**NETWORK LAB REPORT**

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**ROLL NO.:** 20

**CLASS:** BCSE-III

**SECTION:** A1

**ASSIGNMENT NUMBER:** 2

**PROBLEM STATEMENT:**

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

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The report has two sections one for the stop-and-wait protocol and the other for the sliding window go-back-n protocol.

**STOP AND WAIT ARQ:**

**DESIGN**

The program implements the stop and wait ARQ flow control protocol. The program consists of 5 modules.

1. **errorchecker.py**

This file contains the implementation of all the error detection algorithm from assignment1.

1. **sender.py**

This file contains the code to perform the work of the sender. Read from the input file, create the frame to be sent to the receiver and the send the frame to the channel process. This process also receives the acknowledgement sent by the receiver and accordingly resends the frame if ack is not received or is corrupt.

1. **channel.py**

This is the channel process whose task are the following

1. Receive frame from sender
2. Inject error into the frame with a random probability
3. Send the frame to the receiver with a random probability else discard it and wait for the sender to resend, also inject a random probability.
4. Receive the acknowledgement frame from the receiver and send it to the sender with a random probability and also inject delay.
5. **rec.py**

This file contains the code to perform the work of the receiver. It receives the frame sent by the sender from the channel process, generates an acknowledgement and sends it to the channel process.

1. **common.py**

This file contains some common function to be used by all processes.

All inter-process communication has been carried out by making use of the Python3 **socket**.

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| ***Fig. 1.*** *A brief outline of the program design of stop and wait ARQ* |

**Fig. 1** gives a brief outline of the program.

Some important parameters for the design of the program are:

**Frame format:** The frame format used in the sender process is described as follows. The input data is split into frames of 4 bits each. Then for each frame the frame number (0 or 1) is appended to the beginning of the frame. The entire 5 bit data is then encoded using CRC-3. Thus the resulting frame size is 8 bits. This frame is then sent to the channel process.

**Acknowledgement format:** The acknowledgement frame which is sent by the receiver consists of a bit stating the frame number (0 or 1) which is then CRC encoded using CRC-3 thus making 4 bit acknowledgement.

**Assumption:** During the design one assumption that has been made is that the number of bits in the input file is a multiple of 4.

**Input format:** The input for the program is a text file consisting of a string of only 0s and 1s.

**Output format:** The program output simulates the flow control protocol.

**IMPLEMENTATION**

The assignment has been implemented in Python3. The detailed description is given below.

***errorchecker.py:*** This is the same error checking module as present in Assignment 1.

***common.py:***

This module contains some commonly used function in the modules.

The port specifications are given below

portSenderReceive=11001

portSenderSend=11002

portReceiverReceive=11003

portReceiverSend=11004

frame\_size=4

*createSocket(port):*

This function creates a socket and binds it to a port

*# Function to create a socket and bind it to a port*

**def** createSocket(port):

s=socket.socket(socket.AF\_INET, socket.SOCK\_STREAM)

s.bind(('', port))

**return** s

*allowConn(port):*

Function to establish a connection with the port.

*# Function to receive a connection*

**def** allowConn(s):

s.listen(5)

c, addr=s.accept()

**return** c, addr

*createConn(port):*

Function to create a socket with a port and connect to it.

*# Function to create a socket and connect to it*

**def** createConn(port):

sock=socket.socket()

sock.connect(('',port))

**return** sock

*send\_frame(frame,c):*

Function to send a frame through a particular socket.

*# Function to send a frame*

**def** send\_frame(frame, c):

*# Send the frame to the other process*

c.send(frame.encode())

*prepare\_frame(frame,c):*

Function to prepare the frame for the sender given the frame number by converting it to binary and applying crc..

*# Function to prepare a frame*

**def** prepare\_frame(frame,sn):

frame=str(sn)+frame

*# CRC application*

crcframe=err.crc([frame], err.generator\_poly, frame\_size)

**return** crcframe[0]

*generateAck(rn):*

Function to generate acknowledgement for the receiver given the frame number by converting it to binary and applying crc.

*# Function to generate ack*

**def** generateAck(rn):

*# Generate crc appended code*

ack=bin(rn)[2:]

crcframe=err.crc([ack], err.generator\_poly, frame\_size)

**return** crcframe[0]

*readFile(filename, frame\_size):*

Function to read the input file and split into frames.

