King Fahad University of Petroleum and Minerals

Computer Engineering Department

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COE 541

Term Project

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BACKGROUND

The Project is to Simulate and Evaluate **IEEE802.11 Network Support for Real-time Services.** IEEE802.11 specifies the Physical Layer (PHY) and the Medium Access Control (MAC) layer for the Wireless Local Area Network (WLAN). Unlike wired LAN, addressing in WLAN is not trivial because stations are not fixed in location. Moreover the assumption that all stations are hearing the signal is not always true. Hence, the main objective of IEEE802.11 is to serve mobile stations.

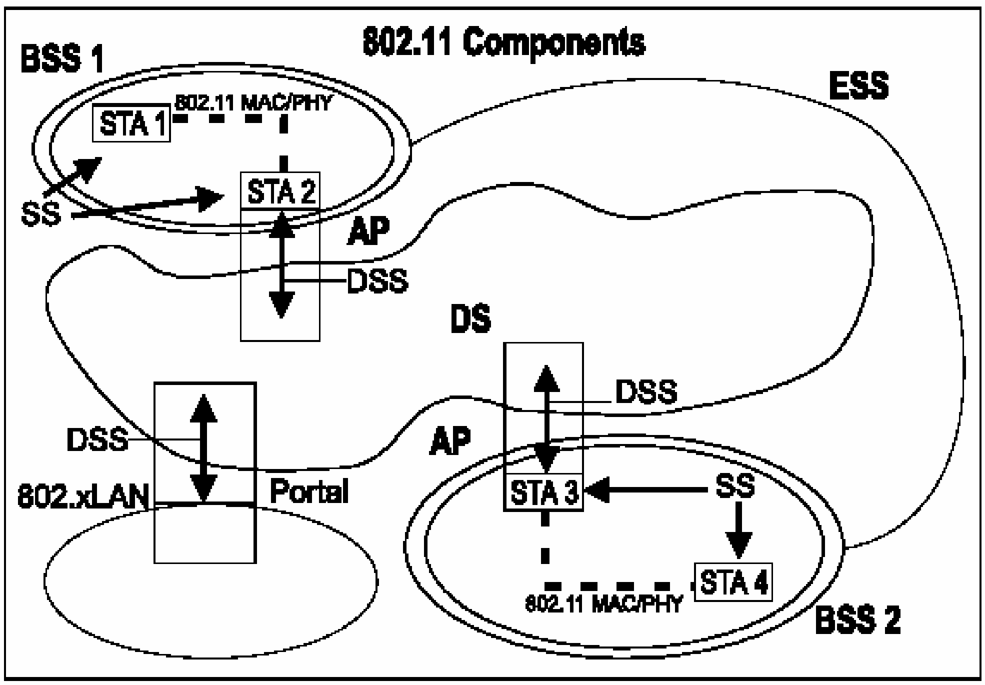

Figure1, source: IEEE 802.11-1999 Standard

In the MAC layer we have two main sublayers named Distributed Coordination Function (DCF) and Point Coordination Function (PCF). The bellow figure may explain more details about these layers.

Basically, the DCF fundamental access method is the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). The sensing can be performed in either the MAC layer or in the Physical layer. DCF is mandatory in each Station (STA), while the PCF is implemented in the Access Points that links the STAs to the Distribution System DS. Real time services depend on the PCF and some QoS parameters.

