Computer Networks Lab Report – Assignment 2

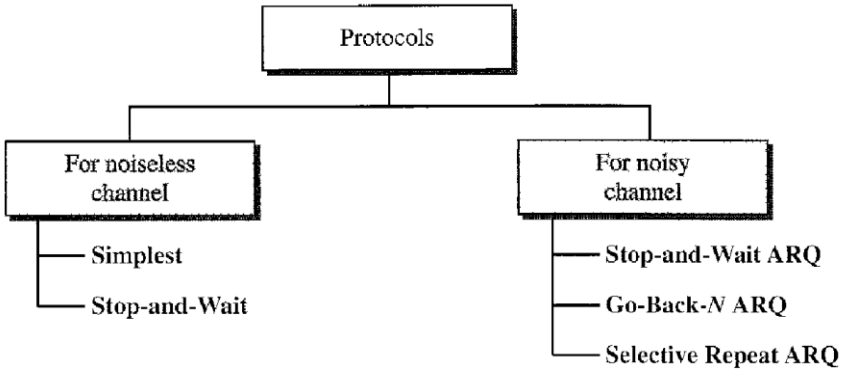
TITLE

Name – Sourav Dutta
Roll – 001610501076
Class – BCSE 3rd year
Group – A3
Assignment Number – 2

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

Sender, Receiver and Channel all are independent processes. There may be multiple Transmitter and Receiver processes, but only one Channel process. The channel process introduces random delay and/or bit error while transferring frames. Define your own frame format or you may use IEEE 802.3 Ethernet frame format.
Hints: Some points you may consider in your design.
Following functions may be required in Sender.
Send: This function, invoked every time slot at the sender, decides if the sender should (1) do nothing, (2) retransmit the previous data frame due to a timeout, or (3) send a new data frame. Also, you have to consider current network time measure in time slots.
Recv_Ack: This function is invoked whenever an ACK packet is received. Need to consider network time when the ACK was received, ack_num and timestamp are the sender's sequence number and timestamp that were echoed in the ACK. This function must call the timeout function.
Timeout: This function should be called by ACK method to compute the most recent data packet's round-trip time and then recompute the value of timeout.
Following functions may be required in Receiver.
Recv: This function at the receiver is invoked upon receiving a data frame from the sender.
Send_Ack: This function is required to build the ACK and transmit.
Sliding window:
The sliding window protocols (Go-Back-N and Selective Repeat) extend the stop-and-wait protocol by allowing the sender to have multiple frames outstanding (i.e., unacknowledged) at any given time. The maximum number of unacknowledged frames at the sender cannot exceed its "window size". Upon receiving a frame, the receiver sends an ACK for the frame's sequence number. The receiver then buffers the received frames and delivers them in sequence number order to the application.
Performance metrics: Receiver Throughput (packets per time slot), RTT, bandwidth-delay product, utilization percentage.
Submission date – 07/03/2019

DESIGN

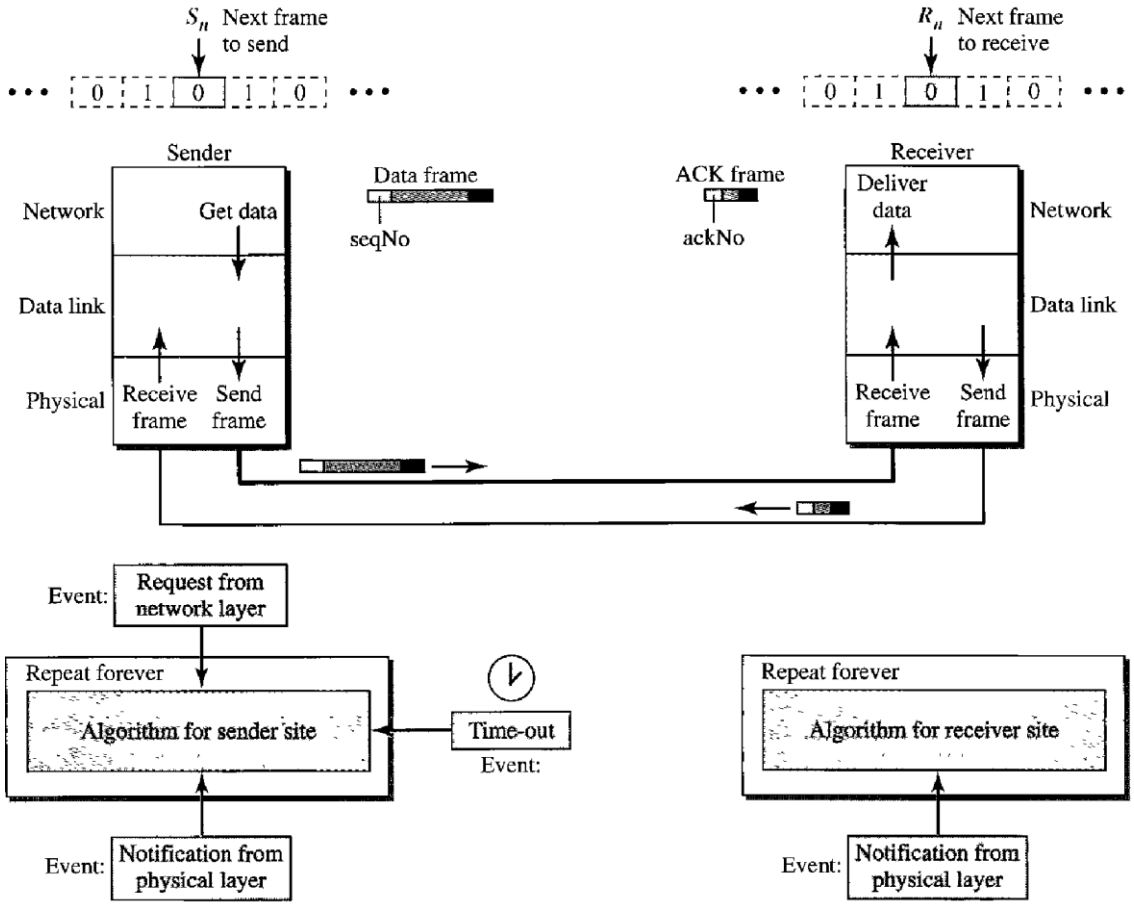


We will see how the data link layer can combine framing, flow control and error control to achieve the delivery of data from one node to another. In our implementation, as the channel will be injecting errors, we are going to implement the three protocols for noisy channel.

