordering:


various servers boot up, create Vectors and Queues, estblish rank
After all hosts connect, initate Chat
after sending a message, update vector
Check Queue
Queue not Empty
Loop through the queue
For Each element: i, if i == j, the sender's vector[i] must be one larger than the local host's vector[i]. Otherwise the sender's vector[i] must be smaller than or equal to the local host's vector[i].
If conditions meet, print message, update vector, dequeue if not, wait
Empty Queue
Loop through the Hosts
// check if chat member #i has something
if receieved a message, loop through your vector as well as the vector recieved
For Each element: i, if i == j, the sender's vector[i] must be one larger than the local host's vector[i]. Otherwise the sender's vector[i] must be smaller than or equal to the local host's vector[i].
If conditions meet, print, update vector, if not, add it to the queues

In casual ordering, there isn't a central server, instead order is kept through a vector that is passed around the clients. The vector tracks the recency of the messages to keep order. If the recency is wrong, then it means there is another message that needs to be received, and the program will check back later and put the message in a queue.

2. Discussions about the efficiency of algorithm, possible improvements:
    a. Consistent ordering:
        i. Efficiency: It does not scale well due to the nested for loops, and will run at O(N^2) time. And will put a lot of strain on the server if multiple users enter. And latency will develop and impeding the timely delivery of messages
        ii. Improvements: Should add features such as time stamps and Global Sequencer on servers to ensure correct delivery of messages.
    b. Casual ordering:
        i. Efficiency: Casual ordering can balance load and scale better due to its P2P nature, but due to the added Metadata, the packets becomes larger. Casual ordering will buildup queues in networks with more congestions.
        ii. As networks become more congested, more messages will be delivered incorrectly, therefore a total order may be needed to be created in order to make sure all peers have the same version of message history.

Execution snapshot:

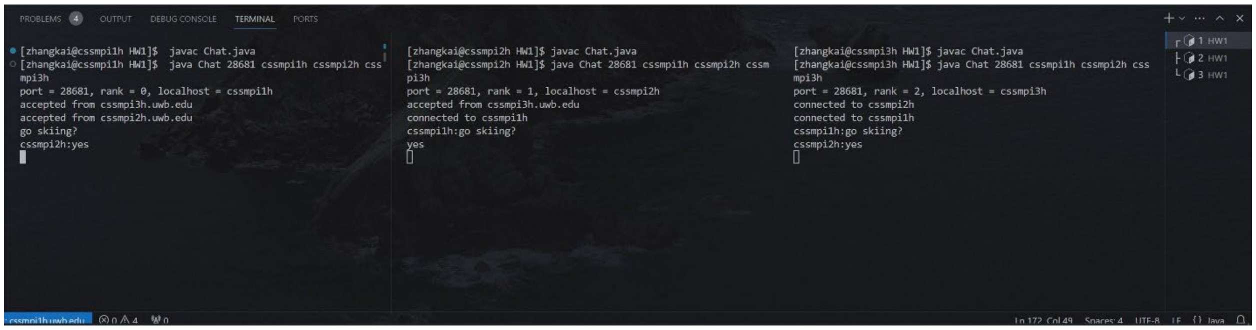


```
[zhangkai@cssmpi1h HW1]$ java ChatServer 28681
one
Added connection: one
two
Added connection: two
three
Added connection: three
Readmsg: One Broadcasting
Output: one: One Broadcasting
Output: one: One Broadcasting
Output: one: One Broadcasting
Readmsg: Two Broadcasting
Output: two: Two Broadcasting
Output: two: Two Broadcasting
Output: two: Two Broadcasting
Readmsg: Three Broadcasting
Output: three: Three Broadcasting
Output: three: Three Broadcasting
Output: three: Three Broadcasting
```

```
[zhangkai@cssmpi2h HW1]$ java ChatClient one cssmpi1h 28681
One Broadcasting
one: One Broadcasting
two: Two Broadcasting
three: Three Broadcasting
```

```
[zhangkai@cssmpi3h HW1]$ java ChatClient two cssmpi1h 28681
one: One Broadcasting
Two Broadcasting
two: Two Broadcasting
three: Three Broadcasting
```

```
[zhangkai@cssmpi4h HW1]$ java ChatClient three cssmpi1h 28681
one: One Broadcasting
two: Two Broadcasting
Three Broadcasting
three: Three Broadcasting
```



```
[zhangkai@cssmpi1h HW1]$  javac Chat.java
[zhangkai@cssmpi1h HW1]$  java Chat 28681 cssmpi1h cssmpi2h css
mpi3h
port = 28681, rank = 0, localhost = cssmpi1h
accepted from cssmpi3h.uwb.edu
accepted from cssmpi2h.uwb.edu
go skiing?