*# Function to read the file and split into frames*

**def** readfile(filename, frame\_size):

*# Open the file for reading*

f=open(filename,'r')

data=f.read()

*# Now split the data into frames*

list\_of\_frames=[data[i:i+frame\_size] **for** i **in** range(0, len(data), frame\_size)]

**return** list\_of\_frames

*ins\_error(frame, list\_of\_bits):*

Function to insert error at certain bit positions in the frame.

*# Function to introduce error*

**def** ins\_error(frame, list\_of\_bit):

new=list(frame)

*# Inserting error in the given bit position here*

**for** i **in** range(len(list\_of\_bit)):

**if**(new[list\_of\_bit[i]]=='0'):

new[list\_of\_bit[i]]='1'

**elif** (new[list\_of\_bit[i]]=='1'):

new[list\_of\_bit[i]]='0'

new=''.join(new)

**return** new

***sender.py:***

This is the code for the sender process.

timeoutTime=5

frame\_size=4

*isValid(ack,sn):*

This function checks if the acknowledgement received is valid by performing a CRC check and also matching with the expected sequence number.

*# Check if ack is valid using crc*

**def** isValid(ack,sn):

**if**(ack[0]!=str((sn+1)%2)):

**return** False

*# Now check CRC*

**if**(int(err.modulo2div(ack,err.generator\_poly),2)!=0):

**return** False

**return** True

*send\_all(list\_of\_frames):*

Function to send all the frames to the channel process via the sockets. It first connects to the sockets and sends the frames and waits. If it encounters a timeout it resends the frame.

*# Function to send all the frames*

**def** send\_all(list\_of\_frames):

sockSend=co.createSocket(co.portSenderSend) *# sender socket to send data to channel*

c, addr=co.allowConn(sockSend)

sockRec=co.createConn(co.portSenderReceive) *# Socket to receive data from channel*

sockRec.settimeout(timeoutTime)

**print**('Connected to channel')

*# implementing stop and wait arq*

sn=0

i=0

**while**(i<(len(list\_of\_frames))): *# While there are frames send*

**print**(15\*'-')

canSend=True

sn=(i)%2

stored\_frame=list\_of\_frames[i]

**if**(stored\_frame!='#'):

stored\_frame=co.prepare\_frame(list\_of\_frames[i],sn)

**print**('Sending frame '+str(i)+' '+stored\_frame)

co.send\_frame(stored\_frame, c)

canSend=False

**try**:

ack=sockRec.recv(1024).decode()

**except** **Exception** **as** e:

*# Resend so repeat this iteration of loop*

**print**('Timeout.. Resending')

**continue**

**if**(ack=='#'):

**break**

**print**('Ack received '+ack)

**if**(ack **and** isValid(ack,sn)): *# Wrong acknowledgement*

**print**('Correct ack received')

canSend=True

i=i+1

**elif**(**not** isValid(ack,sn)):

*# invalid ack so resend*

**print**('Wrong ack.. resending')

**print**(15\*'-')

*# Close the sockets*

sockSend.close()

sockRec.close()

***channel.py:***

This module implements the channel process. It first creates the appropriate sockets and then it goes into an infinite loop waiting for the sender to send. It receives the frame from the sender, may inject error and injects delay and the sends it to the receiver and also does the same for the receiver. It may also not send a frame to the sender or receiver (this is to simulate a lost acknowledgement or a lost frame).

*# This is the channel process*

*# First create the required sockets*

**import** **common** **as** **co**

**import** **random**

**import** **time**

probas=10

randSendF=2 *# Random probability of sending frame or not*

randSendAck=2

randErrF=1

randErrAck=1

*# \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* SENDER \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

sockSenderReceive=co.createConn(co.portSenderSend) *# Socket to receive data from sender*

sockSenderSend=co.createSocket(co.portSenderReceive) *# Socket to send data to sender*

senderSend, addr=co.allowConn(sockSenderSend)

**print**('Channel connected to sender')

*#\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

*#\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* RECEIVER \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

sockReceiverReceive=co.createConn(co.portReceiverSend) *# Socket to receive data from receiver*

sockReceiverReceive.settimeout(3)

sockReceiverSend=co.createSocket(co.portReceiverReceive) *# Socket to send data to receiver*

receiverSend, addr=co.allowConn(sockReceiverSend)