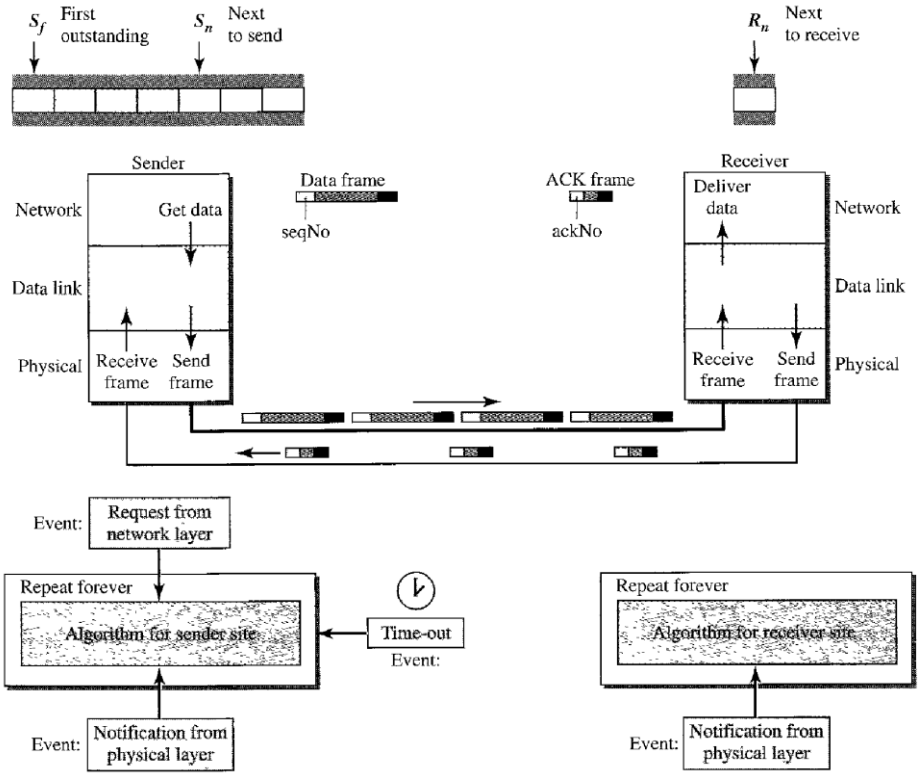
In this assignment, we shall discuss the following data link layer protocols in detail.

1. Stop and Wait protocol
2. Go Back N Sliding Window protocol
3. Selective Repeat Sliding Window protocol

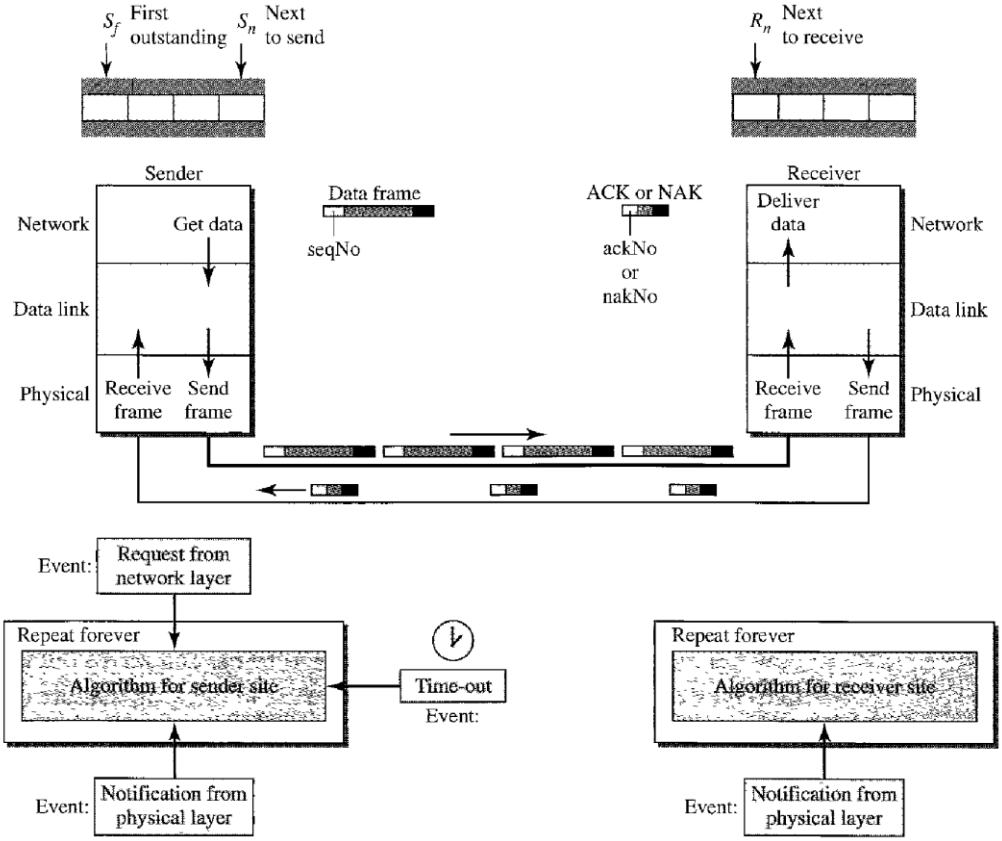
DESIGN OF STOP AND WAIT PROTOCOL:



DESIGN OF GO BACK N SLIDING WINDOW PROTOCOL:



DESIGN OF SELECTIVE REPEAT SLIDING WINDOW PROTOCOL:



I have implemented the error detection module in three program files.

- **sender.py** (Sender program (we can create multiple sender processes))
- **channel.py** (Program for single channel process)
- **receiver.py** (Receiver program (we can create multiple receiver processes))

The individual files fulfils different assignment purposes, following which have been explained in details :

1. **sender.py** – The following are the tasks performed in this Sender program :
    a. We can create more than one sender processes, to send a message to channel.
    b. It first waits for the user to input a binary input string.
    c. The appropriate frame is created using the above input string.
    d. This frame is then sent to channel.
    e. It waits for a ACK/NAK to be received from channel, notifying the successful delivery of binary input message.
    f. If it does not receives a ACK/NAK for a time period of 2s, it resends again(according to the protocols defined).

2. **channel.py** – The following are the tasks performed in this Channel program :
    a. The channel process first takes number of senders and receivers as input.
    b. It initiates and connects all the sender and receiver processes.
    c. It receives the frame from any of the current senders.
    d. It then injects error randomly into the data frame.
    e. Then the frame is sent to one of the receiver process.
    f. The receiver then sends a ACK/NAK for the data received, to the channel.
    g. The channel then passes the ACK/NAK status to its corresponding sender.

3. **receiver.py** – The following are the tasks performed in this Receiver program :
    a. The receiver process first waits for a message to be received from channel.
    b. It then adds a random amount of time delay, before the message is sent back to its channel.
    c. It checks for any error in the data frame received, and sends a message ACK/NAK accordingly.
    d. The above message is then sent to channel.