cssmpi2h:yes
```

```
[zhangkai@cssmpi2h HW1]$ javac Chat.java
[zhangkai@cssmpi2h HW1]$ java Chat 28681 cssmpi1h cssmpi2h cssm
pi3h
port = 28681, rank = 1, localhost = cssmpi2h
accepted from cssmpi3h.uwb.edu
connected to cssmpi1h
cssmpi1h:go skiing?
yes
```

```
[zhangkai@cssmpi3h HW1]$ javac Chat.java
[zhangkai@cssmpi3h HW1]$ java Chat 28681 cssmpi1h cssmpi2h css
mpi3h
port = 28681, rank = 2, localhost = cssmpi3h
connected to cssmpi2h
connected to cssmpi1h
cssmpi1h:go skiing?
cssmpi2h:yes
```

Source Code:

ChatServer.java:

```
// Make sure to change the file name into ChatServer.java
/**
 * ChatServer.java:<p>
 *
 *
 * @author  Munehiro Fukuda (CSS, University of Washington, Botheel)
 * @since   1/23/05
 * @version 2/5/05
 */

import java.net.*;           // for Socket and ServerSocket
import java.io.*;            // for IOException
import java.util.*;          // for Vector
```

```java
public class ChatServer {
    // a list of existing client connections to be declared here.
    ArrayList<Connection> connList = new ArrayList<Connection>();
    /**
     * Creates a server socket with a given port, and thereafter goes into
     * an infinitive loop where:<p>
     * <ol>
     * <li> accept a new connection if there is one.
     * <li> add this connection into a list of existing connections
     * <li> for each connection, read a new message and write it to all
     *      existing connections.
     * <li> delete the connection if it is already disconnected.
     * </ol>
     *
     * @param port an IP port
     */
    public ChatServer( int port ) {
        try{
            ServerSocket server = new ServerSocket(port);
            while( true ) {
                try {
                    // Create a sersver socket
                    // ServerSocket server = ....
                    server.setSoTimeout( 500 ); //will be blocked for 500ms upon
accept
                    Socket client = server.accept();// accept a new connection
                    if(client == null){   // if this connection is not null
                        continue;
                        //add the new connection into a list of existing
connections
                    }else{
                        Connection conn = new Connection(client);
                        connList.add(conn);
                        System.out.println("Added connection: " + conn.name);
                    }

                } catch ( SocketTimeoutException e) {
                    //System.out.println("Socket exception");
                }
                // for each connection, read a new message and write it to all
                // existing connections
                for (Connection connection:connList) {
                    String message = connection.readMessage();
                    //System.out.println("Broadcast: " + message);
                    if(message == null){// read a new message if exist.
                        continue;// make sure that this read won't be blocked.
                    }else{
                        for(Connection allconns:connList){
                            // if you got a message, write it to all connections.
                            if(allconns.isAlive() == true){
                                allconns.writeMessage(message);
                            }else{
                                connList.remove(allconns);
                                // delete this connection if the client
disconnected it
                            }
                        }
                    }
                }
            }
                //server.close();
        }catch (IOException e){
            e.printStackTrace();
        }

    }

    /**
     * Usage: java ChatServer <port>
     *
     * @param args a String array where args[0] includes port.