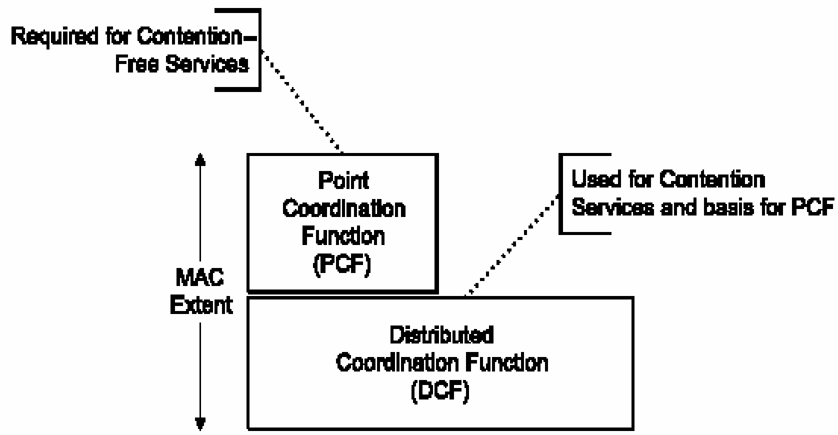

Figure 2, source: IEEE 802.11-1999 Standard

There are two ways to transfer data frames under the DCF. The essential method is called the Basic Access method. The second method is the Ready-to-Send (RTS) and Clear-to-Send (CTS) method which are specified in the figure 3. The former method uses the Inter-frame Space (IFS) for priority access. An IF defines the minimal period that all stations should be idle after a successful transmission. There are three categories of priority levels that IFS defines, and they are ordered according to highest tot the lowest priority:

1. Short IFS (SIFS)
2. Point Coordination IFS (PIFS)
3. DCF IFS (DIFS)

A collision is defined when two stations sense the channel ant the same instant after waiting DIFS then start transmission. Otherwise, all stations should not transmit if there is a station occupying the channel. To avoid such problem all stations will randomly backoff. The backoff counter will be decremented when ever the channel is sensed idle; otherwise, it will freeze until the medium is idle for a period longer than DIFS.

In this project the target was to simulate real time services behavior using the 802.11, yet due to limitation in time and time the project will cover throughput analysis of the DCF using the basic access mechanism.

