NETWORK LAB REPORT

NAME: ANURAN CHAKRABORTY
ROLL NO.: 20
CLASS: BCSE-III
SECTION: A1

ASSIGNMENT NUMBER: 3

PROBLEM STATEMENT:
implement p-persistent CSMA with exponential backoff and additive backoff. Measure the performance parameters like throughput (i.e., average amount of data bits successfully transmitted per unit time) and forwarding delay (i.e., average end-to-- end delay, including the queuing delay and the transmission delay) experienced by the CSMA frames (IEEE 802.3). Plot the comparison graphs for throughput and forwarding delay by varying p. State your observations on the impact of different data rates for exponential/additive backoff along with p-persistent CSMA.

DEADLINE: 14TH MARCH, 2019
SUBMITTED ON: 14TH MARCH, 2019
REPORT SUBMITTED ON: 28TH MARCH, 2019

The report has two sections one for the CSMA protocol and the other for the CSMA/CD protocol.

CSMA:

DESIGN

The program implements the CSMA protocol. The program consists of 3 modules.

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. The sender continuously senses the channel to check whether it is busy. If the channel is busy it waits else if it is idle it sends the frame with a probability p or it waits for a random period of time and then again checks.

2. **channel.py**
   This is the channel process whose task are the following
   a) Receive frame from sender
   b) Send this frame to the receiver
   c) A parallel thread sends a continuous signal to the sender stating whether the channel is free or not.

3. **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.

4. **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**.

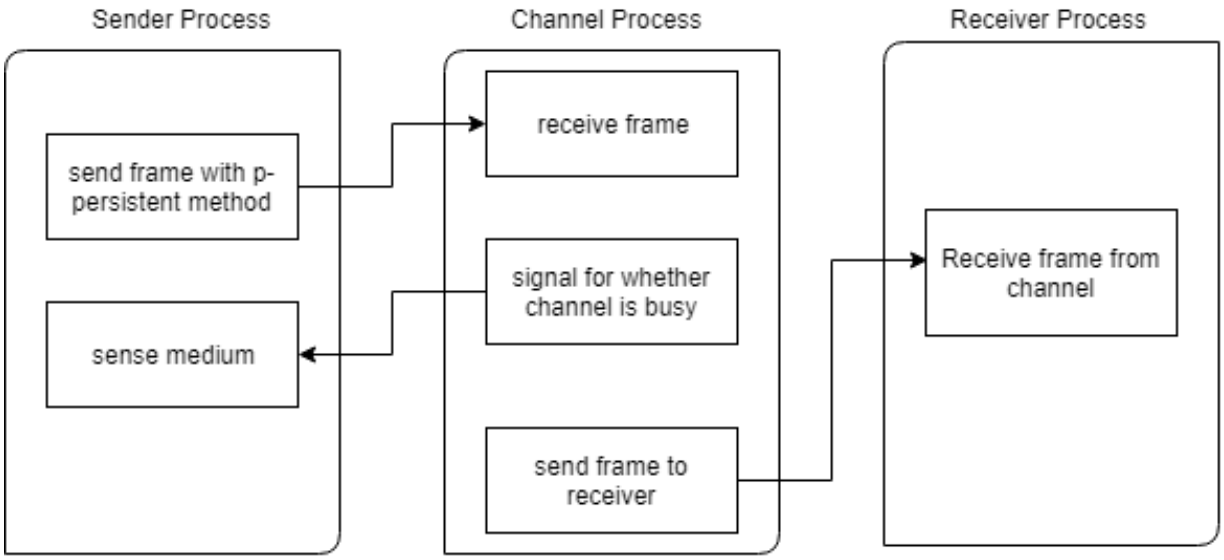


Fig. 1. *A brief outline of the program design of CSMA*

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. This frame is then sent to the channel process.

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 CSMA protocol.

IMPLEMENTATION

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

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.

```
import common as co
import time
import socket
import random
import time
import threading

isBusyChannel=0
sockSend=co.createConn(co.portSenderReceive)  # Socket to send data to channel

time.sleep(1)
sockSignal=co.createConn(co.portSenderSignal) # Socket to send data to channel
print('Connected to channel')

probab=10
p=4
timeSlot=2

list_of_frames=co.readfile('input.txt', co.frame_size)
list_of_frames.append('#')

sendThread=threading.Thread(target=send_frame, args=(list_of_frames,)) #
create the sending thread
senseThread=threading.Thread(target=sense_medium) # create the sending thread

sendThread.start()
senseThread.start()

sendThread.join()
```

```
sendThread.join()
```

send_frame(list_of_frames):