     */
    public static void main( String args[] ) {
        // check if args[0] has port
        if ( args.length != 1 ) {
            System.err.println( "Syntax: java Chatserver <port>" );
            System.exit( 1 );
        }

        // start a chat server
        new ChatServer( Integer.parseInt( args[0] ) );
    }

    /**
     * Represents a connection from a different chat client.
     */
    private class Connection {
        private Socket socket;         // a socket of this connection
        private InputStream rawIn;     // a byte-stream input from client
```

```java
    private OutputStream rawOut;  // a byte-stream output to client
    private DataInputStream in;   // a filtered input from client
    private DataOutputStream out; // a filtered output to client
    private String name;          // a client name
    private boolean alive;        // indicate if the connection is alive

    /**
     * Creates a new connection with a given socket
     *
     * @param client a socket representing a new chat client
     */
    public Connection( Socket client ) {
        socket = client;
        try {
            rawIn = socket.getInputStream();
            rawOut = socket.getOutputStream();
            in = new DataInputStream(rawIn);
            out = new DataOutputStream(rawOut);
            name = in.readUTF();
            alive = true;
            System.out.println(name);
        } catch (IOException e) {
            // TODO: handle exception
            e.printStackTrace();
        }
        // from socket, initialize rawIn, rawOut, in, and out.
        // the first message is a client name in unicode format
        // upon a successful initialization, alive should be true.
    }

    /**
     * Reads a new message in unicode format and returns it with this
     * client's name.
     *
     * @return a unicode message with the client's name
     */
    public String readMessage( ) {
        try {
            if(rawIn.available() > 0){
                String toReturn;
                toReturn = in.readUTF();
                System.out.println("Readmsg: " + toReturn);
                return name + ": " + toReturn;
            }else{
                //System.out.println("Unavailible readmsg");
```

```java
                    return null;
                }
            } catch (IOException e) {
                e.printStackTrace();
                return null;
            }

            // read a message if it's available.
            // don't block. use available( ).
            // if it returns a positive number, you can read it.
            // otherwise, skip reading.
        }

        /**
         * Writes a given message through this client's socket.
         *
         * @param message a String to write to the client
         */
        public void writeMessage( String message ) {
            try {
                // write a message
                System.out.println("Output: " + message);
                out.writeUTF(message);
                out.flush();
                // use flush( ) to send it immediately.
            } catch (IOException e) {
                alive = false;
                e.printStackTrace();
            }

            // if an exception occurs, you can identify that this connection
            // was gone.
        }

        /**
         * Checks if this connection is still live.
         */
        public boolean isAlive( ) {
            // if the connection was broken, return false.
            return alive;
        }
    }
}
```

Chat.java:

```
import java.net.*;  // ServerSocket, Socket
import java.util.ArrayList;
import java.util.Vector;
import java.io.*;   // InputStream, ObjectInputStream, ObjectOutputStream

public class Chat {
    // Each element i of the follwoing arrays represent a chat member[i]
    private Socket[] sockets = null;             // connection to i
    private InputStream[] indata = null;         // used to check data from i
    private ObjectInputStream[] inputs = null;   // a message from i
    private ObjectOutputStream[] outputs = null; // a message to i

    private int[] vector = null;
    private Vector<int[]> vec_queue = new Vector<int[]>();              //
maintains vector stamps from the others
    private Vector<String>  msg_queue = new Vector<String>( );      //
    private Vector<Integer> src_queue = new Vector<Integer>( );


    /**
     * Is the main body of the Chat application. This constructor establishes
     * a socket to each remote chat member, broadcasts a local user's message
     * to all the remote chat members, and receive a message from each of them.
     *
     * @param port  IP port used to connect to a remote node as well as to
     *              accept a connection from a remote node.