**print**('Channel connected to receiver')

*#\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

**while** True:

**print**(15\*'-')

*# Receive the frame from the sender*

stored\_frame=sockSenderReceive.recv(1024).decode()

**print**('Frame received from sender '+stored\_frame)

*# Insert error and other stuffs here*

*# Send frame with a probability p*

p=random.randint(0,probas)

**print**(p)

**if**(p>=randSendF **or** len(stored\_frame)<8): *# Ending marker should always be sent*

*# Introduce error here with a probability*

p2=random.randint(0,probas)

**if**(p2<=randErrF **and** len(stored\_frame)>=8):

**print**("Introducing error")

stored\_frame=co.ins\_error(stored\_frame,[1])

*# Send the frame to the receiver*

**print**('Sending frame to receiver '+stored\_frame)

*# Add sleep here*

time.sleep(2)

co.send\_frame(stored\_frame, receiverSend)

**print**('Sent frame '+stored\_frame)

*# Dont Send the frame*

**else**:

**print**('Not sending frame')

**continue**

**try**:

*# Wait ack from receiver*

ack=sockReceiverReceive.recv(1024).decode()

**print**('Ack received from receiver '+ack)

**except** **Exception** **as** e:

*# Resend so repeat this iteration of loop*

**print**('Timeout.. waiting for sender to send')

**continue**

*# Insert error and other stuffs here*

*# send the frame with a probability*

p=random.randint(0,probas)

**print**(p)

**if**(p>=randSendAck **or** stored\_frame=='#'):

*# Introduce error here with a probability*

p2=random.randint(0,probas)

**if**(p2<=randErrAck **and** stored\_frame=='#'):

**print**("Introducing error")

ack=co.ins\_error(ack,[1])

**print**('Sending ack to sender '+ack)

*# Add sleep here*

time.sleep(2)

*# Send the ack to the sender*

co.send\_frame(ack, senderSend)

**if**(stored\_frame=='#'):

**break**

**else**:

**print**('Not sending acknowledgement')

**continue**

**print**(15\*'-')

sockSenderReceive.close()

sockSenderSend.close()

sockReceiverReceive.close()

sockReceiverSend.close()

***rec.py***

This module is the receiver process.

*isValid(ack,sn):*

This function checks if the frame received is valid by performing a CRC check and also matching with the expected sequence number on the receiver side.

*# Function to check if frame is valid*

**def** isValid(frame, rn):

**if**(frame[0]!=str(rn)):

**return** 0

*# Now check CRC*

**if**(int(err.modulo2div(frame,err.generator\_poly),2)!=0):

**return** 1

**return** 2

*receive():*

Function to receive a frame from the channel and send the ack.

**def** receive():

*# Establish connection*

sockRec=co.createSocket(co.portReceiverSend)

c, addr=co.allowConn(sockRec)

sockSend=co.createConn(co.portReceiverReceive)

**print**('Connected to channel')

*# Connection established*

rn=0

**while** True:

*# Wait till frame received*

**print**(15\*'-')

frame=sockSend.recv(1024).decode()

**print**('Frame received '+frame)

**if**(frame=='#'):

ack='#'

**else**:

**if**(isValid(frame, rn)==0): *# wrong frame no received send ack for prev*

**print**('Invalid frame')

**print**('Sending ack for previous frame')

ackno=(rn)%2

**elif**(isValid(frame, rn)==1):

**print**('Error in frame')

**continue**

**else**: *# Valid frame*

ackno=(rn+1)%2

*# For valid data frame*

rn=(rn+1)%2

*# Send an acknowledgement*

ack=co.generateAck(ackno)

*# Send the ack*

**print**('Sending ack '+ack)

co.send\_frame(ack,c)

**if**(frame=='#'): *# Means end frame*

**break**

**print**(15\*'-')

*# Close the sockets*

sockSend.close()

sockRec.close()

**print**('Demonstrating STOP AND WAIT ARQ')

receive()

**OUTPUTS**

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**RESULTS**

The throughput here was measured in terms of the attempts it took to send the entire data. With random frame loss and random error insertion it took an average of 20 attempts by the sender to send 10 frames of data. Average propagation time was 2 seconds and with delay inserted it was average of 3 seconds.

