Networks Lab Report
Assignment 2

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1 Objectives

Implement three data link layer protocols, Stop and Wait, Go Back N Sliding Window and Selective Repeat Sliding Window for flow control.

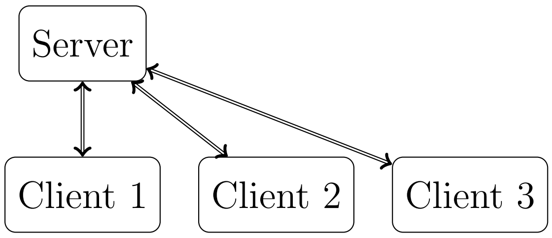
2 Design and Implementation

2.1 Program structure

The implementation is done using sockets. The clients and server communicate with each other using sockets. Listening on the channel is done through a separate thread (for both client and server). There can be multiple client instances. All the clients are connected to the central server.

2.1.1 The Server class

The server class instance acts as a medium to connect two clients. Whenever the server is starts listening and accepting client socket connections. Each time a client connection is made, its control is passed on to the client handler thread. The client handler thread then listens for incoming frames from the assigned client socket. The server also maintains a list of mappings of clients with port numbers and client addresses. When ever a client tries to connect to a server. The server maps the port number with the client address. When a client tries to sent messages to another client, the server checks the destination address of the message, finds the port mapped to the address and forwards the message to the destination client.



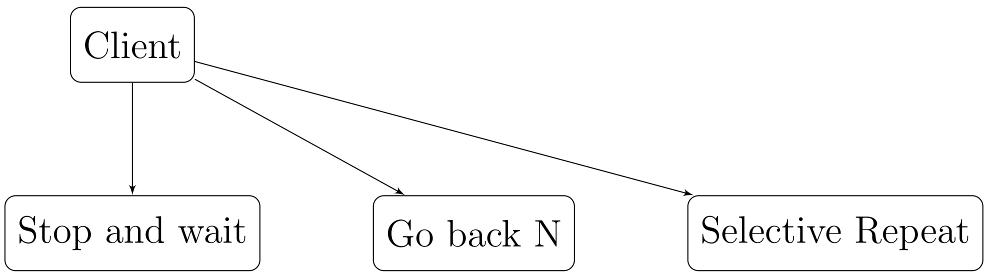
2.1.2 The Client class

The client class provides all the basic infrastructure for communication with the server. Listening is done on a separate thread for each client. Whenever a client tries to connect to a server, it sends a request to connect frame which contains the address of the client. In the server side, the server registers the port number and the address in its address list and sends back an request accept frame.
The Client class has six specialization subclasses. Each pair of subclass (a sender client and a receiver client) implements one of the three data link layer protocols.

Stop and Wait in SAWSenderClient and SAWReceiverClient

Go back N in GNSenderClient and GNReceiverClient

Selective Repeat in SRSenderClient and SRReceiverClient

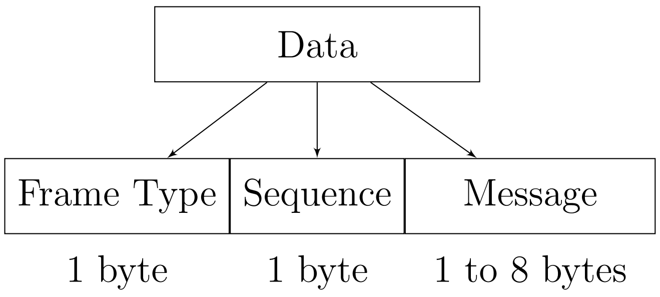


2.1.3 The Frame structure

Preamble	Destination	Source	Data
1 byte	1 byte	1 byte	1 to 10 bytes

Preamble stores information about the frame type.
If the preamble is set to 00000000 then it is for dhcpLite request
If the preamble is set to 00000001 then it is for dhcpLite granted
If the preamble is set to 00000010 then it is for dhcpLite rejected
If the preamble is set to 10000000 then it is for data transfer

For noisy channel, the Data bytes are further divided as follows:



Frame type specifies the type of frame:
00000000 signifies Message frame
10000000 signifies Awk frame
11000000 signifies Nak frame

3 Code snippets

3.1 Server

```java
package dllp;

import java.io.*;
import java.net.ServerSocket;
import java.net.Socket;
import java.util.*;

/**Frame format:
 * 1 byte premble
 * 1 bytes destination address
 * 1 bytes source address
 * 1 - 10 bytes of data
 *
 *
 * If the premble is set to 00000000 then it is for dhcpLite request
 * If the premble is set to 00000001 then it is for dhcpLite granted
 * If the premble is set to 00000010 then it is for dhcpLite rejected
 * If the premble is set to 10000000 then it is for data transfer
 */

public class Server {