IMPLEMENTATION

1. STOP AND WAIT PROTOCOL

Code Snippet of sender.py:

```
import socket
import sys
import time
def createFrame(data):
      countOnes = 0
      for ch in data:
            if ch == '1':
                  countOnes += 1
      data += str(countOnes%2)
      return data

def Main(senderno):
      print('Initiating Sender #',senderno)
      host = '127.0.0.1'
      port = 8080

      mySocket = socket.socket()
```

```
	mySocket.connect((host, port))

	while True:
		print()
		data = input("Enter $ ")
		prevtime = time.time()
		data = createFrame(data)
		print('Sending to channel :',str(data))
		mySocket.send(data.encode())
		if not data:
			break
		if data == 'q0':
			break
		rdata = mySocket.recv(1024).decode()
		print('Received from channel :',str(rdata))
		curtime = time.time()
		print('Round trip time: ',str(curtime-prevtime))
		if curtime-prevtime > 2:
			timeout = 1
		else:
			timeout = 0
		fileout = open('checktime.txt', "w")
		fileout.write(str(timeout))
		fileout.close()
		while timeout==1:
			print()
			prevtime = time.time()
			if timeout == 1:
				print('TIMEOUT of 2s EXPIRED !!')
			else:
				print('THE FRAME GOT CORRUPTED !!!')
			print('Again Sending to channel :',str(data))
			mySocket.send(data.encode())
			rdata = mySocket.recv(1024).decode()
			print('Again Received from channel :',str(rdata))
			curtime = time.time()
			print('Round trip time:',str(curtime-prevtime),'seconds')
			#print('Bandwidth-delay product:',str((curtime-
prevtime)*8),'bits/seconds')
			if curtime-prevtime > 2:
				timeout = 1
			else:
				timeout = 0
			fileout = open('checktime.txt', "w")
			fileout.write(str(timeout))
			fileout.close()

	mySocket.close()

if __name__ == '__main__':
	if len(sys.argv) > 1:
		senderno = int(sys.argv[1])
	else:
		senderno = 1
	Main(senderno)
```

Code Snippet of receiver.py:

```
import socket
import sys
import time
import random
```

```
def waitRandomTime():
      x = random.randint(0,5)
      if x <= 1:
            time.sleep(2)

def checkError(frame):
      countOnes = 0
      for ch in frame:
            if ch == '1':
                  countOnes += 1
      return countOnes%2

def Main(senderno):
      print('Initiating Receiver #',senderno)
      host = '127.0.0.2'
      port = 9090

      mySocket = socket.socket()
      mySocket.connect((host, port))

      while True:
            print()
            data = mySocket.recv(1024).decode()
            if not data:
                  break
            if data == 'q0':
                  break

            print('Received from channel :', str(data))
            waitRandomTime()
            if checkError(data) == 0:
                  rdata = 'ACK'
            else:
                  time.sleep(2)
                  rdata = 'TIMEOUT'

            print('Sending to channel :',str(rdata))
            mySocket.send(rdata.encode())
      mySocket.close()

if __name__ == '__main__':
      if len(sys.argv) > 1:
            senderno = int(sys.argv[1])
      else:
            senderno = 1
      Main(senderno)
```

Code Snippet of channel.py:

```
import socket
import time
import subprocess
import random
import os

def injectRandomError(frame):
      pos = random.randint(0, len(frame)-1)
      frame = frame[:pos]+'1'+frame[pos+1:]
      return frame

class Channel():

      def __init__(self, totalsender, totalreceiver):
```

```
        self.totalsender = totalsender
        self.senderhost = '127.0.0.1'
        self.senderport = 8080
        self.senderconn = []

        self.totalreceiver = totalreceiver
        self.receiverhost = '127.0.0.2'
        self.receiverport = 9090
        self.receiverconn = []

    def initSenders(self):
        senderSocket = socket.socket()
        senderSocket.bind((self.senderhost, self.senderport))
        senderSocket.listen(self.totalsender)
        for i in range(1, self.totalsender+1):
            conn = senderSocket.accept()
            self.senderconn.append(conn)
        print('Initiated all sender connections')

    def closeSenders(self):
        for conn in self.senderconn:
            conn[0].close()
        print('Closed all sender connections')

    def initReceivers(self):
        receiverSocket = socket.socket()
        receiverSocket.bind((self.receiverhost, self.receiverport))
        receiverSocket.listen(self.totalreceiver)
        for i in range(1, self.totalreceiver+1):
            conn = receiverSocket.accept()
            self.receiverconn.append(conn)
        print('Initiated all receiver connections')

    def closeReceivers(self):
        for conn in self.receiverconn:
            conn[0].close()
        print('Closed all receiver connections')

    def processData(self):
        while True:
            for i in range(len(self.senderconn)):
                print()
                conn = self.senderconn[i]
                data = conn[0].recv(1024).decode()
                if not data:
                    break
                if data == 'q0':
                    break

                print('Received from Sender',i+1,':',str(data))

                recvno = random.randint(0,len(self.receiverconn)-1)
                print('Sending to Receiver',recvno+1)
                rconn = self.receiverconn[recvno]
                data = injectRandomError(data)
                rconn[0].sendto(data.encode(), rconn[1])


                rdata = rconn[0].recv(1024).decode()
                print('Received from Receiver',recvno+1,':', str(rdata))

                print('Sending to Sender',i+1)
                conn[0].send(rdata.encode())
```

```
                        time.sleep(0.002)
                        filein = open('checktime.txt',"r")
                        timeout = int(filein.read())
                        filein.close()
                        os.remove('checktime.txt')
                        print(timeout)
                        while timeout==1:
                              print()
                              data = conn[0].recv(1024).decode()
                              print('Again Received from
Sender',i+1,':',str(data))
                              data = injectRandomError(data)
                              print('Again Sending to Receiver',recvno+1)
                              rconn[0].sendto(data.encode(), rconn[1])
                              rdata = rconn[0].recv(1024).decode()
                              print('Again Received from Receiver',recvno+1,':',
str(rdata))
                              print('Again Sending to Sender',i+1)
                              conn[0].send(rdata.encode())

                              time.sleep(0.002)
                              filein = open('checktime.txt',"r")
                              timeout = int(filein.read())
                              filein.close()
                              os.remove('checktime.txt')
                              print(timeout)

                  if data == 'q0':
                        break
            return

if __name__ == '__main__':
      totalsen = int(input('Enter number of senders: '))
      totalrecv = int(input('Enter number of receivers: '))

      ch = Channel(totalsen, totalrecv)
      ch.initSenders()
      ch.initReceivers()
      ch.processData()
      ch.closeSenders()
      ch.closeReceivers()
```

2. GO BACK N SLIDING WINDOW PROTOCOL

Code Snippet of sender.py:

```
import socket
import sys
import time
def createFrame(data):
      countOnes = 0
      for ch in data:
            if ch == '1':
                  countOnes += 1
      data += str(countOnes%2)
      return data

def extractMessage(frame):
      endidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/' and endidx == -1:
```

```
                endidx = i
                break
        return frame[:endidx]

def extractCount(frame):
        startidx = -1
        endidx = -1
        for i in range(len(frame)-1):
                if frame[i] == '/':
                        if startidx == -1:
                                startidx = i+1
                        else:
                                endidx = i
        cnt = frame[startidx:endidx]
        return int(cnt)

def extractStatus(frame):
        count = 0
        startidx = -1
        for i in range(len(frame)-1):
                if frame[i] == '/':
                        count += 1
                if count == 2 and startidx == -1:
                        startidx = i+1
                        break
        return frame[startidx:]

def Main(senderno):
        count = 0
        sentframes = []
        print('Initiating Sender #',senderno)
        host = '127.0.0.1'
        port = 8080

        mySocket = socket.socket()
        mySocket.connect((host, port))

        while True:
                print()
                data = input("Enter $ ")
                #prevtime = time.time()
                data = createFrame(data) + '/' + str(count) + '/'
                msg = extractMessage(data)
                print('Sending to channel :',str(msg))
                mySocket.send(data.encode())
                sentframes.append(data)
                count += 1

                if not msg:
                        break
                if msg == 'q0':
                        break
        mySocket.close()

if __name__ == '__main__':
        if len(sys.argv) > 1:
                senderno = int(sys.argv[1])
        else:
                senderno = 1
        Main(senderno)
```