**ANALYSIS**

Overall the implementation of the assignment is more or less correct. Some possible bugs can arise due to the assumption that the input size is a multiple of the frame size. However, this can easily be overcome by padding the last frame of the input data with 0s so that it is a multiple of the frame size. Currently the program works only for single sender and receiver processes but the program may be modified to work with multiple sender and multiple receiver processes.

**COMMENTS**

Overall the lab assignment was a great learning experience as we got to implement the well-known flow control protocols ourselves. The assignment can be rated as moderately difficult.

**GO BACK N SLIDING WINDOW:**

**DESIGN**

The program implements the go back N flow control protocol. The program consists of 5 modules.

1. **errorchecker.py**

This file contains the implementation of all the error detection algorithm from assignment1.

1. **gbn\_sender.py**

This file contains the code to perform the work of the sender. Read from the input file, create the frame to be sent to the receiver and the send the frame to the channel process. This process also receives the acknowledgement sent by the receiver and accordingly resends the frame if ack is not received or is corrupt. Here as the sending and receiving can be done simultaneously they are run as two separate threads one sending the frame till window size is full and the other receiving the acknowledgement and deleting the required frames. A third thread in the sender process handles the timeout and resending operation.

1. **channel\_gbn.py**

This is the channel process where two threads are created. One thread receives a frame from the sender injects delay and error and sends it to the receiver. The second thread receives an acknowledgement frame from the receiver and sends it to the sender.

1. **gbn\_receiver.py**

This file contains the code to perform the work of the receiver. It receives the frame sent by the sender from the channel process, generates an acknowledgement and sends it to the channel process.

1. **common.py**

This file contains some common function to be used by all processes.

All inter-process communication has been carried out by making use of the Python3 **socket**.

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| ***Fig. 2.*** *A brief outline of the program design of go back n* |

**Fig. 2** gives a brief outline of the program.

Some important parameters for the design of the program are:

**Window size:** The window size assumed is 3 (22-1).

**Frame format:** The frame format used in the sender process is described as follows. The input data is split into frames of 4 bits each. Then for each frame the frame number converted to binary (00 to 11) is appended to the beginning of the frame. The entire 6 bit data is then encoded using CRC-3. Thus the resulting frame size is 9 bits. This frame is then sent to the channel process.

**Acknowledgement format:** The acknowledgement frame which is sent by the receiver consists of a bit stating the frame number in binary which is then CRC encoded using CRC-3 thus making 5 bit acknowledgement.

**Assumption:** During the design one assumption that has been made is that the number of bits in the input file is a multiple of 4.

**Input format:** The input for the program is a text file consisting of a string of only 0s and 1s.

**Output format:** The program output simulates the flow control protocol.

**IMPLEMENTATION**

The assignment has been implemented in Python3. The detailed description is given below.

***errorchecker.py:*** This is the same error checking module as present in Assignment 1.

***common.py:***

This module contains some commonly used function in the modules.

The port specifications are given below

portSenderReceive=11001

portSenderSend=11002

portReceiverReceive=11003

portReceiverSend=11004

frame\_size=4

m=2

window\_size=2\*\*m-1

*createSocket(port):*

This function creates a socket and binds it to a port

*# Function to create a socket and bind it to a port*

**def** createSocket(port):

s=socket.socket(socket.AF\_INET, socket.SOCK\_STREAM)

s.bind(('', port))

**return** s

*allowConn(port):*

Function to establish a connection with the port.

*# Function to receive a connection*

**def** allowConn(s):

s.listen(5)

c, addr=s.accept()

**return** c, addr

*createConn(port):*

Function to create a socket with a port and connect to it.

*# Function to create a socket and connect to it*

**def** createConn(port):

sock=socket.socket()

sock.connect(('',port))

**return** sock

*send\_frame(frame,c):*

Function to send a frame through a particular socket.

*# Function to send a frame*

**def** send\_frame(frame, c):

*# Send the frame to the other process*

c.send(frame.encode())

*prepare\_frame\_gbn(frame,c):*

Function to prepare the frame for the sender given the frame number by converting it to binary and applying crc.

**def** prepare\_frame\_gbn(frame,sn):

sn=sn%(window\_size+1)

sn=bin(sn)

sn=sn[2:].zfill(3)

frame=str(sn)+frame

*# CRC application*

crcframe=err.crc([frame], err.generator\_poly, frame\_size)

**return** crcframe[0]

*generateAck\_gbn(rn):*

Function to generate acknowledgement for the receiver given the frame number by converting it to binary and applying crc.