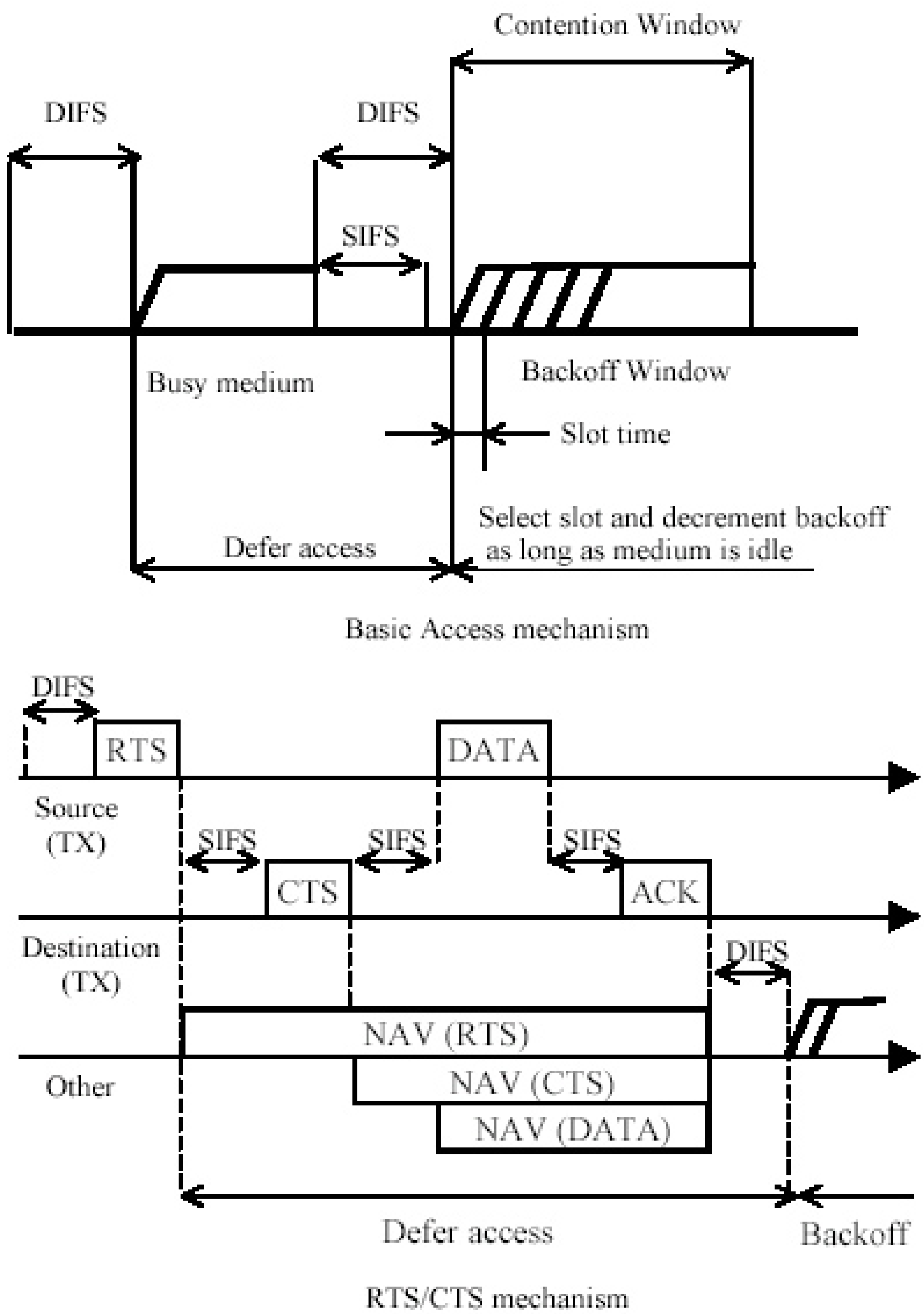

Figure 3, source:Throughput and Delay Analysis of IEEE 802.11 Protocol

DESIGN CONSIDERATION

The basic objective in this design is to simulate the network throughput in different scenarios. Where in some times we change the number of stations (STA) or sometimes change the Packet size (data_Tx). The design main parameters are:

1. (STA) → Number of stations
2. (P_Tx) → Probability threshold
3. (data_Tx) → Packet size
4. (IFS) → DIFS size, which is normally 10% of the data size
5. (Time_Access) → Time Access
6. (CW) → Contention Window
7. (N_Backoff) → Backoff counter
8. (N_Count) → Successful attempts counter
9. (N_Colision) → Collided attempts counter

The main assumptions in the design are as following:

1. STAs are transmitting randomly through a Bernoulli distribution
2. Hidden STAs are ignored
3. CW is randomly and equally likely selected between [0 CW]

The flowchart for the project design is described in figure 4.

The Algorithm that represents the simulation is the following:

