Computer Networks Assignment 3: Implement 1-persistent, non-persistent and p-persistent CSMA techniques

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Problem Statement: In this assignment, you have to implement 1-persistent, non-persistent and p-persistent CSMA techniques. 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 performance of different CSMA techniques.

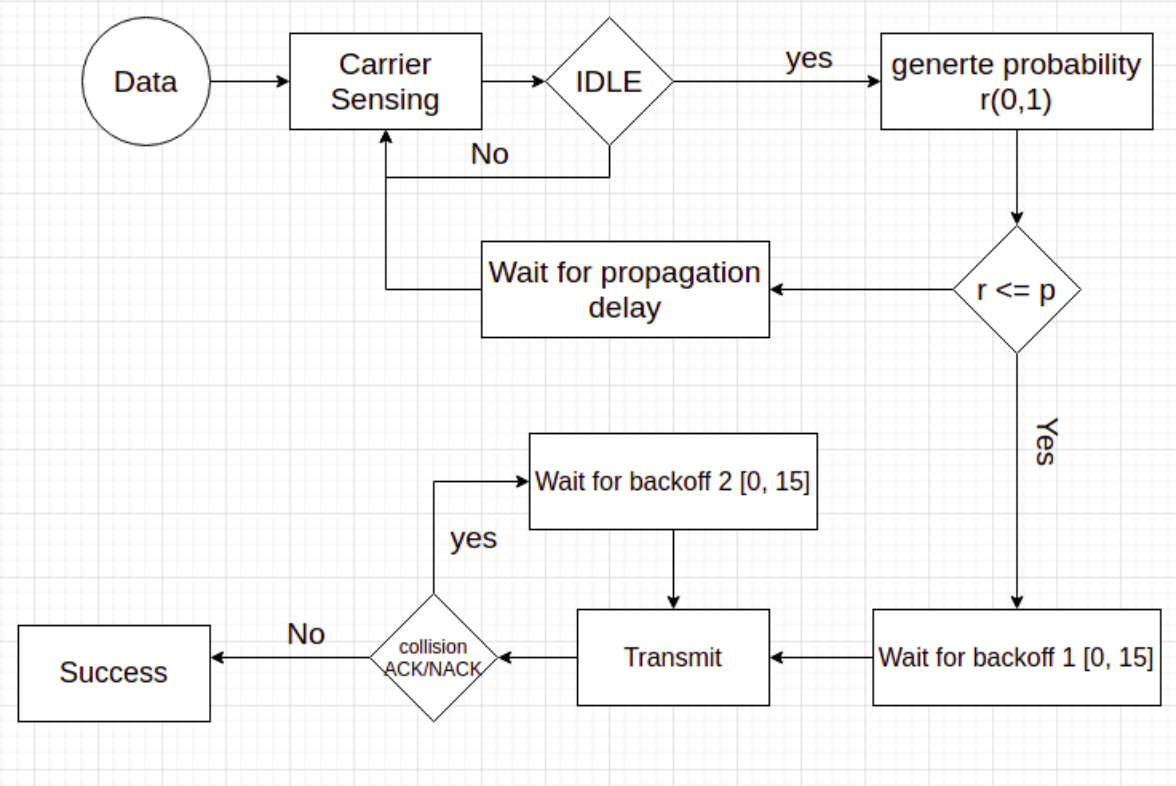
DESIGN: The code has been written in python language and designed using simpy framework.
This entire assignment has been designed using the following features of simpy :

1) To create a simulated network environment having a single receiver,
2) A channel and
3) Option to create multiple stations which can act as senders to the receiver.

There is no actual transfer of packet, but whenever a packet is required to be sent, the channel is kept busy by a particular station having an unique id.

SimPy is a process-based discrete-event simulation framework based on standard Python. Its event dispatcher is based on Python's generators and can also be used for asynchronous networking or to implement multi-agent systems.