*# Function to generate ack*

**def** generateAck(rn):

*# Generate crc appended code*

ack=bin(rn)[2:]

crcframe=err.crc([ack], err.generator\_poly, frame\_size)

**return** crcframe[0]

*readFile(filename, frame\_size):*

Function to read the input file and split into frames.

*# Function to read the file and split into frames*

**def** readfile(filename, frame\_size):

*# Open the file for reading*

f=open(filename,'r')

data=f.read()

*# Now split the data into frames*

list\_of\_frames=[data[i:i+frame\_size] **for** i **in** range(0, len(data), frame\_size)]

**return** list\_of\_frames

*ins\_error(frame, list\_of\_bits):*

Function to insert error at certain bit positions in the frame.

*# Function to introduce error*

**def** ins\_error(frame, list\_of\_bit):

new=list(frame)

*# Inserting error in the given bit position here*

**for** i **in** range(len(list\_of\_bit)):

**if**(new[list\_of\_bit[i]]=='0'):

new[list\_of\_bit[i]]='1'

**elif** (new[list\_of\_bit[i]]=='1'):

new[list\_of\_bit[i]]='0'

new=''.join(new)

**return** new

***sender\_gbn.py:***

This is the code for the sender process. The global variables sn and sf are pointers to the end and beginning and of the window respectively and sw is the window size defined in common.py.

timeoutTime=17

frame\_size=4

sw=co.window\_size

sf=0

sn=0

stored\_buffer={i:'' **for** i **in** range(sw)}

**print**('Demonstrating Go Back N ARQ')

list\_of\_frames=co.readfile('input.txt', frame\_size)

**print**(list\_of\_frames)

list\_of\_frames.append('#') *# Attach a blank frame*

sockSend=co.createSocket(co.portSenderSend) *# sender socket to send data to channel*

sender, addr=co.allowConn(sockSend)

sockRec=co.createConn(co.portSenderReceive) *# Socket to receive data from channel*

sockRec.settimeout(timeoutTime)

**print**('Connected to channel')

send\_all(list\_of\_frames)

*isValid(ack,sn):*

This function checks if the acknowledgement received is valid by performing a CRC check.

*# Check if ack is valid using crc*

**def** isValid(ack):

*# Now check CRC*

**if**(int(err.modulo2div(ack,err.generator\_poly),2)!=0):

**return** False

**return** True

*send\_all(list\_of\_frames):*

Function to send all the frames to the channel process via the sockets. It creates the required threads for sending and receiving.

*# Function to send all the frames*

**def** send\_all(list\_of\_frames):

sendThread=threading.Thread(target=sendFrame, args=(list\_of\_frames,)) *# create the sending thread*

receiveThread=threading.Thread(target=receiveFrame) *# create the receiving thread*

sendThread.start()

receiveThread.start()

sendThread.join()

**print**('Send thread end')

receiveThread.join()

*# Close the sockets*

sockSend.close()

sockRec.close()

*sendFrame():*

This function is run as a separate thread which sends all the frames to the channel until window size is full.

*# Function to send list of frames*

**def** sendFrame(list\_of\_frames):

**global** sn

**global** stored\_buffer

**global** sw

i=0

**while** True:

*# Store\_frame(sn)*

stored\_frame=list\_of\_frames[i]

**print**('sn: '+str(sn)+' sf: '+str(sf)+' sw: '+str(sw))

**if**(stored\_frame!='#'):

stored\_frame=co.prepare\_frame\_gbn(list\_of\_frames[i],(i%(co.window\_size+1)))

*# Else send the blank frame*

*# If window size reached wait*

**if**((sn-sf)<sw):

*# Sendframe(sn)*

stored\_buffer[sn%sw]=stored\_frame

**print**('Sending frame '+str(i)+' '+stored\_frame)

co.send\_frame(stored\_frame, sender)

sn=(sn+1)

**if** (i<len(list\_of\_frames)-1):

i=i+1

**else**:

**print**('Window Size full')

**print**(stored\_buffer)

time.sleep(5)

*receiverFrame():*

This function is run as a separate thread which receives ack from the channel process, checcks if it is a valid ack and accordingly deletes the required frames. In case of a timeout this function also starts the resend thread which resends all the frames in the range sf and sn.