This function takes as its parameter a list of frames and sends all the frames to the channel. It checks whether the channel is busy by checking the **isBusyChannel** flag and accordingly follows the p-persistent strategy to send the frames.

```
# Function to send frames
def send_frame(list_of_frames):

        i=0
        while(True):
                # Sense the channel and check if flag is 1 then dont send
                if(isBusyChannel==0): # Channel is free
                        # Send the frame with a probability p
                        pr=random.randint(0,probab)
                        if(pr<=p):
                                # Send the frame
                                print('Sending frame '+str(i))
                                co.send_frame(list_of_frames[i], sockSend)
                                if(list_of_frames[i]!='#'):
                                        i=i+1
                                time.sleep(3)
                        else:
                                print('Waiting '+str(timeSlot))
                                time.sleep(timeSlot)
                                continue

                else: # Channel is busy
                        print('Channel busy')
                        time.sleep(2)
                        continue
```

sense_medium():

This function continuously receives a signal from the channel process which is an indication of whether the channel is busy or not and accordingly sets the **isBusyChannel** flag. This function is run as a separate thread in the program.

```
# Function to sense the medium
def sense_medium():
        global isBusyChannel
```

```
        while(True):
                if(sockSignal.recv(1024).decode()=='1'):
                        # Means channel is busy
                        isBusyChannel=1
                else:
                        # Means channel is not busy
                        isBusyChannel=0
```

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 and keeps it in a buffer. The frames from the buffer is then sent to the receiver. The channel has actually 4 parallel threads running. One main thread continuously checks if any new sender has connected to the channel. Whenever a new sender connects to the channel it starts a new thread to service that sender. In a parallel thread the frames are sent to the receiver.

```
# This is the channel process
import socket
import threading
import common as co
import time

sockSenderRec=co.createSocket(co.portSenderReceive)
sockSenderSignal=co.createSocket(co.portSenderSignal)
sockReceiverSend=co.createSocket(co.portReceiverSend)
allow_new_conn()s
```

allow_new_conn():

This function checks if a new connection is established.

```
def allow_new_conn():
        sockReceiverSend.listen(5)
        receive, addrrec=sockReceiverSend.accept()

        recThread=threading.Thread(target=send_to_receiver, args=[receive])
        recThread.start()

        while(True):
                # Wait for a connection
                sockSenderRec.listen(5)
                c, addr=sockSenderRec.accept()
                print('Connected to sender')
```

```
                sockSenderSignal.listen(5)
                signal,addrsignal=sockSenderSignal.accept()

                # Start a new thread for the sender
                sendThread=threading.Thread(target=receive_from_sender,
args=[c,addr])
                sendThread.start()

                signalThread=threading.Thread(target=send_signal,
args=[signal, addrsignal])
                signalThread.start()
```

send_to_receiver(receive):

This function sends the frames to the receiver.

```
# Function to send to receiver
def send_to_receiver(receive):

        while(True):
                # If buffer not empty send the frame and clear buffer
                if(len(co.shared_buffer)>0):
                        # Send the frame
                        print('Sending frame to receiver ')
                        time.sleep(4)
                        co.send_frame(co.shared_buffer[0], receive)
                        del co.shared_buffer[0]
                else:
                        continue
```

receive_from_sender(c, addr):

This function services (receives data from sender) each sender in separate threads.

```
# Function to receive data from sender
def receive_from_sender(c, addr):
        # Receive data from the sender and keep it in stored buffer
        print('Started new connection to '+str(addr))

        while(True):
                # Receive data from sender
                frame=c.recv(1024).decode()
                time.sleep(2)
                co.shared_buffer.append(frame)
                print(co.shared_buffer)
```

send_signal(s, saddr):

This function continuously sends every sender the signal whether the channel is busy or not.

```
def send_signal(s, saddr):
        signal=0

        while(True):
                if(len(co.shared_buffer)>=1): # Channel is busy
                        signal=1
                else: # Channel not busy
                        signal=0

                # Send the signal via socket
                co.send_frame(str(signal), s)
```