STRUCTURE DIAGRAM:



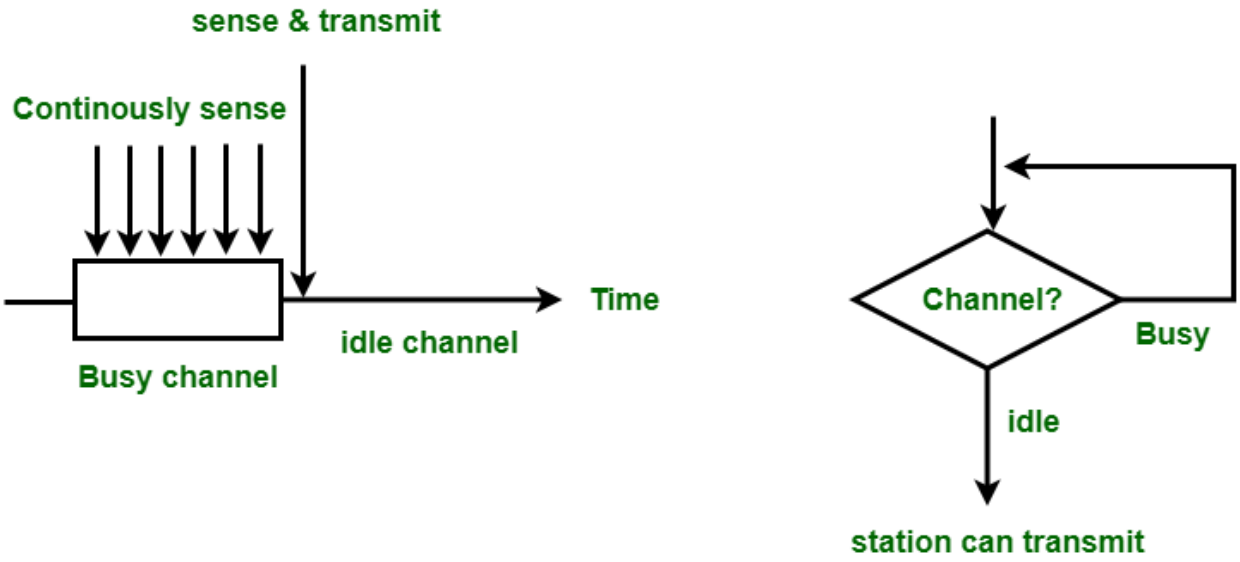
IMPLEMENTATION:

CSMA persistent methods:

1) ***1 persistent:***

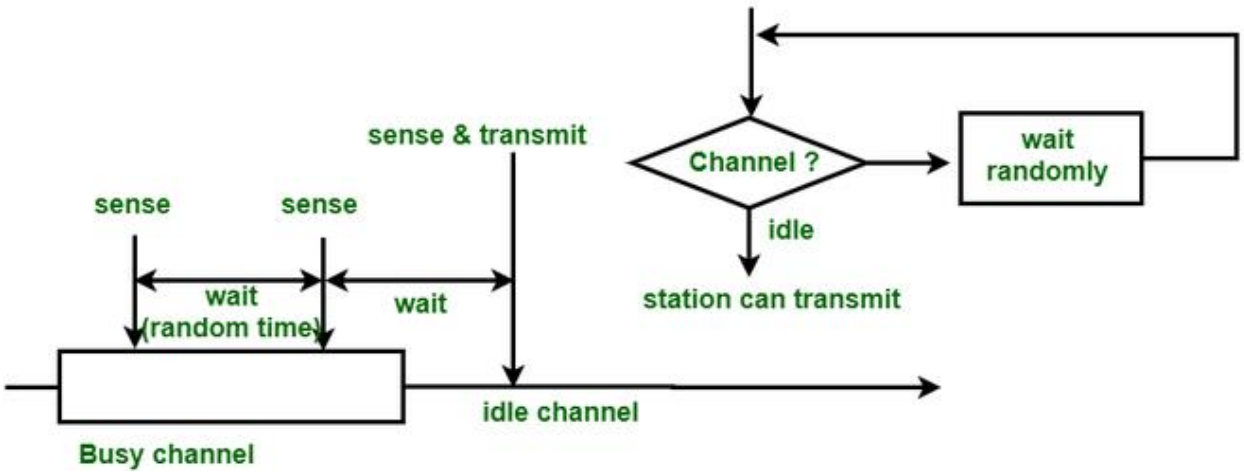
In 1-persistent CSMA, the station continuously senses the channel to check its state i.e. idle or busy so that it can transfer data or not. In case when the