```

```java
public static final String DHCPLITE_REQUEST   = "00000000";
public static final String DHCPLITE_GRANTED   = "00000001";
public static final String DHCPLITE_REJECTED  = "00000010";
public static final String DATA_TRANSFER  = "10000000";
public static final double ERROR_P    = 0.3;

private static Map<String, ClientHandler> dns = new HashMap<String,
↪  ClientHandler>();

private static class ClientHandler implements Runnable {
  private Socket soc;
  public PrintWriter out;
  public BufferedReader in;

  public ClientHandler(Socket s) {
    soc = s;
    try {
      out = new PrintWriter(soc.getOutputStream(), true);
      in = new BufferedReader(
        new InputStreamReader(
          soc.getInputStream()
          )
        );
    } catch (IOException e) {
      e.printStackTrace();
      System.exit(0);
    }
  }

  public void dataTranser(String msg) {
    /**Function for data tranfer between clients
     * void dataTranser(String message_to_be_send)
     * */
    String destination = msg.substring(8,16);
    String source = msg.substring(16,24);
    double p = Math.random();
    if(p>ERROR_P) {
      dns.get(destination).out.println(msg);
      System.out.println("Message passed from:"
          + source
          + " to:"
          + destination);
    } else {
      System.out.println("Error while passing message from:"
          + source
          + " to:"
          + destination);
    }
  }

  public void dhcpLite(String msg) {
    /**Function mac address registration on server
     * void dhcpLite(String dhcp_message_received_from_server)
     * */
    try {
      String mac_addr = msg.substring(8,16);
      if(dns.containsKey(mac_addr)) {
        out.println(DHCPLITE_REJECTED);
        soc.close();
      } else {
        dns.put(mac_addr,this);
        out.println(DHCPLITE_GRANTED);
        System.out.println("Connection established with:"
            + mac_addr
            + " at socket:"
            + soc.getRemoteSocketAddress().toString());
      }
    } catch (StringIndexOutOfBoundsException e) {
      System.out.println("Socket:"
          + soc.getRemoteSocketAddress()
          + " Requested an invalid mac_address registration");
      out.println(DHCPLITE_REJECTED);
    } catch (Exception e) {
      e.printStackTrace();
      System.exit(0);
    }
  }

  public void run() {
    System.out.println("Attempting to connect:"
        + soc.getRemoteSocketAddress().toString());

    /** starts listeining to client indefinitely */
    try {
      while(!soc.isClosed()) {
        if(in.ready()) {
          String msg = in.readLine();
          //System.out.println("Received:" + msg);
          if(msg.substring(0,8).equals(DHCPLITE_REQUEST))
            dhcpLite(msg);
          else if(msg.substring(0,8).equals(DATA_TRANSFER)) {
            //System.out.println("Data:" + msg);
            dataTranser(msg);
          }
          else
            System.out.println("Unknown premble:" + msg.substring(0,8));
        }
      }
    } catch (IOException e) {
      e.printStackTrace();
      System.exit(0);
    }
  }
}

public static int PORT = 8888;
public static void run() {
  try {
    ServerSocket serversocket = new ServerSocket(PORT);
    System.out.println("Server Started!");
    while(true) {
      Socket soc = serversocket.accept();
      new Thread(new ClientHandler(soc)).start();
    }
    //serversocket.close();
  } catch (IOException e) {
    e.printStackTrace();
  }
}


public static void main(String[] args) {
  run();
}
}
```

3.2 Generic Client

(It is an abstract class)

```java
package dllp;
import java.net.Socket;
import java.net.UnknownHostException;
import java.util.*;
import java.io.*;
import java.lang.Runnable;

public abstract class ClientClass {

  public static final String DHCPLITE_REQUEST   = "00000000";
  public static final String DHCPLITE_GRANTED   = "00000001";
  public static final String DHCPLITE_REJECTED  = "00000010";
  public static final String DATA_TRANSFER  = "10000000";

```

```
protected PrintWriter out;
protected BufferedReader in;
protected String mac_addr;
protected Socket soc;
protected Thread listenerThread;
protected static final Object obj = new Object();

private boolean dhcpLite(String mac) {
  /**Function to establish dhcpLite connection
   * It registers the mac accress of the client on the server dns
   * boolean dhcpLite(String mac_address)
   * If the mac address arguement is null
   * the client asks the user to enter a mac_address
   * */
  try {
    if(mac == null || mac.isEmpty()) {
      Scanner sc = new Scanner(System.in);
      System.out.print("Enter the mac address: ");
      mac_addr = sc.nextLine();
      while(mac_addr.length() != 8) {
        System.out.print("Please enter a valid mac address: ");
        mac_addr = sc.nextLine();
      }
      sc.close();
    } else {
      mac_addr = mac;
      if(mac_addr.length() != 8) {
        System.out.println("Invalid mac address for client");
        System.exit(0);
      }
    }

    out.println(DHCPLITE_REQUEST + mac_addr);
    String msg = in.readLine();
    if(msg.substring(0,8).equals(DHCPLITE_GRANTED)) {
      System.out.println("Connected Established");
      return true;
    } else if(msg.substring(0,8).equals(DHCPLITE_REJECTED)) {
      System.out.println("Connection denied by server dns!");
      return false;
    } else {
      System.out.println("Unexpected error occurred!");
      return false;
    }
  } catch (IOException e) {
    e.printStackTrace();
    System.exit(0);
  }