     * @param rank  this local node's rank (one of 0 through to #members - 1)
     * @param hosts a list of all computing nodes that participate in chatting
     */
    public Chat( int port, int rank, String[] hosts ) throws IOException {
        // print out my port, rank and local hostname
        System.out.println( "port = " + port + ", rank = " + rank +
                    ", localhost = " + hosts[rank] );

        // create sockets, inputs, outputs, and vector arrays
        sockets = new Socket[hosts.length];
        indata = new InputStream[hosts.length];
        inputs = new ObjectInputStream[hosts.length];
        outputs = new ObjectOutputStream[hosts.length];
        int[] vector = new int[hosts.length]; //this is the timestamp


        // establish a complete network
        ServerSocket server = new ServerSocket( port );
        for ( int i = hosts.length - 1; i >= 0; i-- ) {
```

```java
            if ( i > rank ) {
            // accept a connection from others with a higher rank
            Socket socket = server.accept( );
            String src_host = socket.getInetAddress( ).getHostName( );

            // find this source host's rank
            for ( int j = 0; j < hosts.length; j++ )
                if ( src_host.startsWith( hosts[j] ) ) {
                    // j is this source host's rank
                    System.out.println( "accepted from " + src_host );

                    // store this source host j's connection, input stream
                    // and object intput/output streams.
                    sockets[j] = socket;
                    indata[j]= socket.getInputStream( );
                    inputs[j] =
                        new ObjectInputStream( indata[j] );
                    outputs[j] =
                        new ObjectOutputStream( socket.getOutputStream( ));
                }
            }
            if ( i < rank ) {
                // establish a connection to others with a lower rank
                sockets[i] = new Socket( hosts[i], port );
                System.out.println( "connected to " + hosts[i] );

                // store this destination host j's connection, input stream
                // and object intput/output streams.
                outputs[i]
                    = new ObjectOutputStream( sockets[i].getOutputStream( ) );
                indata[i] = sockets[i].getInputStream( );
                inputs[i]
                    = new ObjectInputStream( indata[i] );
            }
        }

        // create a keyboard stream
        BufferedReader keyboard
            = new BufferedReader( new InputStreamReader( System.in ) );

        // now goes into a chat
        while ( true ) {
            // read a message from keyboard and broadcast it to all the others.
            if ( keyboard.ready( ) ) {
                // since keyboard is ready, read one line.
                String message = keyboard.readLine( );
            if ( message == null ) {
                // keyboard was closed by "^d"
                break; // terminate the program
            }
            // broadcast a message to each of the chat members.
            vector[rank] += 1; // v(gi)[i] = v(gi) + 1
            for ( int i = 0; i < hosts.length; i++ )
                if ( i != rank ) {
                    // of course I should not send a message to myself
                    outputs[i].writeObject( vector ); //sends vector
                    outputs[i].writeObject( message ); //sends message
                    outputs[i].flush( ); // make sure the message was sent
                }
            }

            // read a message from each of the chat members
            for ( int i = 0; i < hosts.length; i++ ) {
                // to intentionally create a misordered message deliveray,
                // let's slow down the chat member #2.
                try {
                    if ( rank == 2 )
                    Thread.currentThread( ).sleep( 5000 ); // sleep 5 sec.
                } catch ( InterruptedException e ) {}

                checkqueue(i, hosts, vector);

                // check if chat member #i has something
                if ( i != rank && indata[i].available( ) > 0 ) {
                    // read a message from chat member #i and print it out
                    // to the monitor
                    try {// insert filter here
                        //Read inputs[i].readObject( ). This will be a vector.
                        int[] sendVector = (int[])inputs[i].readObject( );

                        //read inputs[i].readObject( ) one more time. This will
be an actual message.
                        String message = (String)inputs[i].readObject( );

                        //check if this received vector and my vector. If this
received vector is ready to accept
                        boolean print = false;

                        for(int j = 0; j < vector.length; j++){ //For each
element
```

```
                            if(i == j){
                                if(sendVector[i]+1 == vector[i]){
                                    print = true;
                                    // sender’s vector[i] must be one larger than
the local host’s vector[i].