rec.py

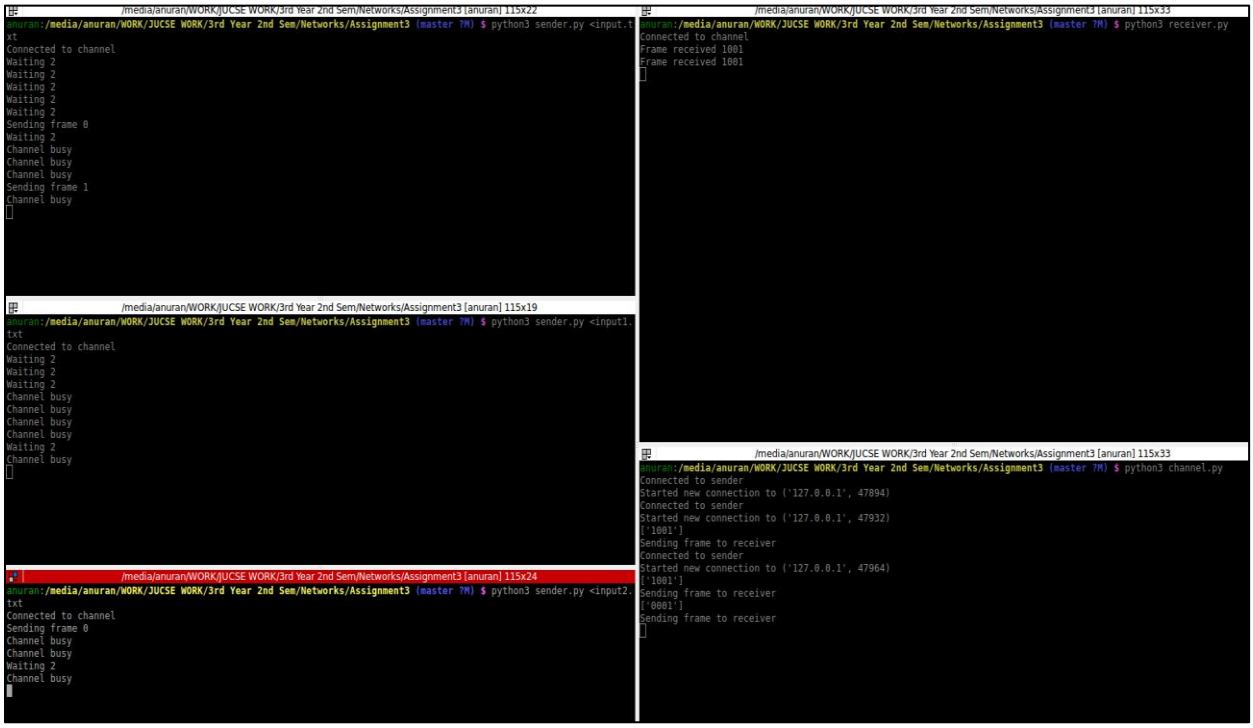
This module is the receiver process.

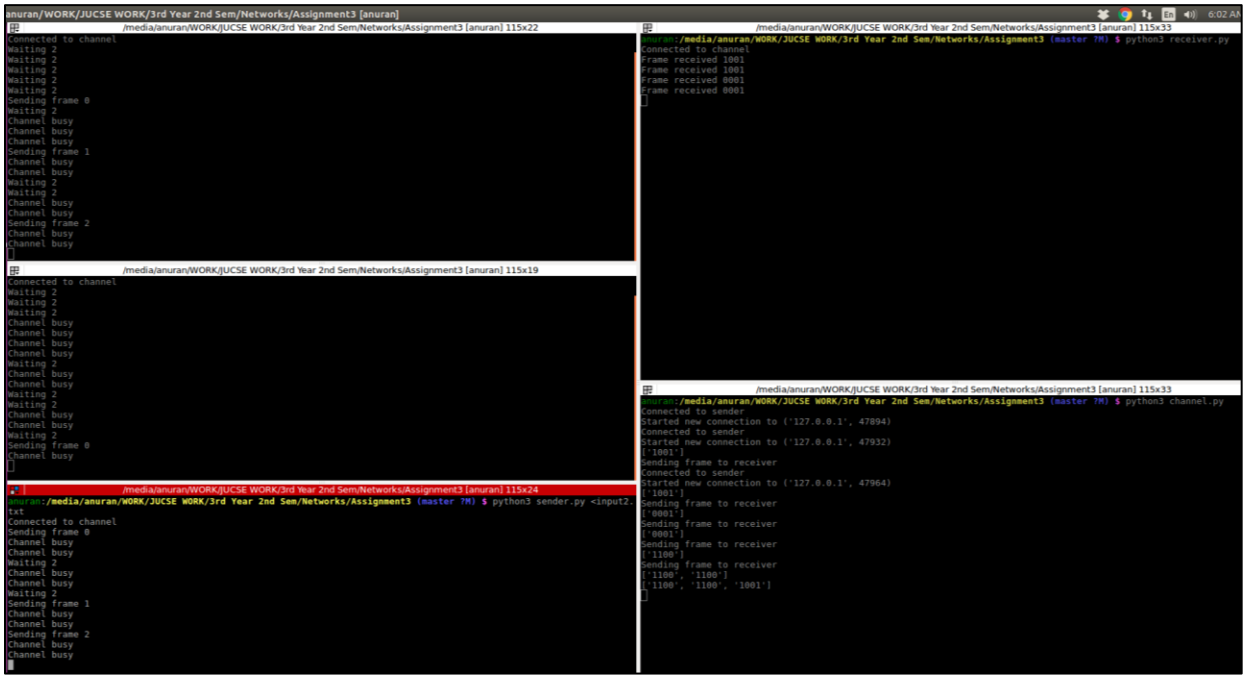
receive_frame():