Code Snippet of receiver.py:

```
import socket
import sys
import time
import random

def waitRandomtime():
      x = random.randint(0,5)
      if x <= 1:
            time.sleep(2)

def checkError(frame):
      countOnes = 0
      for ch in frame:
            if ch == '1':
                  countOnes += 1
      return countOnes%2

def extractMessage(frame):
      endidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/' and endidx == -1:
                  endidx = i
                  break
      return frame[:endidx]

def extractCount(frame):
      startidx = -1
      endidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/':
                  if startidx == -1:
                        startidx = i+1
                  else:
                        endidx = i
      cnt = frame[startidx:endidx]
      return int(cnt)

def extractStatus(frame):
      count = 0
      startidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/':
                  count += 1
            if count == 2 and startidx == -1:
                  startidx = i+1
                  break
      return frame[startidx:]

def Main(senderno):
      print('Initiating Receiver #',senderno)
      host = '127.0.0.2'
      port = 9090

      mySocket = socket.socket()
      mySocket.connect((host, port))

      while True:
            print()
            data = mySocket.recv(1024).decode()
            data = str(data)
            msg = extractMessage(data)
            if not msg:
```

```
                  break
            if msg == 'q0':
                  break

            print('Received from channel :', str(data))
            waitRandomtime()
            if checkError(msg) == 0:
                  rdata = 'ACK'
            else:
                  rdata = 'NAK'

            print('Sending to channel :',str(rdata))
            mySocket.send(rdata.encode())

      mySocket.close()

if __name__ == '__main__':
      if len(sys.argv) > 1:
            senderno = int(sys.argv[1])
      else:
            senderno = 1
      Main(senderno)
```

Code Snippet of channel.py:

```
import socket
import time
import subprocess
import random
import os

def injectRandomError(frame):
      pos = random.randint(0, len(frame)-1)
      frame = frame[:pos]+'1'+frame[pos+1:]
      return frame

def extractMessage(frame):
      endidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/' and endidx == -1:
                  endidx = i
                  break
      return frame[:endidx]

def extractCount(frame):
      startidx = -1
      endidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/':
                  if startidx == -1:
                        startidx = i+1
                  else:
                        endidx = i
      cnt = frame[startidx:endidx]
      return int(cnt)

def extractStatus(frame):
      count = 0
      startidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/':
                  count += 1
            if count == 2 and startidx == -1:
```

```
                  startidx = i+1
                  break
      return frame[startidx:]

class Channel():

      def __init__(self, totalsender, totalreceiver, windowsize):
            self.totalsender = totalsender
            self.senderhost = '127.0.0.1'
            self.senderport = 8080
            self.senderconn = []

            self.totalreceiver = totalreceiver
            self.receiverhost = '127.0.0.2'
            self.receiverport = 9090
            self.receiverconn = []

            self.windowsize = windowsize
            self.slidingwindow = []
            self.currentcount = 0
            #self.statuswindow = []

      def initSenders(self):
            senderSocket = socket.socket()
            senderSocket.bind((self.senderhost, self.senderport))
            senderSocket.listen(self.totalsender)
            for i in range(1, self.totalsender+1):
                  conn = senderSocket.accept()
                  self.senderconn.append(conn)
            print('Initiated all sender connections')

      def closeSenders(self):
            for conn in self.senderconn:
                  conn[0].close()
            print('Closed all sender connections')

      def initReceivers(self):
            receiverSocket = socket.socket()
            receiverSocket.bind((self.receiverhost, self.receiverport))
            receiverSocket.listen(self.totalreceiver)
            for i in range(1, self.totalreceiver+1):
                  conn = receiverSocket.accept()
                  self.receiverconn.append(conn)
            print('Initiated all receiver connections')

      def closeReceivers(self):
            for conn in self.receiverconn:
                  conn[0].close()
            print('Closed all receiver connections')

      def processData(self):
            while True:
                  for i in range(len(self.senderconn)):
                        print()

                        conn = self.senderconn[i]
                        data = conn[0].recv(1024).decode()
                        prevtime = time.time()
                        data = str(data)
                        origmsg = extractMessage(data)
                        if not origmsg:
                              break
                        if origmsg == 'q0':
```

```
                        break
                    print('Received from Sender',i+1,':',str(data))


                    recvno = random.randint(0,len(self.receiverconn)-1)
                    print('Sending to Receiver',recvno+1)
                    rconn = self.receiverconn[recvno]
                    cnt = extractCount(data)
                    msg = injectRandomError(origmsg)
                    newdata = msg + '/' + str(cnt) + '/'
                    rconn[0].sendto(newdata.encode(), rconn[1])

                    #received from receiver
                    rdata = rconn[0].recv(1024).decode()
                    rdata = str(rdata)
                    time.sleep(0.5)
                    curtime = time.time()
                    if curtime-prevtime > 2:
                        timeout = 1
                        newdata += 'TIMEOUT'
                    else:
                        timeout = 0
                        newdata += rdata

                    self.slidingwindow.append([data, newdata, i, recvno])


                    msg = extractMessage(newdata)
                    cnt = extractCount(newdata)
                    status = extractStatus(newdata)
                    print(msg,str(cnt),status)
                    print('Round trip time: ',str(curtime-prevtime))
                    print('Current frame no:',str((self.currentcount %
windowsize)+1))
                    if (self.currentcount % windowsize)+1 == self.windowsize:
                        idx = 0
                        flag = 1

                        while flag == 1:
                            idx = 0
                            flag = 0
                            while idx < self.windowsize:
                                currframe = self.slidingwindow[idx][1]
                                msg = extractMessage(currframe)
                                cnt = extractCount(currframe)
                                status = extractStatus(currframe)

                                if status == 'NAK' or status ==
'TIMEOUT':
                                    flag = 1
                                    break
                                idx += 1
                            print(' ------------------------------ ')
                            if flag==1:
                                print('RESEND FROM FRAME
NO:',str(idx+1))
                            else:
                                print('BLOCK OF WINDOW
SIZE',self.windowsize,'SUCCESSFULLY SENT')
                            print(' ------------------------------ ')
                            '''fileout = open('flag.txt', "w")
                            fileout.write(str(flag))
                            fileout.close()'''
```

```
                                    while flag == 1 and idx < self.windowsize:
                                          print()
                                          prevtime = time.time()
                                          prevframe = self.slidingwindow[idx][0]
                                          currframe = self.slidingwindow[idx][1]
                                          sendno = self.slidingwindow[idx][2]
                                          recvno = self.slidingwindow[idx][3]
                                          conn = self.senderconn[sendno]
                                          rconn = self.receiverconn[recvno]

                                          #sending all frames to its sender from
first NAK
                                          #conn[0].send(currframe.encode())

                                          #data = conn[0].recv(1024).decode()
                                          print('Current frame no:',str(idx+1))
                                          print('Again Sending to
Receiver',recvno+1)

                                          msg = extractMessage(prevframe)
                                          msg = injectRandomError(msg)
                                          data = msg + '/' + str(cnt) + '/'
                                          rconn[0].sendto(data.encode(),
rconn[1])

                                          # receiving ACK or NAK from receiver
                                          rdata = rconn[0].recv(1024).decode()
                                          rdata = str(rdata)
                                          data += rdata

                                          msg = extractMessage(data)
                                          cnt = extractCount(data)
                                          stat = extractStatus(data)
                                          curtime = time.time()
                                          print(msg,str(cnt),stat)
                                          print('Round trip time: ',str(curtime-
prevtime))
                                          self.slidingwindow[idx][1] = data
                                          idx += 1


                                    '''fileout = open('flag.txt', "w")
                                    fileout.write(str(0))
                                    fileout.close()   '''


                              self.currentcount += 1
                        if origmsg == 'q0':
                              break
                  return

if __name__ == '__main__':
      totalsen = int(input('Enter number of senders: '))
      totalrecv = int(input('Enter number of receivers: '))
      windowsize =int(input('Enter window size: '))

      ch = Channel(totalsen, totalrecv, windowsize)
      ch.initSenders()
      ch.initReceivers()
      ch.processData()
      ch.closeSenders()
      ch.closeReceivers()
```