```

```java
  return false;
}

protected class Listener implements Runnable {
  /**Thread to listen to in comming messages */
  public void run() {
    try {
        while(soc.isConnected()) {
          if(in.ready()) {
            String msg = in.readLine();
            String premble = msg.substring(0,8);
            if(premble.equals(DATA_TRANSFER)) {
              //System.out.println("M:" + Integer.parseInt(msg.substring(8).substring(24,32),2));
              receiveMsg(msg.substring(8));
            }
          }
        }
    } catch (IOException e) {
      e.printStackTrace();
      System.exit(0);
    }
  }
}

protected void sendMsg(String msg, String destination_mac) {
  /** Function for sending messages to other clients */
  String message = DATA_TRANSFER + destination_mac + mac_addr + msg;
  out.println(message);
}

protected abstract void receiveMsg(String msg);

public void run(String mac) {
  try {
    soc = new Socket("localhost",8888);
    System.out.println("Client started with local address:" +
        soc.getLocalSocketAddress().toString()
        );
    out = new PrintWriter(soc.getOutputStream(), true);
    in = new BufferedReader(
      new InputStreamReader(
        soc.getInputStream()
        )
      );

    if(!dhcpLite(mac))
      return;

      listenerThread = new Thread(new Listener());
      listenerThread.start();

    } catch (UnknownHostException e) {
      e.printStackTrace();
      System.exit(0);
    } catch (IOException e) {
      e.printStackTrace();
      System.exit(0);
    }
  }
}
```

3.3 Stop and wait Sender client

```java
package dllp;

public class SAWReceiverClientClass extends ClientClass {
  /**Send and Wait data link layer protocol implementation */

  protected static final String SENDER_MAC_ADDR     = "10101010";
  protected static final String RECEIVER_MAC_ADDR   = "10101011";
  protected static final String MESSAGE_HEADER    = "00000000";
  protected static final String AWK_HEADER    = "10000000";

  protected String MSG;

  public SAWReceiverClientClass() {
    super();
  }


  public void run() {
    super.run(RECEIVER_MAC_ADDR);
    System.out.println("Receiver is listening...");
  }

  @Override
  protected void receiveMsg(String msg) {
    String dest_mac = msg.substring(0,8);
    String source_mac = msg.substring(8,16);
    String info = msg.substring(16,24);
    if(info.equals(MESSAGE_HEADER)) {
      super.sendMsg(AWK_HEADER,SENDER_MAC_ADDR);
      System.out.println("Message received: " + msg.substring(24) + " From client: " + source_mac);
      System.out.println("Sending Awk to:" + source_mac);
    }
  }
}
```

3.4 Stop and wait Receiver client

```
package dllp;

public class SAWReceiverClientClass extends ClientClass {
  /**Send and Wait data link layer protocol implementation */

  protected static final String SENDER_MAC_ADDR     = "10101010";
  protected static final String RECEIVER_MAC_ADDR   = "10101011";
  protected static final String MESSAGE_HEADER    = "00000000";
  protected static final String AWK_HEADER    = "10000000";

  protected String MSG;

  public SAWReceiverClientClass() {
    super();
  }


  public void run() {
    super.run(RECEIVER_MAC_ADDR);
    System.out.println("Receiver is listening...");
  }

  @Override
  protected void receiveMsg(String msg) {
    String dest_mac = msg.substring(0,8);
    String source_mac = msg.substring(8,16);
    String info = msg.substring(16,24);
    if(info.equals(MESSAGE_HEADER)) {
      super.sendMsg(AWK_HEADER,SENDER_MAC_ADDR);
      System.out.println("Message received: " + msg.substring(24) + " From
      ↪  client: " + source_mac);
      System.out.println("Sending Awk to:" + source_mac);
    }
  }
}
```

4 Results

4.1 Go back N

No of messages passed: 100
Error probability: 0.3
Total time elapsed: 9550ms
Thoughput: (100)/(9550/1000) = 10.471

4.2 Selective Repeat

No of messages passed: 50
Error probability: 0.3
Total time elapsed: 30070ms
Thoughput: (50)/(30070/1000) = 1.662

5 Output logs

Here are the logs of the two noisy channel algorithm. 100 messages were sent in the trial run for Go back N protocol, and 50 messages for Selective Repeat protocol.

5.1 Go Back N

5.1.1 Server log

```
Server Started!
Attempting to connect:/127.0.0.1:57972
Connection established with:10101011 at socket:/127.0.0.1:57972
Attempting to connect:/127.0.0.1:57990
Connection established with:10101010 at socket:/127.0.0.1:57990
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Error while passing message from:10101011 to:10101010
Message passed from:10101010 to:10101011
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Error while passing message from:10101010 to:10101011
```

```
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Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Message passed from:10101011 to:10101010
Message passed from:10101010 to:10101011
Error while passing message from:10101011 to:10101010
```