This function receives frames from the channel process via a socket.

```
import common as co
import socket

sockReceive=co.createConn(co.portReceiverSend)        # Socket to send data to
channel
print('Connected to channel')

# Function to receive a frame
def receive_frame():

        while(True):
                # Receive the frame
                frame=sockReceive.recv(1024).decode()
                print('Frame received '+frame)

receive_frame()
```

OUTPUTS


/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x22
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender.py <input.t
xt
Connected to channel
Waiting 2
Waiting 2
Waiting 2
Waiting 2
Waiting 2
Sending frame 0
Waiting 2
Channel busy
Channel busy
Channel busy
Sending frame 1
Channel busy
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x33
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 receiver.py
Connected to channel
Frame received 1001
Frame received 1001
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x19
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender.py <input1.
txt
Connected to channel
Waiting 2
Waiting 2
Waiting 2
Channel busy
Channel busy
Channel busy
Channel busy
Waiting 2
Channel busy
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x33
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 channel.py
Connected to sender
Started new connection to ('127.0.0.1', 47894)
Connected to sender
Started new connection to ('127.0.0.1', 47932)
['1001']
Sending frame to receiver
Connected to sender
Started new connection to ('127.0.0.1', 47964)
['1001']
Sending frame to receiver
['0001']
Sending frame to receiver
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x24
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender.py <input2.
txt
Connected to channel
Sending frame 0
Channel busy
Channel busy
Waiting 2
Channel busy


anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran]
6:02 AM
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x22
Connected to channel
Waiting 2
Waiting 2
Waiting 2
Waiting 2
Waiting 2
Sending frame 0
Waiting 2
Channel busy
Channel busy
Channel busy
Sending frame 1
Channel busy
Channel busy
Waiting 2
Waiting 2
Channel busy
Channel busy
Sending frame 2
Channel busy
Channel busy
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x33
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 receiver.py
Connected to channel
Frame received 1001
Frame received 1001
Frame received 0001
Frame received 0001
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x19
Connected to channel
Waiting 2
Waiting 2
Waiting 2
Channel busy
Channel busy
Channel busy
Channel busy
Waiting 2
Channel busy
Channel busy
Waiting 2
Waiting 2
Channel busy
Channel busy
Waiting 2
Sending frame 0
Channel busy
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x33
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 channel.py
Connected to sender
Started new connection to ('127.0.0.1', 47894)
Connected to sender
Started new connection to ('127.0.0.1', 47932)
['1001']
Sending frame to receiver
Connected to sender
Started new connection to ('127.0.0.1', 47964)
['1001']
Sending frame to receiver
['0001']
Sending frame to receiver
['0001']
Sending frame to receiver
['1100']
Sending frame to receiver
['1100', '1100']
['1100', '1100', '1001']
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 115x24
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender.py <input2.
txt
Connected to channel
Sending frame 0
Channel busy
Channel busy
Waiting 2
Channel busy
Sending frame 1
Channel busy
Channel busy
Sending frame 2
Channel busy
Channel busy

RESULTS

The throughput here was measured in terms of the attempts it took to send the entire data. With increase in p the number of collisions increased as more station tried to send data simultaneously. However it also sometimes decreased due to immediate sending of data.

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 multiple sender and single 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 CSMA protocol ourselves. The assignment can be rated as moderately difficult.

CSMA/CD:

DESIGN

The program implements the CSMA/CD protocol. The program consists of 3 modules.