3. SELECTIVE REPEAT SLIDING WINDOW PROTOCOL

Code Snippet of sender.py:

```
import socket
import sys
import time
def createFrame(data):
	countOnes = 0
	for ch in data:
		if ch == '1':
			countOnes += 1
	data += str(countOnes%2)
	return data

def extractMessage(frame):
	endidx = -1
	for i in range(len(frame)-1):
		if frame[i] == '/' and endidx == -1:
			endidx = i
			break
	return frame[:endidx]

def extractCount(frame):
	startidx = -1
	endidx = -1
	for i in range(len(frame)-1):
		if frame[i] == '/':
			if startidx == -1:
				startidx = i+1
			else:
				endidx = i
	cnt = frame[startidx:endidx]
	return int(cnt)

def extractStatus(frame):
	count = 0
	startidx = -1
	for i in range(len(frame)-1):
		if frame[i] == '/':
			count += 1
		if count == 2 and startidx == -1:
			startidx = i+1
			break
	return frame[startidx:]

def Main(senderno):
	count = 0
	sentframes = []
	print('Initiating Sender #',senderno)
	host = '127.0.0.1'
	port = 8080

	mySocket = socket.socket()
	mySocket.connect((host, port))

	while True:
		print()
		data = input("Enter $ ")
		#prevtime = time.time()
		data = createFrame(data) + '/' + str(count) + '/'
```

```
            msg = extractMessage(data)
            print('Sending to channel :',str(msg))
            mySocket.send(data.encode())
            sentframes.append(data)
            count += 1

            if not msg:
                  break
            if msg == 'q0':
                  break
      mySocket.close()

if __name__ == '__main__':
      if len(sys.argv) > 1:
            senderno = int(sys.argv[1])
      else:
            senderno = 1
      Main(senderno)
```

Code Snippet of receiver.py:

```
import socket
import sys
import time
import random

def waitRandomTime():
      x = random.randint(0,5)
      if x <= 1:
            time.sleep(2)

def checkError(frame):
      countOnes = 0
      for ch in frame:
            if ch == '1':
                  countOnes += 1
      return countOnes%2

def extractMessage(frame):
      endidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/' and endidx == -1:
                  endidx = i
                  break
      return frame[:endidx]

def extractCount(frame):
      startidx = -1
      endidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/':
                  if startidx == -1:
                        startidx = i+1
                  else:
                        endidx = i
      cnt = frame[startidx:endidx]
      return int(cnt)

def extractStatus(frame):
      count = 0
      startidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/':
```

```
                count += 1
            if count == 2 and startidx == -1:
                startidx = i+1
                break
        return frame[startidx:]

def Main(senderno):
        print('Initiating Receiver #',senderno)
        host = '127.0.0.2'
        port = 9090

        mySocket = socket.socket()
        mySocket.connect((host, port))

        while True:
            print()
            data = mySocket.recv(1024).decode()
            data = str(data)
            msg = extractMessage(data)
            if not msg:
                break
            if msg == 'q0':
                break

            print('Received from channel :', str(data))
            waitRandomTime()
            if checkError(msg) == 0:
                rdata = 'ACK'
            else:
                rdata = 'NAK'

            print('Sending to channel :',str(rdata))
            mySocket.send(rdata.encode())



        mySocket.close()

if __name__ == '__main__':
        if len(sys.argv) > 1:
            senderno = int(sys.argv[1])
        else:
            senderno = 1
        Main(senderno)
```