*# Function to receive ack*

**def** receiveFrame():

**global** sf

**global** sn

**global** sw

**global** stored\_buffer

**while** True:

**try**:

ack=sockRec.recv(1024).decode()

**except** **Exception** **as** e:

*# Resend so repeat this iteration of loop*

**print**('Timeout.. Resending')

resendThread=threading.Thread(target=resendFrameAfterTimeout, args=(stored\_buffer,)) *# create the resending thread*

resendThread.start()

resendThread.join()

**continue**

**print**('Ack received '+str((ack[0:3])))

**if**(ack !='#' **and** isValid(ack)): *# Correct acknowledgement*

**print**('Correct ack received')

ackno=int(ack[0:3],2)

**print**('Ackno '+str(ackno))

*# Purge required frames*

**if**(sn%(sw+1)<sf%(sw+1) **and** ackno<sf%(sw+1)):

**while**((sf%(sw+1))>ackno):

**print**('Deleting frame '+str(sf%sw))

stored\_buffer[sf%sw]=''

sf=(sf+1)

stored\_buffer[sf%sw]=''

**if**(ackno>=(sf%(sw+1)) **and** ackno<=(sn%(sw+1))):

**while**((sf%(sw+1))<ackno):

**print**('Deleting frame '+str(sf%sw))

stored\_buffer[sf%sw]=''

sf=(sf+1)

sf=sf+1

**elif**(ack !='#' **and** **not** isValid(ack)): *# Wrong ack*

*# invalid ack so resend*

**print**('Wrong ack.. resending')

*resendFrameAfterTimeout(list\_of\_frames):*

This function is also run as a separate thread for resending frames after timeout.

*# Function to resend frame after timeout*

**def** resendFrameAfterTimeout(list\_of\_frames):

**global** sn

**global** sf

**global** stored\_buffer

*# Resend frame*

temp=sf

**print**('Resending '+str(sf))

**while**(temp<sn):

**if**(stored\_buffer[temp%sw]!=''):

**print**('Resending frame '+str(temp%(sw))+' '+stored\_buffer[temp%sw])

co.send\_frame(stored\_buffer[temp%sw], sender)

time.sleep(5)

temp=(temp+1)

***channel.py:***

This module implements the channel process. It first creates the appropriate sockets. It then starts two threads one to receive data from sender and send to receiver and other to receive data from receiver and send to sender. It may also not send a frame to the sender or receiver (this is to simulate a lost acknowledgement or a lost frame).

*# This is the channel process*

*# First create the required sockets*

**import** **common** **as** **co**

**import** **random**

**import** **time**

**import** **threading**

probas=10

randSendF=2 *# Random probability of sending frame or not*

randSendAck=2

randErrF=1

randErrAck=-1

*# \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* SENDER \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

sockSenderReceive=co.createConn(co.portSenderSend) *# Socket to receive data from sender*

sockSenderSend=co.createSocket(co.portSenderReceive) *# Socket to send data to sender*

senderSend, addr=co.allowConn(sockSenderSend)

**print**('Channel connected to sender')

*#\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

*#\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* RECEIVER \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

sockReceiverReceive=co.createConn(co.portReceiverSend) *# Socket to receive data from receiver*

*# sockReceiverReceive.settimeout(11)*

sockReceiverSend=co.createSocket(co.portReceiverReceive) *# Socket to send data to receiver*

receiverSend, addr=co.allowConn(sockReceiverSend)

**print**('Channel connected to receiver')

*#\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\**

*receiveFromSender():*

This function receives the frame from the sender and sends it to the receiver after injecting delay and error in the frame.

**def** receiveFromSender():

**while** True:

**print**(15\*'-')

*# Receive the frame from the sender*

stored\_frame=sockSenderReceive.recv(1024).decode()

**print**('Frame received from sender '+stored\_frame)

*# Insert error and other stuffs here*

*# Send frame with a probability p*

p=random.randint(0,probas)

**print**(p)

**if**(p>=randSendF **or** len(stored\_frame)<8): *# Ending marker should always be sent*

*# Introduce error here with a probability*

p2=random.randint(0,probas)

**if**(p2<=randErrF **and** len(stored\_frame)>=8):

**print**("Introducing error")

stored\_frame=co.ins\_error(stored\_frame,[1])

*# Send the frame to the receiver*

**print**('Sending frame to receiver '+stored\_frame)

*# Add sleep here*

*# time.sleep(7)*

co.send\_frame(stored\_frame, receiverSend)

**print**('Sent frame '+stored\_frame)

*# Dont Send the frame*

**else**:

**print**('Not sending frame')

**print**(15\*'-')

*receiveAckFromReceiver():*

This function receives the ack from the receiver and sends it to the sender.