channel is busy, the station will wait for the channel to become idle. When station found idle channel, it transmits the frame to the channel without any delay. It transmits the frame with probability 1. Due to probability 1, it is called 1-persistent CSMA.



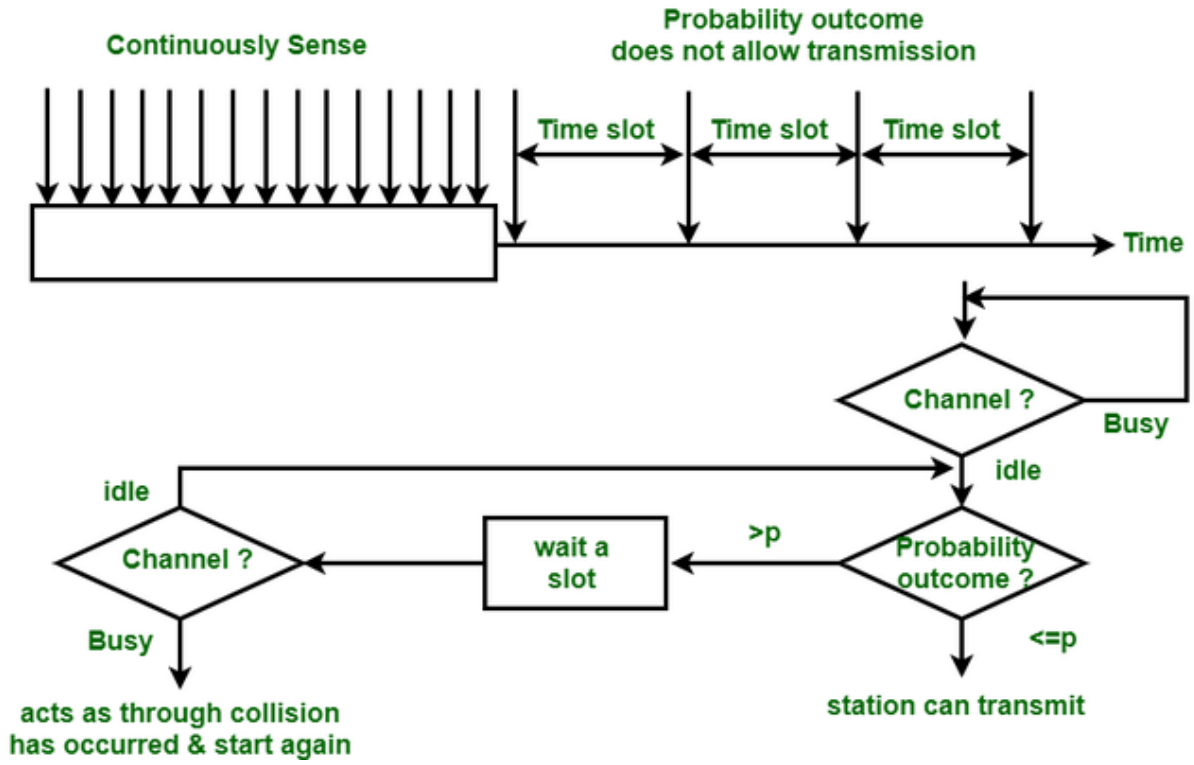
2) ***non-persistent:***

In this method, the station that has frames to send, only that station senses for the channel. In case of an idle channel, it will send frame immediately to that channel. In case when the channel is found busy, it will wait for the random time and again sense for the state of the station whether idle or busy. In this method, the station does not immediately sense for the channel for only the purpose of capturing it when it detects the end of the previous transmission. The main advantage of using this method is that it reduces the chances of collision. The problem with this is that it reduces the efficiency of the network.