5.1.2 Sender client log

```
Client started with local address:/127.0.0.1:57990
Connected Established
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-1 received from:10101011 sf:0 sn:3
Sending Message-3: 000111 to:10101011
Timeout sf:1 sn:0
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Ack-2 received from:10101011 sf:1 sn:0
Sending Message-0: 000111 to:10101011
Ack-1 received from:10101011 sf:2 sn:1
Ack-1 received from:10101011 sf:3 sn:1
Ack-1 received from:10101011 sf:0 sn:1
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Sending Message-3: 000111 to:10101011
Ack-3 received from:10101011 sf:1 sn:0
Ack-3 received from:10101011 sf:2 sn:0
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Invalid Ack received with Ack no:0
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Invalid Ack received with Ack no:0
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-1 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Sending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Invalid Ack received with Ack no:0
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-2 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Timeout sf:2 sn:1
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Sending Message-1: 000111 to:10101011
Timeout sf:3 sn:2
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-2 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Ack-3 received from:10101011 sf:2 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
```

```
Timeout sf:3 sn:2
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Ack-1 received from:10101011 sf:0 sn:3
Sending Message-3: 000111 to:10101011
Ack-3 received from:10101011 sf:1 sn:0
Ack-3 received from:10101011 sf:2 sn:0
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Invalid Ack received with Ack no:0
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-2 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Ack-3 received from:10101011 sf:2 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Ack-1 received from:10101011 sf:3 sn:2
Ack-1 received from:10101011 sf:0 sn:2
Ack-2 received from:10101011 sf:1 sn:2
Sending Message-2: 000111 to:10101011
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Sending Message-1: 000111 to:10101011
Ack-2 received from:10101011 sf:3 sn:2
Ack-2 received from:10101011 sf:0 sn:2
Ack-2 received from:10101011 sf:1 sn:2
Sending Message-2: 000111 to:10101011
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Sending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-2 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-0 received from:10101011 sf:2 sn:1
Ack-0 received from:10101011 sf:3 sn:1
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Ack-1 received from:10101011 sf:0 sn:3
Sending Message-3: 000111 to:10101011
Ack-2 received from:10101011 sf:1 sn:0
Sending Message-0: 000111 to:10101011
Timeout sf:2 sn:1
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Sending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Ack-2 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-0 received from:10101011 sf:2 sn:1
Ack-0 received from:10101011 sf:3 sn:1
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Ack-1 received from:10101011 sf:0 sn:3
Sending Message-3: 000111 to:10101011
Ack-3 received from:10101011 sf:1 sn:0
Ack-3 received from:10101011 sf:2 sn:0
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Invalid Ack received with Ack no:3
Timeout sf:3 sn:2
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Ack-1 received from:10101011 sf:3 sn:2
Ack-1 received from:10101011 sf:0 sn:2
Ack-2 received from:10101011 sf:1 sn:2
Sending Message-2: 000111 to:10101011
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-0 received from:10101011 sf:2 sn:1
Ack-0 received from:10101011 sf:3 sn:1
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-3 received from:10101011 sf:0 sn:3
Ack-3 received from:10101011 sf:1 sn:3
Ack-3 received from:10101011 sf:2 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Ack-1 received from:10101011 sf:3 sn:2
Ack-1 received from:10101011 sf:0 sn:2
Sending Message-2: 000111 to:10101011
Sending Message-3: 000111 to:10101011
Timeout sf:1 sn:0
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Ack-2 received from:10101011 sf:1 sn:0
Sending Message-0: 000111 to:10101011
Invalid Ack received with Ack no:2
Timeout sf:2 sn:1
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Invalid Ack received with Ack no:2
Timeout sf:2 sn:1
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Timeout sf:2 sn:1
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Ack-0 received from:10101011 sf:3 sn:1
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Ack-2 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Sending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Ack-2 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Invalid Ack received with Ack no:2
Timeout sf:2 sn:1
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Ack-1 received from:10101011 sf:2 sn:1
Ack-1 received from:10101011 sf:3 sn:1
Ack-1 received from:10101011 sf:0 sn:1
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Sending Message-3: 000111 to:10101011
Ack-0 received from:10101011 sf:1 sn:0
Ack-0 received from:10101011 sf:2 sn:0
Ack-0 received from:10101011 sf:3 sn:0
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Ack-1 received from:10101011 sf:0 sn:3
Sending Message-3: 000111 to:10101011
Timeout sf:1 sn:0
```

```
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Invalid Ack received with Ack no:1
Timeout sf:1 sn:0
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Ack-2 received from:10101011 sf:1 sn:0
Ack-3 received from:10101011 sf:2 sn:0
Ack-0 received from:10101011 sf:3 sn:0
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Ack-2 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Sending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-1 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Sending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-1 received from:10101011 sf:0 sn:3
Sending Message-3: 000111 to:10101011
Invalid Ack received with Ack no:1
Timeout sf:1 sn:0
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Reseending Message-3: 000111 to:10101011
Ack-2 received from:10101011 sf:1 sn:0
Ack-3 received from:10101011 sf:2 sn:0
Ack-0 received from:10101011 sf:3 sn:0
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Ack-2 received from:10101011 sf:0 sn:3
Ack-2 received from:10101011 sf:1 sn:3
Sending Message-3: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-3 received from:10101011 sf:2 sn:1
Sending Message-1: 000111 to:10101011
Invalid Ack received with Ack no:3
Timeout sf:3 sn:2
Reseending Message-3: 000111 to:10101011
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sf:3 sn:2
Sending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Timeout sf:0 sn:3
Reseending Message-0: 000111 to:10101011
Reseending Message-1: 000111 to:10101011
Reseending Message-2: 000111 to:10101011
Ack-3 received from:10101011 sf:0 sn:3
Ack-3 received from:10101011 sf:1 sn:3
Ack-3 received from:10101011 sf:2 sn:3
Sending Message-3: 000111 to:10101011
```