1. **sender_cd.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. The sender continuously senses the channel to check whether it is busy. If the channel is busy it waits else if it is idle it sends the frame with a probability p or it waits for a random period of time and then again checks. Also, once the sender sends the frame it waits for a signal from the channel which states whether any collision was detected or not. If there is collision then the frame is resent.

2. **channel_cd.py**
   This is the channel process whose task are the following
   a) Receive frame from sender
   b) Send this frame to the receiver
   c) Send jamming signal in case of collision
   d) A parallel thread sends a continuous signal to the sender stating whether the channel is free or not.

3. **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.

4. **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**.

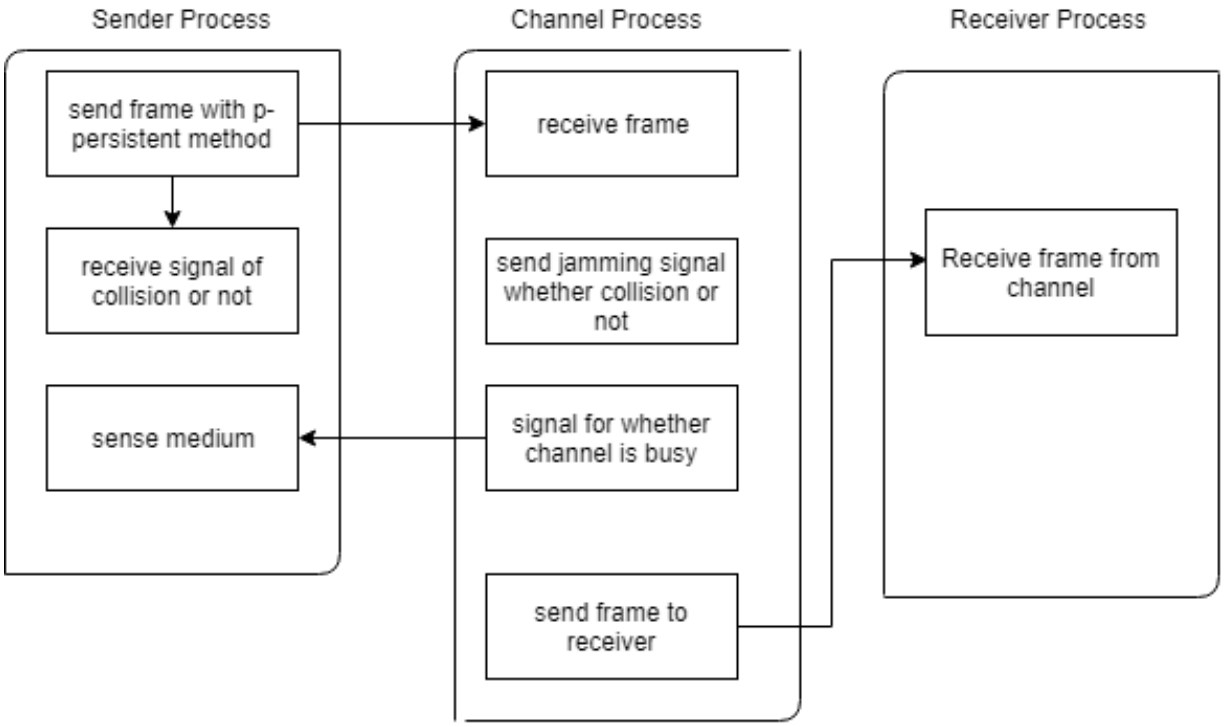


Fig. 1. *A brief outline of the program design of stop and wait ARQ*

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. This frame is then sent to the channel process.

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 CSMA/CD protocol.

IMPLEMENTATION

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

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.

```
import common as co
import time
import socket
import random
import time
import threading

if(len(sys.argv)<2):
        print('Error... usage python3 sender_cd.py input_file')
        sys.exit();
filename=sys.argv[1]

isBusyChannel=0
sockSend=co.createConn(co.portSenderReceive)  # Socket to send data to channel

time.sleep(1)
sockSignal=co.createConn(co.portSenderSignal) # Socket to send data to channel

print('Connected to channel')

probab=10
p=6
timeSlot=2
kmax=15

list_of_frames=co.readfile('input.txt', co.frame_size)
list_of_frames.append('#')
```

```
sendThread=threading.Thread(target=send_frame, args=(list_of_frames,)) #
create the sending thread
senseThread=threading.Thread(target=sense_medium) # create the sending thread

sendThread.start()
senseThread.start()

sendThread.join()
sendThread.join()
```

send_frame(list_of_frames):