Code Snippet of channel.py:

```
import socket
import time
import subprocess
import random
import os

def injectRandomError(frame):
        pos = random.randint(0, len(frame)-1)
        frame = frame[:pos]+'1'+frame[pos+1:]
        return frame

def extractMessage(frame):
        endidx = -1
        for i in range(len(frame)-1):
            if frame[i] == '/' and endidx == -1:
                endidx = i
```

```
                  break
      return frame[:endidx]

def extractCount(frame):
      startidx = -1
      endidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/':
                  if startidx == -1:
                        startidx = i+1
                  else:
                        endidx = i
      cnt = frame[startidx:endidx]
      return int(cnt)

def extractStatus(frame):
      count = 0
      startidx = -1
      for i in range(len(frame)-1):
            if frame[i] == '/':
                  count += 1
            if count == 2 and startidx == -1:
                  startidx = i+1
                  break
      return frame[startidx:]

class Channel():

      def __init__(self, totalsender, totalreceiver, windowsize):
            self.totalsender = totalsender
            self.senderhost = '127.0.0.1'
            self.senderport = 8080
            self.senderconn = []

            self.totalreceiver = totalreceiver
            self.receiverhost = '127.0.0.2'
            self.receiverport = 9090
            self.receiverconn = []

            self.windowsize = windowsize
            self.slidingwindow = []
            self.currentcount = 0
            #self.statuswindow = []

      def initSenders(self):
            senderSocket = socket.socket()
            senderSocket.bind((self.senderhost, self.senderport))
            senderSocket.listen(self.totalsender)
            for i in range(1, self.totalsender+1):
                  conn = senderSocket.accept()
                  self.senderconn.append(conn)
            print('Initiated all sender connections')

      def closeSenders(self):
            for conn in self.senderconn:
                  conn[0].close()
            print('Closed all sender connections')

      def initReceivers(self):
            receiverSocket = socket.socket()
            receiverSocket.bind((self.receiverhost, self.receiverport))
            receiverSocket.listen(self.totalreceiver)
            for i in range(1, self.totalreceiver+1):
```

```
                conn = receiverSocket.accept()
                self.receiverconn.append(conn)
          print('Initiated all receiver connections')

    def closeReceivers(self):
          for conn in self.receiverconn:
                conn[0].close()
          print('Closed all receiver connections')

    def processData(self):
          '''fileout = open('flag.txt', "w")
          fileout.write(str(0))
          fileout.close()'''
          while True:
                for i in range(len(self.senderconn)):
                      print()

                      conn = self.senderconn[i]
                      data = conn[0].recv(1024).decode()
                      prevtime = time.time()
                      data = str(data)
                      origmsg = extractMessage(data)
                      if not origmsg:
                            break
                      if origmsg == 'q0':
                            break
                      print('Received from Sender',i+1,':',str(data))


                      recvno = random.randint(0,len(self.receiverconn)-1)
                      print('Sending to Receiver',recvno+1)
                      rconn = self.receiverconn[recvno]
                      cnt = extractCount(data)
                      msg = injectRandomError(origmsg)
                      newdata = msg + '/' + str(cnt) + '/'
                      rconn[0].sendto(newdata.encode(), rconn[1])

                      #received from receiver
                      rdata = rconn[0].recv(1024).decode()
                      rdata = str(rdata)
                      time.sleep(0.5)
                      curtime = time.time()
                      if curtime-prevtime > 2:
                            timeout = 1
                            newdata += 'TIMEOUT'
                      else:
                            timeout = 0
                            newdata += rdata

                      self.slidingwindow.append([data, newdata, i, recvno])


                      msg = extractMessage(newdata)
                      cnt = extractCount(newdata)
                      status = extractStatus(newdata)
                      print(msg,str(cnt),status)
                      print('Round trip time: ',str(curtime-prevtime))
                      print('Current frame no:',str((self.currentcount %
windowsize)+1))
                      if (self.currentcount % windowsize)+1 == self.windowsize:
                            idx = 0
                            flag = 1
```

```
                              while flag == 1:
                                    idx = 0
                                    flag = 0
                                    nakframes = []
                                    indices = []
                                    while idx < self.windowsize:
                                          currframe = self.slidingwindow[idx][1]
                                          msg = extractMessage(currframe)
                                          cnt = extractCount(currframe)
                                          status = extractStatus(currframe)

                                          if status == 'NAK' or status ==
'TIMEOUT':
                                                flag = 1

      nakframes.append(self.slidingwindow[idx])
                                                indices.append(idx+1)
                                                #break
                                          idx += 1

                                    if flag==0:
                                          print(' ------------------------------
')
                                          print('BLOCK OF WINDOW
SIZE',self.windowsize,'SUCCESSFULLY SENT')
                                          print(' ------------------------------
')
                                    '''fileout = open('flag.txt', "w")
                                    fileout.write(str(flag))
                                    fileout.close()'''
                                    idx = 0

                                    while flag == 1 and idx < len(nakframes):

                                          print()
                                          prevtime = time.time()
                                          prevframe = nakframes[idx][0]
                                          currframe = nakframes[idx][1]
                                          sendno = nakframes[idx][2]
                                          recvno = nakframes[idx][3]
                                          conn = self.senderconn[sendno]
                                          rconn = self.receiverconn[recvno]
                                          stat = extractStatus(currframe)

                                          print(' ------------------------------
')
                                          print('RESENDING FRAME
NO:',str(indices[idx]))
                                          print(' ------------------------------
')
                                          #sending all frames to its sender from
first NAK
                                          #conn[0].send(currframe.encode())

                                          #data = conn[0].recv(1024).decode()
                                          print('Current frame
no:',str(indices[idx]))
                                          print('Again Sending to
Receiver',recvno+1)

                                          msg = extractMessage(prevframe)
                                          msg = injectRandomError(msg)
                                          data = msg + '/' + str(cnt) + '/'
```

```
                                        rconn[0].sendto(data.encode(),
rconn[1])

                                        # receiving ACK or NAK from receiver
                                        rdata = rconn[0].recv(1024).decode()
                                        rdata = str(rdata)
                                        data += rdata

                                        msg = extractMessage(data)
                                        cnt = extractCount(data)
                                        stat = extractStatus(data)
                                        curtime = time.time()
                                        print(msg,str(cnt),stat)
                                        print('Round trip time: ',str(curtime-
prevtime))
                                        self.slidingwindow[indices[idx]-1][1] =
data
                                        idx += 1

                        self.currentcount += 1
                if origmsg == 'q0':
                        break
            return

if __name__ == '__main__':
      totalsen = int(input('Enter number of senders: '))
      totalrecv = int(input('Enter number of receivers: '))
      windowsize =int(input('Enter window size: '))

      ch = Channel(totalsen, totalrecv, windowsize)
      ch.initSenders()
      ch.initReceivers()
      ch.processData()
      ch.closeSenders()
      ch.closeReceivers()
```

TEST CASES

Stop and Wait ARQ:

channel.py :

```
C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\stopnwait>python channel.py
Enter number of senders: 2
Enter number of receivers: 2
Initiated all sender connections
Initiated all receiver connections

Received from Sender 1 : 10010
Sending to Receiver 2
Received from Receiver 2 : TIMEOUT
Sending to Sender 1
1

Again Received from Sender 1 : 10010
Again Sending to Receiver 2
Again Received from Receiver 2 : TIMEOUT
Again Sending to Sender 1
1

Again Received from Sender 1 : 10010
Again Sending to Receiver 2
Again Received from Receiver 2 : ACK
Again Sending to Sender 1
0

Received from Sender 2 : 00101
Sending to Receiver 2
Received from Receiver 2 : ACK
Sending to Sender 2
0
```

Sender.py (1st sender):

```
C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\stopnwait>python sender.py 1
Initiating Sender # 1

Enter $ 1001
Sending to channel : 10010
Received from channel : TIMEOUT
Round trip time:  2.031153678894043

TIMEOUT of 2s EXPIRED !!
Again Sending to channel : 10010
Again Received from channel : TIMEOUT
Round trip time: 4.031170129776001 seconds

TIMEOUT of 2s EXPIRED !!
Again Sending to channel : 10010
Again Received from channel : ACK
Round trip time: 0.015580177307128906 seconds
```

Sender.py (2nd sender):

```
C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\stopnwait>python sender.py 2
```

Initiating Sender # 2

Enter $ 0010
Sending to channel : 00101
Received from channel : ACK
Round trip time: 0.0

Receiver.py (1st receiver):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\stopnwait>python receiver.py 1
Initiating Receiver # 1

Receiver.py (2nd receiver):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\stopnwait>python receiver.py 2
Initiating Receiver # 2

Received from channel : 10011
Sending to channel : TIMEOUT

Received from channel : 10110
Sending to channel : TIMEOUT

Received from channel : 10010
Sending to channel : ACK

Received from channel : 00101
Sending to channel : ACK

Go Back N ARQ:

Channel.py:

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\gobackn>python channel.py
Enter number of senders: 2
Enter number of receivers: 2
Enter window size: 3
Initiated all sender connections
Initiated all receiver connections

Received from Sender 1 : 10010/0/
Sending to Receiver 2
11010 0 NAK
Round trip time: 0.5156002044677734
Current frame no: 1

Received from Sender 2 : 01001/0/
Sending to Receiver 2
01101 0 NAK
Round trip time: 0.5156097412109375
Current frame no: 2