5.1.3 Receiver client log

```
      Client started with local address:/127.0.0.1:57972
      Connected Established
      Receiver is listening.
      Incorrect seqNO received, expected:0 got:1
      Resending Awk-0 to:10101010
      Message-0 received: 00000000000111 From client: 10101010
count:0
      Sending Awk-1 to:10101010
      Incorrect seqNO received, expected:1 got:2
      Message-1 received: 00000001000111 From client: 10101010
count:1
      Sending Awk-2 to:10101010
      Message-2 received: 00000010000111 From client: 10101010
count:2
      Sending Awk-3 to:10101010
      Message-3 received: 00000011000111 From client: 10101010
count:3
      Sending Awk-0 to:10101010
      Message-0 received: 00000000000111 From client: 10101010
count:4
      Sending Awk-1 to:10101010
      Message-1 received: 00000001000111 From client: 10101010
count:5
      Sending Awk-2 to:10101010
      Message-2 received: 00000010000111 From client: 10101010
count:6
      Sending Awk-3 to:10101010
      Message-3 received: 00000011000111 From client: 10101010
count:7
      Sending Awk-0 to:10101010
      Resending Awk-0 to:10101010
      Incorrect seqNO received, expected:0 got:1
      Incorrect seqNO received, expected:0 got:1
      Resending Awk-0 to:10101010
      Incorrect seqNO received, expected:0 got:1
      Message-0 received: 00000000000111 From client: 10101010
count:8
      Sending Awk-1 to:10101010
      Message-1 received: 00000001000111 From client: 10101010
count:9
      Sending Awk-2 to:10101010
      Message-2 received: 00000010000111 From client: 10101010
count:10
      Sending Awk-3 to:10101010
      Message-3 received: 00000011000111 From client: 10101010
count:11
      Sending Awk-0 to:10101010
      Incorrect seqNO received, expected:0 got:1
      Resending Awk-0 to:10101010
      Message-0 received: 00000000000111 From client: 10101010
count:12
      Sending Awk-1 to:10101010
      Message-1 received: 00000001000111 From client: 10101010
count:13
      Sending Awk-2 to:10101010
      Incorrect seqNO received, expected:2 got:3
      Resending Awk-2 to:10101010
      Message-2 received: 00000010000111 From client: 10101010
count:14
      Sending Awk-3 to:10101010
      Message-3 received: 00000011000111 From client: 10101010
count:15
      Sending Awk-0 to:10101010
      Message-0 received: 00000000000111 From client: 10101010
count:16
      Sending Awk-1 to:10101010
      Incorrect seqNO received, expected:1 got:2
      Message-1 received: 00000001000111 From client: 10101010
count:17
      Sending Awk-2 to:10101010
      Message-2 received: 00000010000111 From client: 10101010
count:18
      Sending Awk-3 to:10101010
      Incorrect seqNO received, expected:3 got:0
```

```
        Message-3 received: 00000011000111 From client: 10101010
count:19
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:20
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:21
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:22
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:23
        Sending Awk-0 to:10101010
        Incorrect seqNO received, expected:0 got:1
        Resending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:24
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:25
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:26
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:27
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:28
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:29
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:30
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:31
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:32
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:33
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:34
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:35
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:36
        Sending Awk-1 to:10101010
        Incorrect seqNO received, expected:1 got:2
        Message-1 received: 00000001000111 From client: 10101010
count:37
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:38
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:39
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:40
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:41
        Sending Awk-2 to:10101010
        Incorrect seqNO received, expected:2 got:3
        Message-2 received: 00000010000111 From client: 10101010
count:42
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:43
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:44
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:45
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:46
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:47
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:48
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:49
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:50
        Sending Awk-3 to:10101010
        Resending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:51
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:52
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:53
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:54
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:55
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:56
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:57
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:58
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:59
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:60
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:61
        Sending Awk-2 to:10101010
        Incorrect seqNO received, expected:2 got:3
        Resending Awk-2 to:10101010
        Incorrect seqNO received, expected:2 got:3
        Resending Awk-2 to:10101010
        Incorrect seqNO received, expected:2 got:3
        Resending Awk-2 to:10101010
        Incorrect seqNO received, expected:2 got:3
        Resending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:62
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:63
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:64
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:65
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:66
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:67
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:68
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:69
```

```
        Sending Awk-2 to:10101010
        Incorrect seqNO received, expected:2 got:3
        Resending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:70
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:71
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:72
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:73
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:74
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:75
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:76
        Sending Awk-1 to:10101010
        Incorrect seqNO received, expected:1 got:2
        Incorrect seqNO received, expected:1 got:2
        Resending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:77
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:78
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:79
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:80
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:81
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:82
        Sending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:83
        Sending Awk-0 to:10101010
        Sending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:94
        Sending Awk-3 to:10101010
        Incorrect seqNO received, expected:3 got:0
        Resending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:95
        Sending Awk-0 to:10101010
        Message-0 received: 00000000000111 From client: 10101010
count:96
        Sending Awk-1 to:10101010
        Message-1 received: 00000001000111 From client: 10101010
count:97
        Sending Awk-2 to:10101010
        Resending Awk-2 to:10101010
        Resending Awk-2 to:10101010
        Message-2 received: 00000010000111 From client: 10101010
count:98
        Sending Awk-3 to:10101010
        Incorrect seqNO received, expected:3 got:0
        Resending Awk-3 to:10101010
        Resending Awk-3 to:10101010
        Message-3 received: 00000011000111 From client: 10101010
count:99
        Sending Awk-0 to:10101010
        Time elapsed(in ms): 9550
```