This function takes as its parameter a list of frames and sends all the frames to the channel. It checks whether the channel is busy by checking the **isBusyChannel** flag and accordingly follows the p-persistent strategy to send the frames. If collision is detected it resends the frame and increments max number of attempts. If the maximum number of attempts is reached it aborts the transmission of the frame.

```
# Function to send frames
def send_frame(list_of_frames):

        i=0
        k=0
        while(True):
                # Sense the channel and check if flag is 1 then dont send
                if(isBusyChannel==0): # Channel is free
                        # Send the frame with a probability p
                        pr=random.randint(0,probab)
                        if(pr<=p):
                                # Send the frame
                                print('Sending frame '+str(i))
                                co.send_frame(list_of_frames[i], sockSend)

                                # Wait for signal whether transmission
successfull or collision
                                isCollision=sockSend.recv(1024).decode()
                                if(isCollision=='0'): # No collision
successfull transmission
                                        print('Sent successfully')
                                        if(list_of_frames[i]!='#'):
                                                i=i+1
                                                k=0

                                else:
```

```
                                        # If collision detected
                                        print('Frame collision
detected..resending')
                                        k=k+1
                                        # If max number of attempts exceeded
                                        if(k>kmax):
                                                print('Max attempts for
resending exceeded discarding frame')
                                                i=i+1
                                                k=0
                                                continue
                                        r=random.randint(0,2**k-1)
                                        waitTime=r*timeSlot
                                        time.sleep(waitTime)

                                time.sleep(3)

                        else:
                                print('Waiting '+str(timeSlot))
                                time.sleep(timeSlot)
                                continue

                else: # Channel is busy
                        print('Channel busy')
                        time.sleep(2)
                        continue
```

sense_medium():

This function continuously receives a signal from the channel process which is an indication of whether the channel is busy or not and accordingly sets the **isBusyChannel** flag. This function is run as a separate thread in the program.

```
# Function to sense the medium
def sense_medium():
        global isBusyChannel

        while(True):
                if(sockSignal.recv(1024).decode()=='1'):
                        # Means channel is busy
                        isBusyChannel=1
                else:
                        # Means channel is not busy
                        isBusyChannel=0
```

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 and keeps it in a buffer. The frames from the buffer is then sent to the receiver. The channel has actually 4 parallel threads running. One main thread continuously checks if any new sender has connected to the channel. Whenever a new sender connects to the channel it starts a new thread to service that sender. In a parallel thread the frames are sent to the receiver.

```
# This is the channel process
import socket
import threading
import common as co
import time

# shared_buffer=[]
sockSenderRec=co.createSocket(co.portSenderReceive)
sockSenderSignal=co.createSocket(co.portSenderSignal)
sockReceiverSend=co.createSocket(co.portReceiverSend)

threadLock=threading.Lock()
```

allow_new_conn():

This function checks if a new connection is established.

```
def allow_new_conn():
        sockReceiverSend.listen(5)
        receive, addrrec=sockReceiverSend.accept()

        recThread=threading.Thread(target=send_to_receiver, args=[receive])
        recThread.start()

        while(True):
                # Wait for a connection
                sockSenderRec.listen(5)
                c, addr=sockSenderRec.accept()
                print('Connected to sender')

                sockSenderSignal.listen(5)
                signal,addrsignal=sockSenderSignal.accept()

                # Start a new thread for the sender
                sendThread=threading.Thread(target=receive_from_sender,
args=[c,addr])
                sendThread.start()
```

```
                signalThread=threading.Thread(target=send_signal,
args=[signal, addrsignal])
                signalThread.start()
```

send_to_receiver(receive):

This function sends the frames to the receiver.

```
# Function to send to receiver
def send_to_receiver(receive):

        while(True):
                # If buffer not empty send the frame and clear buffer
                if(len(co.shared_buffer)>0):
                        time.sleep(10)
                        if(len(co.shared_buffer)==1):
                                # Send the frame
                                print('Sending frame to receiver ')
                                co.send_frame(co.shared_buffer[0], receive)
                                del co.shared_buffer[0]
                        else:
                                continue
```

receive_from_sender(c, addr):