Received from Sender 1 : 10100/1/
Sending to Receiver 2
10110 1 NAK
Round trip time: 0.5000448226928711
Current frame no: 3

RESEND FROM FRAME NO: 1

Current frame no: 1
Again Sending to Receiver 2
10011 0 NAK
Round trip time: 2.0155763626098633

Current frame no: 2
Again Sending to Receiver 2
01011 0 NAK
Round trip time: 0.0

Current frame no: 3
Again Sending to Receiver 2
10100 0 ACK
Round trip time: 0.0

RESEND FROM FRAME NO: 1

Current frame no: 1
Again Sending to Receiver 2
10011 0 NAK
Round trip time: 0.0

Current frame no: 2
Again Sending to Receiver 2
01101 0 NAK
Round trip time: 2.000006675720215

Current frame no: 3
Again Sending to Receiver 2
11100 0 NAK
Round trip time: 0.0

RESEND FROM FRAME NO: 1

Current frame no: 1
Again Sending to Receiver 2
10011 0 NAK
Round trip time: 0.0

Current frame no: 2
Again Sending to Receiver 2
01001 0 ACK
Round trip time: 2.0155766010284424

Current frame no: 3
Again Sending to Receiver 2
10100 0 ACK
Round trip time: 0.0

RESEND FROM FRAME NO: 1

Current frame no: 1
Again Sending to Receiver 2
10011 0 NAK
Round trip time: 0.0

Current frame no: 2
Again Sending to Receiver 2
01101 0 NAK
Round trip time: 2.0155653953552246

Current frame no: 3
Again Sending to Receiver 2
10100 0 ACK
Round trip time: 0.0

RESEND FROM FRAME NO: 1

Current frame no: 1
Again Sending to Receiver 2
10010 0 ACK
Round trip time: 0.0

Current frame no: 2
Again Sending to Receiver 2
01101 0 NAK
Round trip time: 2.015582799911499

Current frame no: 3
Again Sending to Receiver 2
10110 0 NAK
Round trip time: 0.0

RESEND FROM FRAME NO: 2

Current frame no: 2
Again Sending to Receiver 2
01001 0 ACK
Round trip time: 0.0

Current frame no: 3
Again Sending to Receiver 2
10101 0 NAK
Round trip time: 2.0155813694000244

RESEND FROM FRAME NO: 3

Current frame no: 3
Again Sending to Receiver 2
11100 0 NAK
Round trip time: 2.002156972885132

RESEND FROM FRAME NO: 3

Current frame no: 3
Again Sending to Receiver 2
10100 0 ACK
Round trip time: 2.0155797004699707

BLOCK OF WINDOW SIZE 3 SUCCESSFULLY SENT

Sender.py (1st sender):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\gobackn>python sender.py 1
Initiating Sender # 1

Enter $ 1001
Sending to channel : 10010

Enter $ 1010
Sending to channel : 10100

Enter $

Sender.py (2nd sender):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\gobackn>python sender.py 2
Initiating Sender # 2

Enter $ 0100
Sending to channel : 01001

Enter $

Receiver.py (1st receiver):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\gobackn>python receiver.py 1
Initiating Receiver # 1

Receiver.py (2nd receiver):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\gobackn>python receiver.py 2
Initiating Receiver # 2

Received from channel : 11010/0/
Sending to channel : NAK

Received from channel : 01101/0/
Sending to channel : NAK

Received from channel : 10110/1/
Sending to channel : NAK

Received from channel : 10011/0/
Sending to channel : NAK

Received from channel : 01011/0/
Sending to channel : NAK

Received from channel : 10100/0/
Sending to channel : ACK

Received from channel : 10011/0/
Sending to channel : NAK

Received from channel : 01101/0/
Sending to channel : NAK

Received from channel : 11100/0/

Sending to channel : NAK

Received from channel : 10011/0/
Sending to channel : NAK

Received from channel : 01001/0/
Sending to channel : ACK

Received from channel : 10100/0/
Sending to channel : ACK

Received from channel : 10011/0/
Sending to channel : NAK

Received from channel : 01101/0/
Sending to channel : NAK

Received from channel : 10100/0/
Sending to channel : ACK

Received from channel : 10010/0/
Sending to channel : ACK

Received from channel : 01101/0/
Sending to channel : NAK

Received from channel : 10110/0/
Sending to channel : NAK

Received from channel : 01001/0/
Sending to channel : ACK

Received from channel : 10101/0/
Sending to channel : NAK

Received from channel : 11100/0/
Sending to channel : NAK

Received from channel : 10100/0/
Sending to channel : ACK

Selective Repeat ARQ:

Channel.py:

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\selectiverepeat>python channel.py
Enter number of senders: 2
Enter number of receivers: 2
Enter window size: 3
Initiated all sender connections
Initiated all receiver connections

Received from Sender 1 : 10010/0/
Sending to Receiver 1
10010 0 ACK
Round trip time: 0.5156097412109375
Current frame no: 1

Received from Sender 2 : 01001/0/
Sending to Receiver 2

01001 0 ACK
Round trip time: 0.5156137943267822
Current frame no: 2

Received from Sender 1 : 10100/1/
Sending to Receiver 1
10101 1 NAK
Round trip time: 0.5155987739562988
Current frame no: 3

RESENDING FRAME NO: 3

Current frame no: 3
Again Sending to Receiver 1
10110 1 NAK
Round trip time: 0.0

RESENDING FRAME NO: 3

Current frame no: 3
Again Sending to Receiver 1
10100 1 ACK
Round trip time: 2.015587329864502

BLOCK OF WINDOW SIZE 3 SUCCESSFULLY SENT

Sender.py (1st sender):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\selectiverepeat>python sender.py 1
Initiating Sender # 1

Enter $ 1001
Sending to channel : 10010

Enter $ 1010
Sending to channel : 10100

Enter $

Sender.py (2nd sender):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\selectiverepeat>python sender.py 2
Initiating Sender # 2

Enter $ 0100
Sending to channel : 01001

Enter $

Receiver.py (1st receiver):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\selectiverepeat>python receiver.py 1
Initiating Receiver # 1

Received from channel : 10010/0/
Sending to channel : ACK

Received from channel : 10101/1/
Sending to channel : NAK

Received from channel : 10110/1/
Sending to channel : NAK

Received from channel : 10100/1/
Sending to channel : ACK

Receiver.py (2nd receiver):

C:\Users\SOURAV\Desktop\comp-networks-lab\ass2\selectiverepeat>python receiver.py 2
Initiating Receiver # 2