3) ***p persistent:***

This is the method that is used when channel has time-slots and that time-slot duration is equal to or greater than the maximum propagation delay time. When the station is ready to send the frames, it will sense the channel. If the channel found to be busy, the channel will wait for the next slot. If the channel found to be idle, it transmits the frame with probability p, thus for the left probability i.e. q which is equal to 1-p the station will wait for the beginning of the next time slot. In case, when the next slot is also found idle it will transmit or wait again with the probabilities p and q. This process is repeated until either the frame gets transmitted or another station has started transmitting.



channel class :- It is a discrete event used to establish a connection between sender and the receiver. It can have two states (True : Busy, False : Idle) , depending on which a sender can acquire it for transferring packets to the receiver. It is also responsible for maintaining the count of successful counts and

collision counts. The receiver is present as part of the channel, since the main objective of this assignment is to study the effectiveness of CSMA protocols, we can avoid creating a real receiver process and use the channel instead. Instead of transferring real packets we can simulate packet transfer using the channel.

packet generator class :- It is responsible for generating packets and placing them in a queue for transfer, by inducing a certain waiting time between the launch of two packets.

mobile class :- It is acting as the sender over here having multiple methods defined within it in order to transmit the packets and for carrier sensing. The carrier sensing checks whether the channel is in a busy state or not and the transmit method is targeting to send the packet as soon as the channel becomes free.