                                }
                            }else{ //i!== j
                                if(sendVector[j] <= vector[j]){
                                    print = true;
                                    // sender’s vector[i] must be smaller than or
equal to the local host’s vector[i].
                                }
                            }
                        }

                        if(print){
                            System.out.println( hosts[i] + ": " + message );
                            vector[i] += 1;
                        }else{
                        //Otherwise this received vector and message are not
ready to print out. Therefor,
                        //Enqueue this received vector into vec_queue.
                            vec_queue.addElement(sendVector);
                        //Enqueue the receive message into msg_queue.
                            msg_queue.add(message);
                        //Enguque Interger( i ), (i.e., this source process ID)
into src_queue.
                            src_queue.add(i);
                        }

                    } catch ( ClassNotFoundException e ) {}
                }
            }
        }
    }

    /**
     * Checkqueue
     * -----------------------------
     * this function would take in the host's ID, the list of hostnames
     * as well as the vector to update it
     * @param host
     * @param hostnames
     * @param vector
     */
    private void checkqueue(int host, String[] hostnames, int[] vector){
        if(src_queue.isEmpty() == false){
            for(int i = 0; i < vec_queue.size(); i++){ //checking the waitlist to
see if any of them are okay to send
                for(int j = 0; j < vector.length; j++){
                    if(host == j){
                        if(vec_queue.get(i)[host]+1 == vector[host]){
                            System.out.println(hostnames[src_queue.get(i)] + ":"
+ msg_queue.get(i));
                            vector[host] += 1;
                            msg_queue.remove(i);
                            vec_queue.remove(i);
                            src_queue.remove(i);
                            i--;
                        }
                    }else{
                        if(vec_queue.get(i)[j] <= vector[j]){
                            System.out.println(hostnames[src_queue.get(i)] + ":"
+ msg_queue.get(i));
                            vector[host] += 1;
                            msg_queue.remove(i);
                            vec_queue.remove(i);
                            src_queue.remove(i);
                            i--;
                        }
                    }
                    if(src_queue.isEmpty()){
                        break;
                    }
                }
            }
        }
    }


    /**
     * Is the main function that verifies the correctness of its arguments and
     * starts the application.
     *
     * @param args receives <port> <ip1> <ip2> ... where port is an IP port
     *             to establish a TCP connection and ip1, ip2, .... are a
     *             list of all computing nodes that participate in a chat.
     */
    public static void main( String[] args ) {
        // verify #args.
```

```java
        if ( args.length < 2 ) {
            System.err.println( "Syntax: java Chat <port> <ip1> <ip2> ..." );
            System.exit( -1 );
        }

        // retrieve the port
        int port = 0;
        try {
            port = Integer.parseInt( args[0] );
        } catch ( NumberFormatException e ) {
            e.printStackTrace( );
            System.exit( -1 );
        }
        if ( port <= 5000 ) {
            System.err.println( "port should be 5001 or larger" );
            System.exit( -1 );
        }

        // retireve my local hostname
        String localhost = null;
        try {
            localhost = InetAddress.getLocalHost( ).getHostName( );
        } catch ( UnknownHostException e ) {
            e.printStackTrace( );
            System.exit( -1 );
        }

        // store a list of computing nodes in hosts[] and check my rank
        int rank = -1;
        String[] hosts = new String[args.length - 1];
        for ( int i = 0; i < args.length - 1; i++ ) {
            hosts[i] = args[i + 1];
            if ( localhost.startsWith( hosts[i] ) )
            // found myself in the i-th member of hosts
            rank = i;
        }

        // now start the Chat application
        try {
            new Chat( port, rank, hosts );
        } catch ( IOException e ) {
            e.printStackTrace( );
            System.exit( -1 );
        }
    }
```

```
}
```