5.2 Selective Repeat

5.2.1 Server log

```
        erver Started!
        Attempting to connect:/127.0.0.1:53752
        Connection established with:10101011 at socket:/127.0.0.1:53752
        Attempting to connect:/127.0.0.1:53754
        Connection established with:10101010 at socket:/127.0.0.1:53754
        Error while passing message from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101011 to:10101010
        Message passed from:10101010 to:10101011
        Message passed from:10101011 to:10101010
        Error while passing message from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101011 to:10101010
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101011 to:10101010
        Message passed from:10101011 to:10101010
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101011 to:10101010
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101011 to:10101010
        Error while passing message from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101011 to:10101010
        Message passed from:10101010 to:10101011
        Error while passing message from:10101011 to:10101010
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Error while passing message from:10101011 to:10101010
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101011 to:10101010
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Error while passing message from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
        Error while passing message from:10101011 to:10101010
        Message passed from:10101010 to:10101011
        Message passed from:10101010 to:10101011
```

```
Message passed from:10101011 to:10101010
Error while passing message from:10101011 to:10101010
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
Error while passing message from:10101011 to:10101010
Error while passing message from:10101011 to:10101010
Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
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Error while passing message from:10101010 to:10101011
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Error while passing message from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
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Error while passing message from:10101010 to:10101011
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Error while passing message from:10101010 to:10101011
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Message passed from:10101010 to:10101011
Error while passing message from:10101011 to:10101010
Error while passing message from:10101011 to:10101010
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Error while passing message from:10101010 to:10101011
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Error while passing message from:10101010 to:10101011
Error while passing message from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Error while passing message from:10101011 to:10101010
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Error while passing message from:10101011 to:10101010
Message passed from:10101011 to:10101010
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
```

```
Error while passing message from:10101011 to:10101010
Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
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Message passed from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
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Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
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Message passed from:10101011 to:10101010
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Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
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Error while passing message from:10101010 to:10101011
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Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101010 to:10101011
Message passed from:10101011 to:10101010
Message passed from:10101010 to:10101011
Error while passing message from:10101011 to:10101010
Message passed from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
Error while passing message from:10101010 to:10101011
Message passed from:10101010 to:10101011
```