Source Code:

```
import simpy
import random

offered_load = 0
throughput = 0
throughputA = 0
throughputB = 0
throughputC = 0

numOfMobiles = int (input ("Enter the number of mobiles : "))
print ("Types of CSMA protocol ")
print ("1. p persistent\n2. 1 persistent\n3. non persistent")
choice = int(input("Enter Choice : "))

# class slotSignal: generate slot signal to Reader and tags
Count = 0
class slotSignal:
    slotEvt = 0  # slot event

    def __init__(self, Tslot):
        self.env = env
        self.Tslot = Tslot
        slotSignal.slotEvt = env.event()  # slot event initialization

        # schedule process
        env.process(self.run())

    def run(self):
```

```
        while True:
            # periodic slot generation
            yield self.env.timeout(self.Tslot)
            # print("slot begins at t = %4.1f" % (self.env.now))
            slotSignal.slotEvt.succeed()  # trigger event, send slot signal
            slotSignal.slotEvt = env.event()  # slot event initialization


# Packet class
class Packet:
    def __init__(self, env):
        self.arvTime = env.now


# on-off traffic model with Poisson distribution
# on = 10 slots, off = random slots
class PacketGenerator:
    arrivalTime = 10000.0

    def __init__(self, env, Ton, Que):
        self.env = env
        self.Ton = Ton
        self.Que = Que

        # schedule process
        env.process(self.run())

    def run(self):
        global offered_load

        yield env.timeout(random.expovariate(1.0 / PacketGenerator.arrivalTime))

        while True:
            # start ON period
            interPktTime = 1
            t = 0.0
            while t < self.Ton:
                yield self.env.timeout(interPktTime)
                self.Que.append(Packet(self.env))
                t += interPktTime
                offered_load += 1

            # start OFF period, wait random time with Poisson distribution
            yield env.timeout(random.expovariate(1.0 /
PacketGenerator.arrivalTime))
```

```
class Channel:
    # define message events
    succeedMsgEvt = 0
    failMsgEvt = 0
    noReplyMsgEvt = 0

    # collision count
    colCount = 0

    # successful read count
    readCount = 0

    # channel state
    channel = False  # True : Busy, False : Idle

    def __init__(self, env, tSlot):
        # initialize message event
        Channel.succeedMsgEvt = env.event()
        Channel.failMsgEvt = env.event()
        Channel.noReplyMsgEvt = env.event()

        # initialize collision count
        Channel.colCount = 0

        self.env = env
        self.tSlot = tSlot  # time slot

        # schedule process
        env.process(self.run())

    def run(self):
        global Count
        Count = 0
        while True:
            # one slot passed
            yield slotSignal.slotEvt

            # receiving the packets

            # check the collision
            tEpsilon = 0.1

            yield self.env.timeout(self.tSlot - tEpsilon)
```

```
            # send the feedback 0.1 time unit before the next slot
            if Channel.colCount == 0:
                Channel.noReplyMsgEvt.succeed(value='no_reply')
                Channel.noReplyMsgEvt = env.event()

            if Channel.colCount == 1:
                Count = Count + 1
                Channel.channel = True
                Channel.succeedMsgEvt.succeed(value='ACK')
                Channel.succeedMsgEvt = env.event()
                # print("\nACK : success at t = %4.1f\n" % self.env.now)

            elif Channel.colCount > 1:
                Channel.failMsgEvt.succeed(value='NACK')
                Channel.failMsgEvt = env.event()
                print("\nNACK : fail at t = %4.1f\n" % int(self.env.now))
                # reset collision count
                Count = Count + Channel.colCount
                Channel.colCount = 0

class Mobile:
    mobileID = 0
    probability = 0
    if choice == 1:
        probability = 1 # probability used in p-persistent CSMA system,
probability * numOfMobiles = 1
    else:
        probability = numOfMobiles #probability used in 1 persistent CSMA system


    def __init__(self, env):
        # slot period
        self.slotTime = 1  # set initial slot number

        # packet queue
        self.Que = []
        PacketGenerator(env, 10, self.Que)

        # set mobile ID
        self.mID = Mobile.mobileID
        Mobile.mobileID += 1

        # mobile status
        self.status = False  # True for transmitting, False for idle
```

```
        self.state = False  # True for ready to transmit, False for not ready to
transmit

        self.count = 0

        self.env = env

        # schedule process
        env.process(self.run())

    def run(self):
        while True:
            yield slotSignal.slotEvt

            # have data to transmit
            if len(self.Que) > 0:
                # carrier sensing : Idle
                if not self.carrierSense():
                    if not self.state:
                        p = random.random()  # random probability [0, 1)
                        if choice  == 3:
                            p = 0

                        if p <= Mobile.probability:  # transmit
                            yield self.env.timeout(random.randint(0, 15))  #
back-off 1
                            self.state = True
                            pass

                        else:
                            yield self.env.timeout(self.slotTime)  # propagation
delay
                            pass

                    else:
                        Channel.colCount += 1

                        ret = yield (Channel.noReplyMsgEvt |
Channel.succeedMsgEvt | Channel.failMsgEvt)
                        values_listed = list(ret.values())  # converted to list

                        if values_listed[0] == 'no_reply':  # no collision
                            yield self.env.timeout(self.slotTime)
                            pass
```

```
                        elif values_listed[0] == 'ACK':  # no collision
                            self.status = True  # change Mobile's status to
transmitting
                            self.transmit()
                            pass

                        elif values_listed[0] == 'NACK':
                            yield self.env.timeout(random.randint(0, 15))
                            # back-off 2: random time 0~15 time slots
                            # self.state = False
                            pass

                else:  # carrier sensing : Busy
                    if self.status:  # Mobile status : transmitting
                        self.transmit()
                        if self.count == 10:
                            # print("\nACK : ID = %d, success at t = %4.1f\n" %
(self.mID, self.env.now))
                            self.count = 0
                            Channel.colCount = 0
                            print("\nACK : ID = %d, success at t = %4.1f\n" %
(self.mID, self.env.now))
                            self.status = False  # change Mobile's status to idle
                            self.state = False
                            yield slotSignal.slotEvt
                            Channel.channel = False  # change channel's status to
Idle
                            pass
                    else:
                        pass
            else:
                yield self.env.timeout(self.slotTime)
                pass

    def carrierSense(self):
        if Channel.channel:
            return True
        else:
            return False

    def transmit(self):
        global throughput
        global throughputA
        global throughputB
        global throughputC
```

```
        print("ID = %d, trasnmitting at t = %4.1f" % (self.mID,
int(self.env.now)))
        del self.Que[0]
        self.count += 1
        throughput += 1
        if self.mID == 0:
            throughputA += 1
        elif self.mID == 1:
            throughputB += 1
        elif self.mID == 2:
            throughputC += 1


env = simpy.Environment()

sim_time = 10000
slotSig = slotSignal(1)
mSet = [Mobile(env) for i in range(numOfMobiles)]
reader = Channel(env, 1)
env.run(until=sim_time)

print("Throughput : " + str(throughput / sim_time)) # average amount of data bits
successfully transmitted per unit time
print("offered load : " + str(offered_load / sim_time)) # measure of the traffic
compared to the channel capacity
print ("Collision Count : " + str (Count))
```