This function services (receives data from sender) each sender in separate threads. It also checks if the buffer has more than one frame in it (meaning collision) and sends a signal accordingly.

```
# Function to receive data from sender
def receive_from_sender(c, addr):
        # Receive data from the sender and keep it in stored buffer
        print('Started new connection to '+str(addr))

        while(True):
                # Receive data from sender
                frame=c.recv(1024).decode()

                threadLock.acquire()
                co.shared_buffer.append(frame)
                print(co.shared_buffer)
                threadLock.release()
                time.sleep(10)

                if(len(co.shared_buffer)>1):
                        # Channel is busy
                        co.send_frame('1',c)
                        # Clear the list
```

```
                        co.shared_buffer.clear()
                else:
                        # Channel not busy
                        co.send_frame('0',c)
```

send_signal(s, saddr):

This function continuously sends every sender the signal whether the channel is busy or not.

```
def send_signal(s, saddr):
        signal=0

        while(True):
                if(len(co.shared_buffer)>=1): # Channel is busy
                        signal=1
                else: # Channel not busy
                        signal=0

                # Send the signal via socket
                co.send_frame(str(signal), s)
```

rec.py

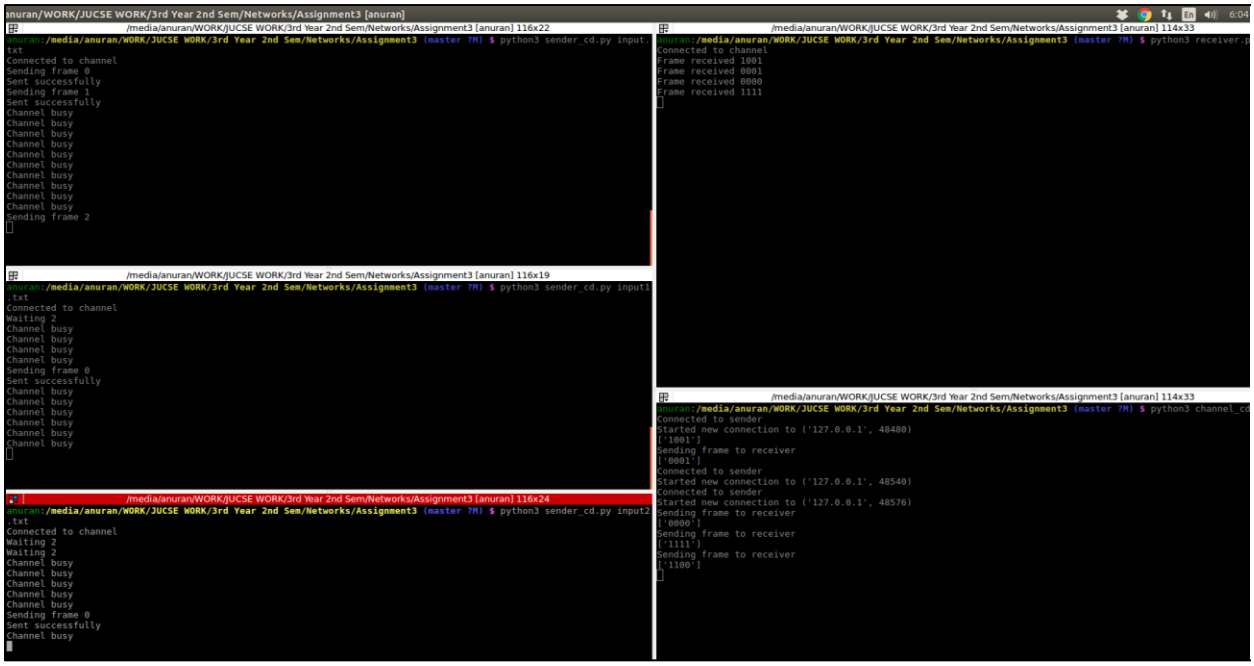
This module is the receiver process.