5.2.2 Sender client log

```
lient started with local address:/127.0.0.1:53754
Connected Established
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Sending Message-3: 000111 to:10101011
Nak-0 received from:10101011 sn:4 sf:0 sw:4
Resending Message-0: 000111 to:10101011
Ack-1 received from:10101011 sn:4 sf:1 sw:4
Sending Message-4: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 3
Resending Message-3: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Ack-2 received from:10101011 sn:5 sf:2 sw:4
Sending Message-5: 000111 to:10101011
Timer timeout - 4
Resending Message-4: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 3
Resending Message-3: 000111 to:10101011
Ack-3 received from:10101011 sn:6 sf:3 sw:4
Sending Message-6: 000111 to:10101011
Ack-4 received from:10101011 sn:7 sf:4 sw:4
Sending Message-7: 000111 to:10101011
Timer timeout - 5
Resending Message-5: 000111 to:10101011
Timer timeout - 4
Resending Message-4: 000111 to:10101011
Ack-5 received from:10101011 sn:0 sf:5 sw:4
Sending Message-0: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Timer timeout - 5
Resending Message-5: 000111 to:10101011
Ack-6 received from:10101011 sn:1 sf:6 sw:4
Sending Message-1: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Ack-7 received from:10101011 sn:2 sf:7 sw:4
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Sending Message-2: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Ack-2 received from:10101011 sn:3 sf:0 sw:4
Ack-2 received from:10101011 sn:3 sf:1 sw:4
Ack-2 received from:10101011 sn:3 sf:2 sw:4
Sending Message-3: 000111 to:10101011
Sending Message-4: 000111 to:10101011
Sending Message-5: 000111 to:10101011
Timer timeout - 3
Timer timeout - 4
Resending Message-4: 000111 to:10101011
Resending Message-3: 000111 to:10101011
Timer timeout - 5
Resending Message-5: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 3
Timer timeout - 4
Resending Message-3: 000111 to:10101011
Resending Message-4: 000111 to:10101011
Timer timeout - 5
Resending Message-5: 000111 to:10101011
Ack-4 received from:10101011 sn:6 sf:3 sw:4
Ack-4 received from:10101011 sn:6 sf:4 sw:4
Sending Message-6: 000111 to:10101011
Sending Message-7: 000111 to:10101011
Ack-6 received from:10101011 sn:0 sf:5 sw:4
Ack-6 received from:10101011 sn:0 sf:6 sw:4
Sending Message-0: 000111 to:10101011
Sending Message-1: 000111 to:10101011
Timer timeout - 6
Timer timeout - 7
Resending Message-6: 000111 to:10101011
Resending Message-7: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Ack-1 received from:10101011 sn:2 sf:7 sw:4
Ack-1 received from:10101011 sn:2 sf:0 sw:4
Ack-1 received from:10101011 sn:2 sf:1 sw:4
Sending Message-2: 000111 to:10101011
Sending Message-3: 000111 to:10101011
Sending Message-4: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 4
Timer timeout - 3
Resending Message-4: 000111 to:10101011
Resending Message-3: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 4
Resending Message-4: 000111 to:10101011
Timer timeout - 3
Resending Message-3: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Timer timeout - 2
Timer timeout - 4
Resending Message-2: 000111 to:10101011
Timer timeout - 3
Resending Message-4: 000111 to:10101011
Resending Message-3: 000111 to:10101011
Ack-3 received from:10101011 sn:5 sf:2 sw:4
Ack-3 received from:10101011 sn:5 sf:3 sw:4
Ack-4 received from:10101011 sn:5 sf:4 sw:4
Sending Message-5: 000111 to:10101011
Sending Message-6: 000111 to:10101011
Sending Message-7: 000111 to:10101011
Ack-5 received from:10101011 sn:0 sf:5 sw:4
Sending Message-0: 000111 to:10101011
Ack-6 received from:10101011 sn:1 sf:6 sw:4
Sending Message-1: 000111 to:10101011
Timer timeout - 6
Timer timeout - 7
Resending Message-6: 000111 to:10101011
Resending Message-7: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Ack-7 received from:10101011 sn:2 sf:7 sw:4
Sending Message-2: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
```

```
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 7
Timer timeout - 0
Resending Message-7: 000111 to:10101011
Resending Message-0: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Ack-2 received from:10101011 sn:3 sf:0 sw:4
Ack-2 received from:10101011 sn:3 sf:1 sw:4
Ack-2 received from:10101011 sn:3 sf:2 sw:4
Sending Message-3: 000111 to:10101011
Sending Message-4: 000111 to:10101011
Sending Message-5: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Ack-3 received from:10101011 sn:6 sf:3 sw:4
Sending Message-6: 000111 to:10101011
Timer timeout - 3
Timer timeout - 4
Timer timeout - 5
Resending Message-5: 000111 to:10101011
Resending Message-3: 000111 to:10101011
Resending Message-4: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Timer timeout - 3
Timer timeout - 5
Resending Message-3: 000111 to:10101011
Timer timeout - 4
Resending Message-5: 000111 to:10101011
Resending Message-4: 000111 to:10101011
Ack-5 received from:10101011 sn:7 sf:4 sw:4
Ack-5 received from:10101011 sn:7 sf:5 sw:4
Sending Message-7: 000111 to:10101011
Sending Message-0: 000111 to:10101011
Ack-6 received from:10101011 sn:1 sf:6 sw:4
Sending Message-1: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Timer timeout - 7
Timer timeout - 0
Resending Message-7: 000111 to:10101011
Resending Message-0: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Ack-0 received from:10101011 sn:2 sf:7 sw:4
Ack-0 received from:10101011 sn:2 sf:0 sw:4
Sending Message-2: 000111 to:10101011
Sending Message-3: 000111 to:10101011
Ack-2 received from:10101011 sn:4 sf:1 sw:4
Ack-2 received from:10101011 sn:4 sf:2 sw:4
Sending Message-4: 000111 to:10101011
Sending Message-5: 000111 to:10101011
Ack-4 received from:10101011 sn:6 sf:3 sw:4
Ack-4 received from:10101011 sn:6 sf:4 sw:4
Sending Message-6: 000111 to:10101011
Sending Message-7: 000111 to:10101011
Timer timeout - 5
Timer timeout - 4
Resending Message-5: 000111 to:10101011
Resending Message-4: 000111 to:10101011
Ack-5 received from:10101011 sn:0 sf:5 sw:4
Sending Message-0: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Timer timeout - 5
Resending Message-5: 000111 to:10101011
Ack-6 received from:10101011 sn:1 sf:6 sw:4
Sending Message-1: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Ack-7 received from:10101011 sn:2 sf:7 sw:4
Sending Message-2: 000111 to:10101011
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Ack-0 received from:10101011 sn:3 sf:0 sw:4
Sending Message-3: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Ack-1 received from:10101011 sn:4 sf:1 sw:4
Sending Message-4: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Timer timeout - 3
Resending Message-3: 000111 to:10101011
Timer timeout - 4
Resending Message-4: 000111 to:10101011
Timer timeout - 1
Resending Message-1: 000111 to:10101011
Ack-2 received from:10101011 sn:5 sf:2 sw:4
Sending Message-5: 000111 to:10101011
Timer timeout - 2
Resending Message-2: 000111 to:10101011
Ack-3 received from:10101011 sn:6 sf:3 sw:4
Sending Message-6: 000111 to:10101011
Timer timeout - 3
Resending Message-3: 000111 to:10101011
Ack-4 received from:10101011 sn:7 sf:4 sw:4
Sending Message-7: 000111 to:10101011
Timer timeout - 5
Resending Message-5: 000111 to:10101011
Timer timeout - 4
Resending Message-4: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Timer timeout - 5
Resending Message-5: 000111 to:10101011
Timer timeout - 4
Resending Message-4: 000111 to:10101011
Ack-5 received from:10101011 sn:0 sf:5 sw:4
Sending Message-0: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Timer timeout - 5
Resending Message-5: 000111 to:10101011
Timer timeout - 6
Resending Message-6: 000111 to:10101011
Ack-7 received from:10101011 sn:1 sf:6 sw:4
Ack-7 received from:10101011 sn:1 sf:7 sw:4
Sending Message-1: 000111 to:10101011
Timer timeout - 7
Resending Message-7: 000111 to:10101011
Timer timeout - 0
Resending Message-0: 000111 to:10101011
Timer timeout - 1
```