**def** receiveAckFromReceiver():

**while** True:

**print**(15\*'=')

*# Wait ack from receiver*

ack=sockReceiverReceive.recv(1024).decode()

**print**('Ack received from receiver '+ack)

*# Insert error and other stuffs here*

*# send the frame with a probability*

p=random.randint(0,probas)

**print**(p)

**if**(p>=randSendAck):

*# Introduce error here with a probability*

p2=random.randint(0,probas)

**if**(p2<=randErrAck):

**print**("Introducing error")

ack=co.ins\_error(ack,[1])

**print**('Sending ack to sender '+ack)

*# Add sleep here*

*# time.sleep(7)*

*# Send the ack to the sender*

co.send\_frame(ack, senderSend)

**else**:

**print**('Not sending acknowledgement')

**print**(15\*'=')

*mainChannel():*

It creates the required threads and starts the threads one for receiving data from sender and the other for receiving from receiver.

**def** mainChannel():

sendThread=threading.Thread(target=receiveFromSender) *# create the sending thread*

receiveThread=threading.Thread(target=receiveAckFromReceiver) *# create the receiving thread*

receiveThread.start()

sendThread.start()

sendThread.join()

receiveThread.join()

mainChannel()

sockSenderReceive.close()

sockSenderSend.close()

sockReceiverReceive.close()

sockReceiverSend.close()

***gbn\_receiver.py***

This module is the receiver process.

*isValid(ack,sn):*

This function checks if the frame received is valid by performing a CRC check and also matching with the expected sequence number on the receiver side.

*# Function to check if frame is valid*

**def** isValid(frame, rn):

**if**(int(err.modulo2div(frame,err.generator\_poly),2)!=0):

**return** False

**elif**(int(frame[0:3],2)%(co.window\_size+1)!=rn):

**return** False

**return** True

*receive():*

Function to receive a frame from the channel and send the ack.

**def** receive():

*# Establish connection*

sockRec=co.createSocket(co.portReceiverSend)

c, addr=co.allowConn(sockRec)

sockSend=co.createConn(co.portReceiverReceive)

**print**('Connected to channel')

*# Connection established*

rn=0

**while** True:

*# Wait till frame received*

**print**(15\*'-')

frame=sockSend.recv(1024).decode()

**print**('Expecting: '+str(rn))

**print**('Frame received '+frame)

**if**(frame!='#' **and** **not** isValid(frame, rn)): *# wrong frame no received send ack for prev*

**print**('Invalid frame..Not sending ack')

**elif**(frame!='#'):

ackno=frame[0:3]

*# Send an acknowledgement*

ack=co.generateAck\_gbn(ackno)

time.sleep(5)

*# Send the ack*

**print**('Sending ack '+ack)

co.send\_frame(ack,c)

rn=(rn+1)%(co.window\_size+1)

**else**:

*# For valid frame*

ack='#'

time.sleep(5)

*# Send the ack*

**print**('Sending ack '+ack)

co.send\_frame(ack,c)

**print**(15\*'-')

*# Close the sockets*

sockSend.close()

sockRec.close()

**print**('Demonstrating Go Back N ARQ')

receive()

**OUTPUTS**

|  |
| --- |
|  |
|  |

**RESULTS**

The throughput here was measured in terms of the attempts it took to send the entire data. With random frame loss and random error insertion it took an average of 7 attempts by the sender to send 10 frames of data with a window of size 3. Average propagation time for a frame was 2 seconds and with delay inserted it was average of 3 seconds per frame. So total delay for the window is 9 seconds.

**ANALYSIS**

Overall the implementation of the assignment is more or less correct. Some possible bugs can arise due to the assumption that the input size is a multiple of the frame size. However, this can easily be overcome by padding the last frame of the input data with 0s so that it is a multiple of the frame size. Currently the program works only for single sender and receiver processes but the program may be modified to work with multiple sender and multiple receiver processes.

**COMMENTS**

Overall the lab assignment was a great learning experience as we got to implement the well-known flow control protocols ourselves. The assignment can be rated as difficult.