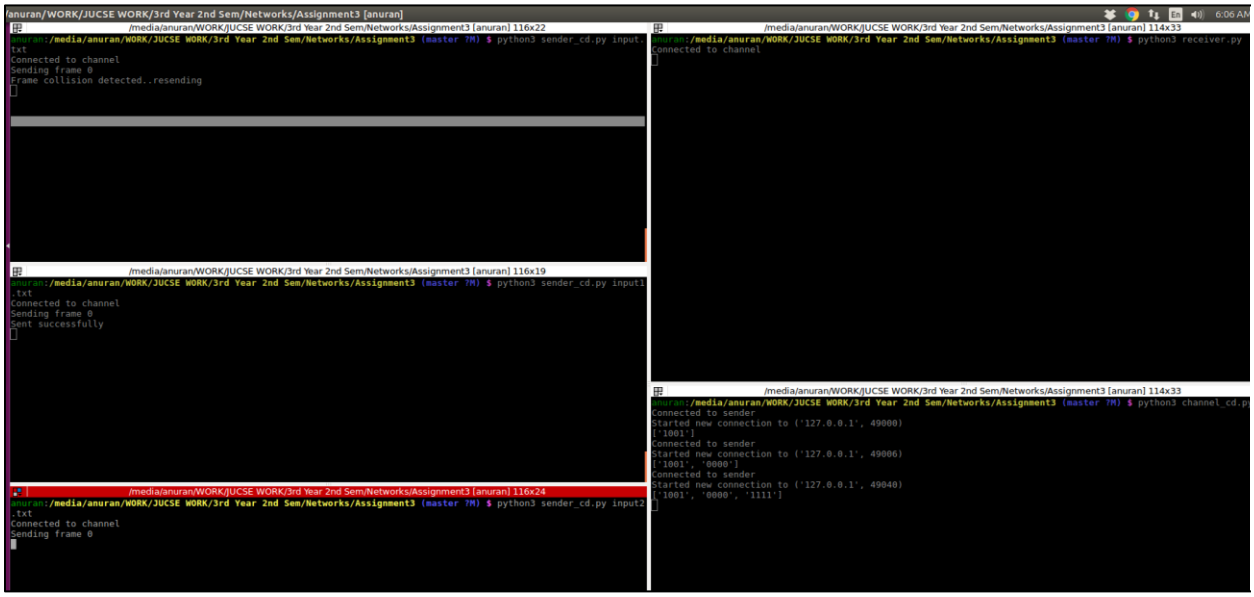
receive_frame():

This function receives frames from the channel process via a socket.

```
import common as co
import socket

sockReceive=co.createConn(co.portReceiverSend)        # Socket to send data to
channel
print('Connected to channel')

# Function to receive a frame
def receive_frame():

        while(True):
                # Receive the frame
                frame=sockReceive.recv(1024).decode()
                print('Frame received '+frame)

receive_frame()
```

OUTPUTS


/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 116x22
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender_cd.py input.txt
Connected to channel
Sending frame 0
Sent successfully
Sending frame 1
Sent successfully
Channel busy
Channel busy
Channel busy
Channel busy
Channel busy
Channel busy
Channel busy
Channel busy
Channel busy
Channel busy
Sending frame 2
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 114x33
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 receiver.py
Connected to channel
Frame received 1001
Frame received 0001
Frame received 0000
Frame received 1111
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 116x19
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender_cd.py input1.txt
Connected to channel
Waiting 2
Channel busy
Channel busy
Channel busy
Channel busy
Sending frame 0
Sent successfully
Channel busy
Channel busy
Channel busy
Channel busy
Channel busy
Channel busy
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 114x33
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 channel_cd.py
Connected to sender
Started new connection to ('127.0.0.1', 48480)
['1001']
Sending frame to receiver
['0001']
Connected to sender
Started new connection to ('127.0.0.1', 48540)
Connected to sender
Started new connection to ('127.0.0.1', 48576)
Sending frame to receiver
['0000']
Sending frame to receiver
['1111']
Sending frame to receiver
['1100']
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 116x24
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender_cd.py input2.txt
Connected to channel
Waiting 2
Waiting 2
Channel busy
Channel busy
Channel busy
Channel busy
Channel busy
Sending frame 0
Sent successfully
Channel busy


/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 116x22
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender_cd.py input.txt
Connected to channel
Sending frame 0
Frame collision detected..resending
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 114x33
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 receiver.py
Connected to channel
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 116x19
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender_cd.py input1.txt
Connected to channel
Sending frame 0
Sent successfully
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 114x33
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 channel_cd.py
Connected to sender
Started new connection to ('127.0.0.1', 49000)
['1001']
Connected to sender
Started new connection to ('127.0.0.1', 49006)
['1001', '0000']
Connected to sender
Started new connection to ('127.0.0.1', 49040)
['1001', '0000', '1111']
/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 [anuran] 116x24
anuran:/media/anuran/WORK/JUCSE WORK/3rd Year 2nd Sem/Networks/Assignment3 (master ?M) $ python3 sender_cd.py input2.txt
Connected to channel
Sending frame 0

RESULTS

The throughput here was measured in terms of the attempts it took to send the entire data. With increase in p the number of collisions increased as more station tried to send data simultaneously. However, it also sometimes decreased due to immediate sending of data.

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 multiple sender and single 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 CSMA/CD protocol ourselves. The assignment can be rated as moderately difficult.