Result:

A test has been performed for 500 mobiles(nodes,senders,stations) and **throughput**(average amount of data bits successfully transmitted per unit time), **offered load**(measure of traffic compared to channel capacity) and **collision count** were observed for each of the 3 different types of CSMA persistent methods.
Simulation time: 10000

CSMA PROTOCOLS	THROUGHPUT	OFFERED LOAD	COLLISION COUNT
1 persistent	0.5248	0.5264	5079
non persistent	0.5060	0.5065	4717
p persistent	0.4771	0.4780	4523

ANALYSIS:

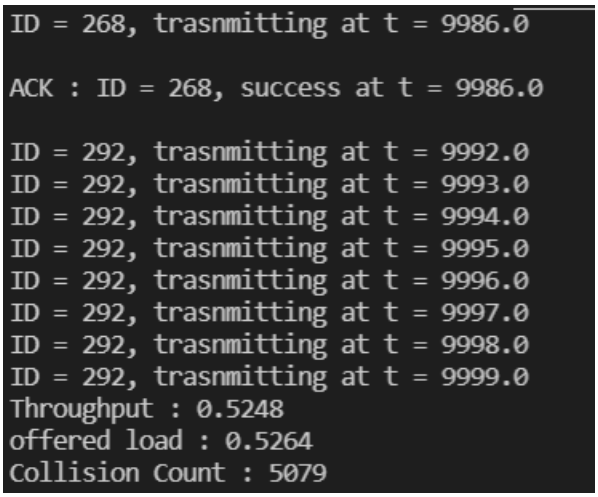
Collision Count :

1 persistent > non persistent > p persistent

OUTPUT:

Output screenshots->

1 persistent:



non persistent:

```
ID = 221, trasnmitting at t = 9989.0
ID = 221, trasnmitting at t = 9990.0
ID = 221, trasnmitting at t = 9991.0
ID = 221, trasnmitting at t = 9992.0
ID = 221, trasnmitting at t = 9993.0
ID = 221, trasnmitting at t = 9994.0
ID = 221, trasnmitting at t = 9995.0
ID = 221, trasnmitting at t = 9996.0
ID = 221, trasnmitting at t = 9997.0

ACK : ID = 221, success at t = 9997.0

Throughput : 0.506
offered load : 0.5065
Collision Count : 4717
```

p persistent:

```
ID = 92, trasnmitting at t = 9991.0
ID = 92, trasnmitting at t = 9992.0
ID = 92, trasnmitting at t = 9993.0
ID = 92, trasnmitting at t = 9994.0
ID = 92, trasnmitting at t = 9995.0
ID = 92, trasnmitting at t = 9996.0
ID = 92, trasnmitting at t = 9997.0
ID = 92, trasnmitting at t = 9998.0

ACK : ID = 92, success at t = 9998.0

ID = 467, trasnmitting at t = 9999.0
Throughput : 0.4771
offered load : 0.478
Collision Count : 4523
```