Received from channel : 01001/0/
Sending to channel : ACK

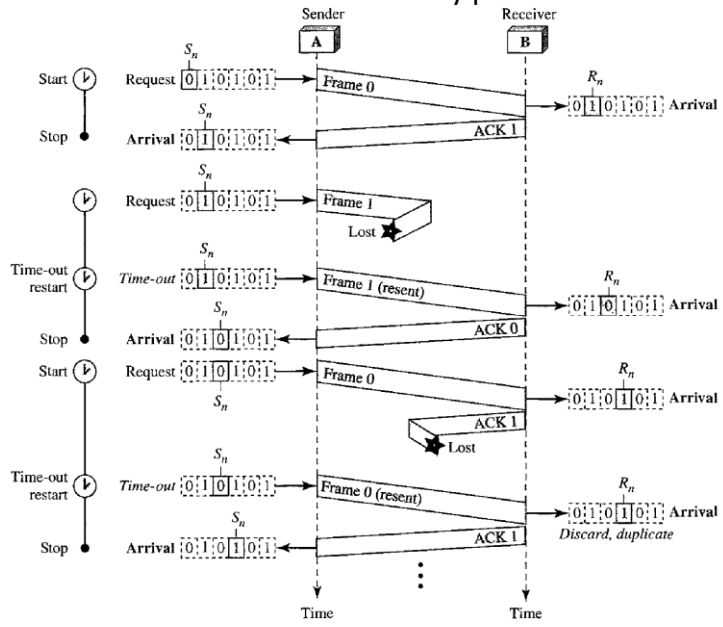
RESULTS AND ANALYSIS

Stop and Wait ARQ:

Stop and Wait ARQ adds a simple error control mechanism to the Stop and Wait protocol for noiselsess channel. To detect and correct corrupted frames, we need to add redundancy bits to our data frame. When the frame arrives at the receiver site, it is checked if it is corrupted.

The corrupted and lost frames need to be resent in this protocol. If the receiver does not respond when there is an error, the sender keeps a copy of the sent frame. At the same time, it starts a timer. If the timer expires and there is no ACK for the sent frame, the frame is resent, the copy is held, and the timer is restarted.

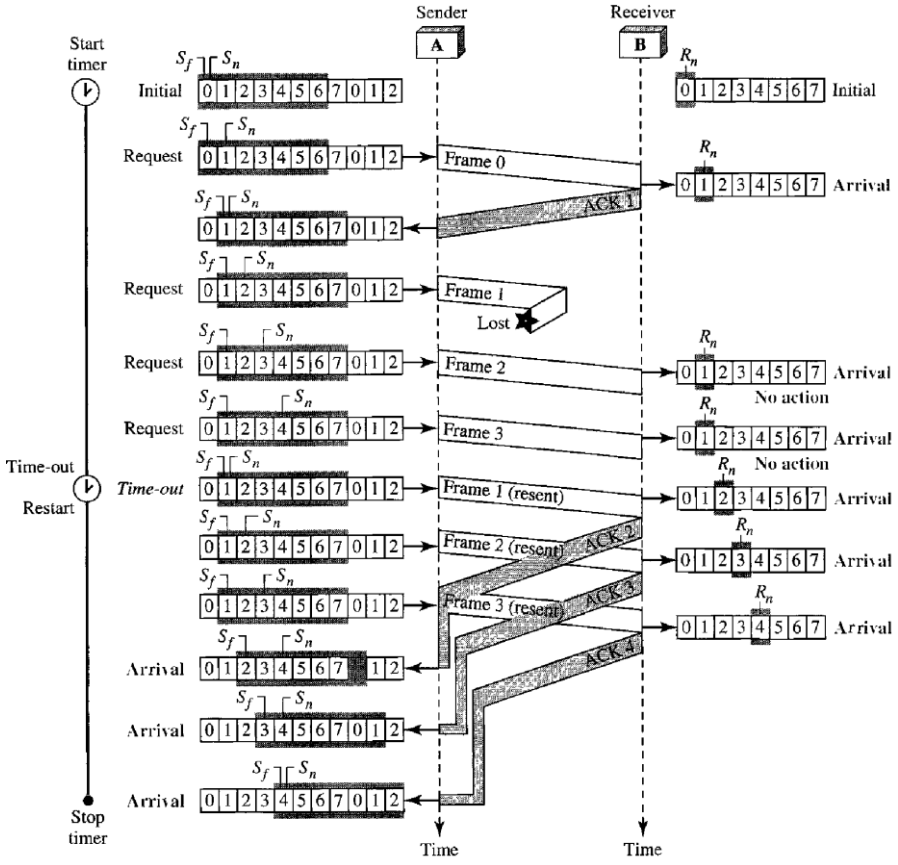
The Stop and Wait ARQ is very inefficient if our channel is thick and long. By thick, we mean that our channel has a large bandwidth; by long, we mean the round-trip delay is long. The product of the two is called the bandwidth-delay product. It is the volume of the pipe in bits.



Go Back N ARQ:

To improve the efficiency of transmission (filling the pipe), multiple frames are in transition while waiting for acknowledgment. In this protocol, we can send several frames before receiving acknowledgments; we keep a copy of these frames until acknowledgments arrive.

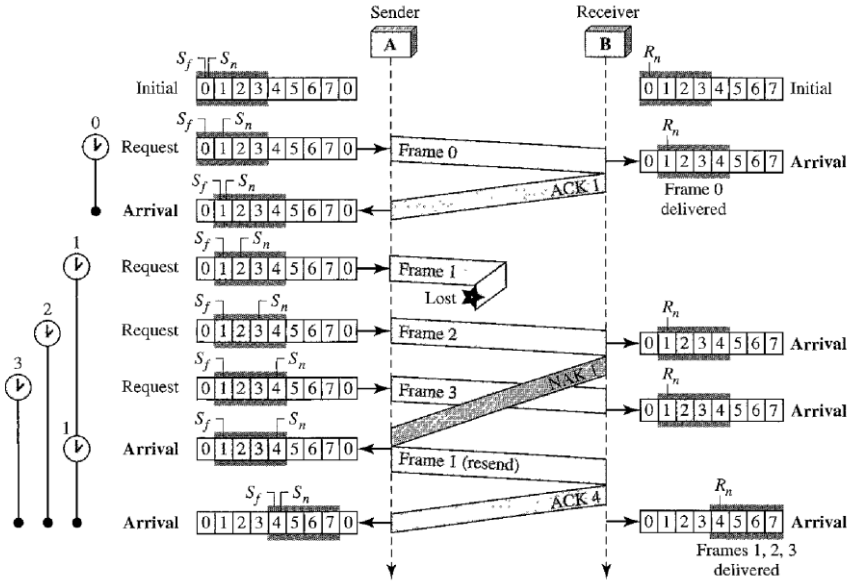
In this protocol, when the timer expires, the sender resends all the outstanding frames. For example, suppose the sender has already sent frame 6, bur the timer for frame 3 expires. This means that frame 3 has not been acknowledged; the sender goes back and sends frames 3, 4, 5, and 6 again.



Selective Repeat ARQ:

Go Back N ARQ simplifies the process at the receiver site. The receiver keeps track of only one variable, and there is no need to buffer out-of-order frames; they are simply discarded. However, it is very inefficient for a noisy link. In a noisy link a frame has a higher probability of damage, which means the resending of multiple frames. This resending uses up the bandwidth and slows down the transmission.

For noisy links, there is another mechanism that does not resend N frames when just one frame is damaged; only the damaged frame is resent. This mechanism is called Selective Repeat ARQ. It is more efficient for noisy links, but the processing at the receiver is more complex.



COMMENTS

This assignment has helped me in understanding the different data link layer protocols immensely, by researching and implementing them. It has also helped in understanding the demerits of a protocol, and how such demerits are overcome by other protocols.