5.2.3 Receiver client log

```
Client started with local address:/127.0.0.1:53752
Connected Established
Receiver is listening...
Sending Nak-0 to:10101010
Message-0 received: 000111 from client: 10101010 count:0
Sending Awk-1 to:10101010
Message-1 received: 000111 from client: 10101010 count:1
Sending Awk-2 to:10101010
Message-2 received: 000111 from client: 10101010 count:2
Sending Awk-3 to:10101010
Message-3 received: 000111 from client: 10101010 count:3
Sending Awk-4 to:10101010
Message-4 received: 000111 from client: 10101010 count:4
Sending Awk-5 to:10101010
Message-5 received: 000111 from client: 10101010 count:5
Sending Awk-6 to:10101010
Message-6 received: 000111 from client: 10101010 count:6
Sending Awk-7 to:10101010
Message-7 received: 000111 from client: 10101010 count:7
Sending Awk-0 to:10101010
Message-0 received: 000111 from client: 10101010 count:8
Sending Awk-1 to:10101010
Message-1 received: 000111 from client: 10101010 count:9
Sending Awk-2 to:10101010
Message-2 received: 000111 from client: 10101010 count:10
Sending Awk-3 to:10101010
Message-3 received: 000111 from client: 10101010 count:11
Sending Awk-4 to:10101010
Message-4 received: 000111 from client: 10101010 count:12
Sending Awk-5 to:10101010
Message-5 received: 000111 from client: 10101010 count:13
Sending Awk-6 to:10101010
Message-6 received: 000111 from client: 10101010 count:14
Sending Awk-7 to:10101010
Message-7 received: 000111 from client: 10101010 count:15
Sending Awk-0 to:10101010
Message-0 received: 000111 from client: 10101010 count:16
Sending Awk-1 to:10101010
Message-1 received: 000111 from client: 10101010 count:17
Sending Awk-2 to:10101010
Message-2 received: 000111 from client: 10101010 count:18
Sending Awk-3 to:10101010
Message-3 received: 000111 from client: 10101010 count:19
Sending Awk-4 to:10101010
Message-4 received: 000111 from client: 10101010 count:20
Sending Awk-5 to:10101010
Message-5 received: 000111 from client: 10101010 count:21
Sending Awk-6 to:10101010
Message-6 received: 000111 from client: 10101010 count:22
Sending Awk-7 to:10101010
Message-7 received: 000111 from client: 10101010 count:23
Sending Awk-0 to:10101010
Message-0 received: 000111 from client: 10101010 count:24
Sending Awk-1 to:10101010
Message-1 received: 000111 from client: 10101010 count:25
Sending Awk-2 to:10101010
Message-2 received: 000111 from client: 10101010 count:26
Sending Awk-3 to:10101010
Message-3 received: 000111 from client: 10101010 count:27
Sending Awk-4 to:10101010
Message-4 received: 000111 from client: 10101010 count:28
Sending Awk-5 to:10101010
Message-5 received: 000111 from client: 10101010 count:29
Sending Awk-6 to:10101010
Message-6 received: 000111 from client: 10101010 count:30
Sending Awk-7 to:10101010
Message-7 received: 000111 from client: 10101010 count:31
Sending Awk-0 to:10101010
Message-0 received: 000111 from client: 10101010 count:32
Sending Awk-1 to:10101010
Message-1 received: 000111 from client: 10101010 count:33
Sending Awk-2 to:10101010
Message-2 received: 000111 from client: 10101010 count:34
Sending Awk-3 to:10101010
Message-3 received: 000111 from client: 10101010 count:35
Sending Awk-4 to:10101010
Message-4 received: 000111 from client: 10101010 count:36
Sending Awk-5 to:10101010
Message-5 received: 000111 from client: 10101010 count:37
Sending Awk-6 to:10101010
Message-6 received: 000111 from client: 10101010 count:38
Sending Awk-7 to:10101010
Message-7 received: 000111 from client: 10101010 count:39
Sending Awk-0 to:10101010
Message-0 received: 000111 from client: 10101010 count:40
Sending Awk-1 to:10101010
Message-1 received: 000111 from client: 10101010 count:41
Sending Awk-2 to:10101010
Message-2 received: 000111 from client: 10101010 count:42
Sending Awk-3 to:10101010
Message-3 received: 000111 from client: 10101010 count:43
Sending Awk-4 to:10101010
Message-4 received: 000111 from client: 10101010 count:44
Sending Awk-5 to:10101010
Message-5 received: 000111 from client: 10101010 count:45
Sending Awk-6 to:10101010
Message-6 received: 000111 from client: 10101010 count:46
Sending Awk-7 to:10101010
Message-7 received: 000111 from client: 10101010 count:47
Sending Awk-0 to:10101010
Message-0 received: 000111 from client: 10101010 count:48
Sending Awk-1 to:10101010
Message-1 received: 000111 from client: 10101010 count:49
Sending Awk-2 to:10101010
Time elapsed(in ms): 30070
```

6 Comments

- I faced a lot of problems with synchronizing threads. Especially in the Selective Repeat protocol. In that protocol each timer runs in a different thread, Receiver client listens in a separate thread. Sender client sends and receives in two different threads.
- I implemented the assignment in java. But I felt that it would have been a lot easier if implemented in Python. Implementing in java took me total of 1266 lines and a lot of sleepless nights. 1 week was certainly not enough time to complete the assignment.
- Java is not a event driven language. But the protocols are event driven. Thus I felt, implementing the protocols this way took a lot of effort, and shifted the focus of the assignment from learning the use of the protocols to thread synchronization in java. I felt that if we had an event driven environment available the assignment would have been a lot easier.
- Regardless of all the difficulties faces, I learnt a lot about sockets and threads and the flow control protocols.