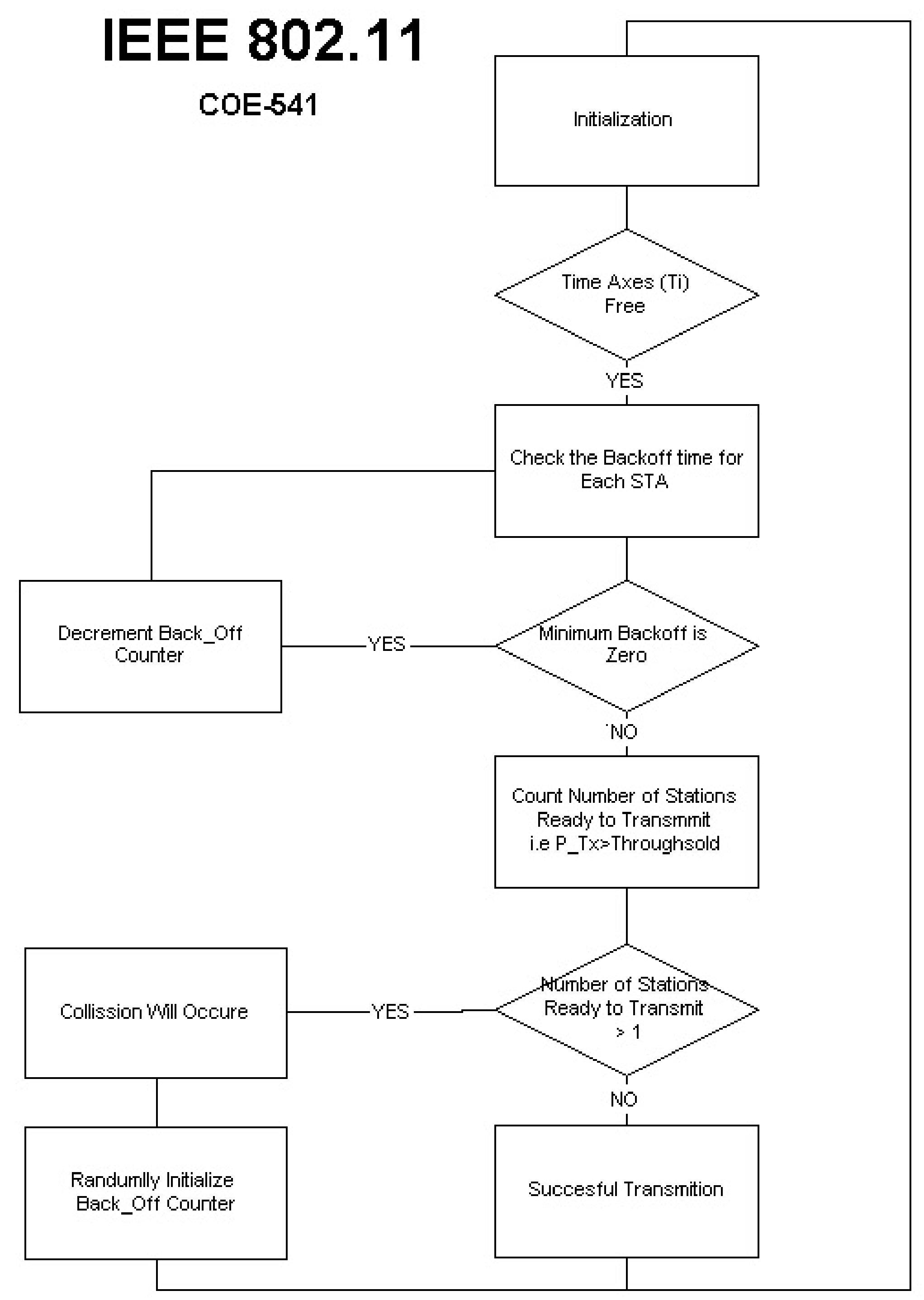

Figure 4

Results and Findings

1. **System behavior and throughput versus number of stations (STA) with random probability:**

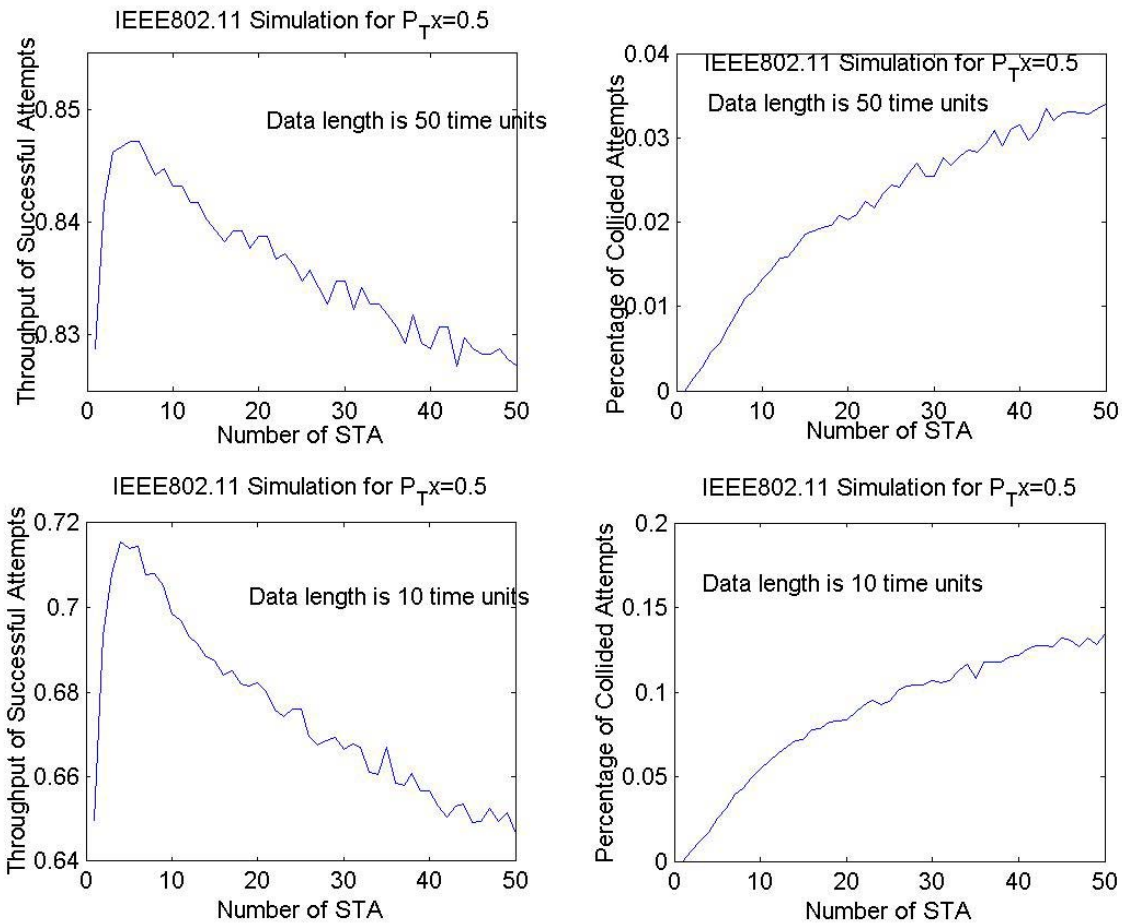

Figure 5

It can be seen from figure 5 that when using the basic access mechanism with random access to the media, i.e. STA has probability to transmit; we will find the following results:

a. the throughput is high for large number of STAs (65% for 50 STA)
b. the number of collided attempts is almost negligible
c. by using longer data packet size throughput improves

2. **System behavior and throughput versus number of station for full load**

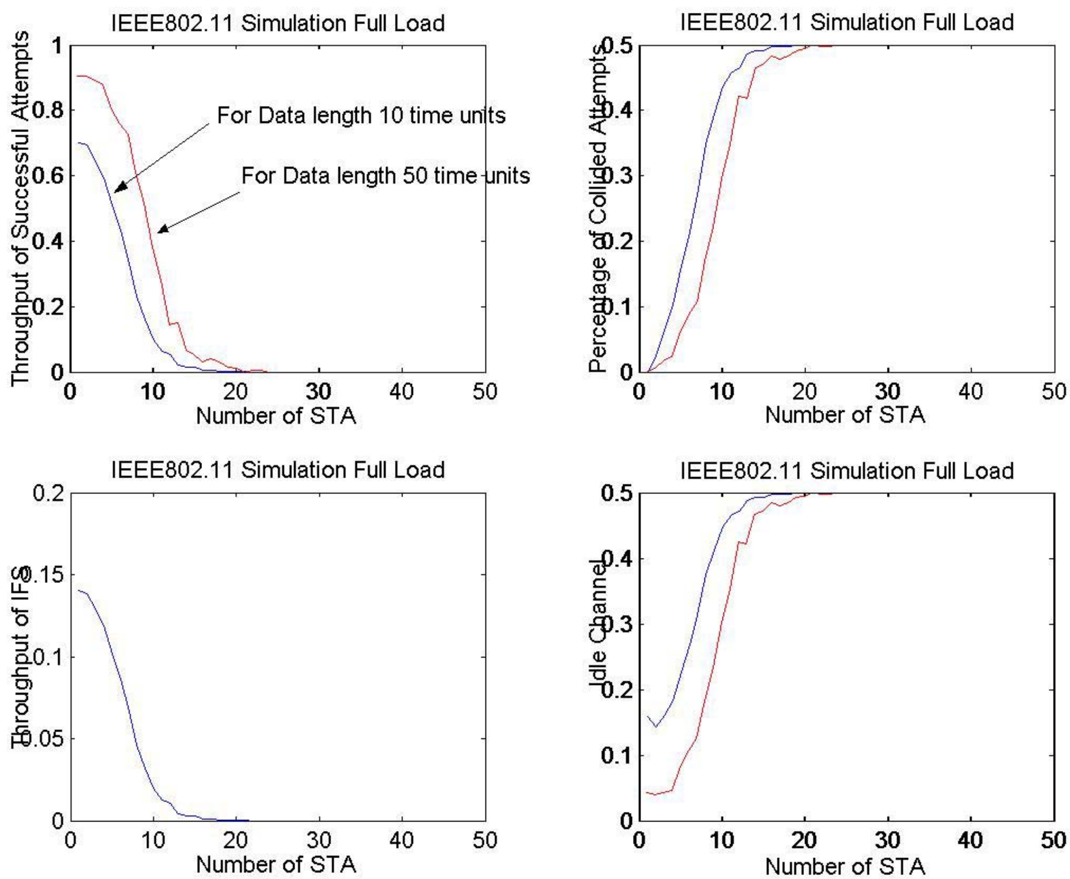

Figure 6

It can be seen from figure 6 that in a situation where all stations are ready to transmit once they sense the channel is free we will find the following results:

d. for a single Access Point (AP) the throughput decays rapidly is the number of stations increases and most the time will be spent in retransmission

e. the throughput can be improved if we increased the packet size for a certain number of STAs

3. System behavior and throughput versus the probability that a station is ready to transmit

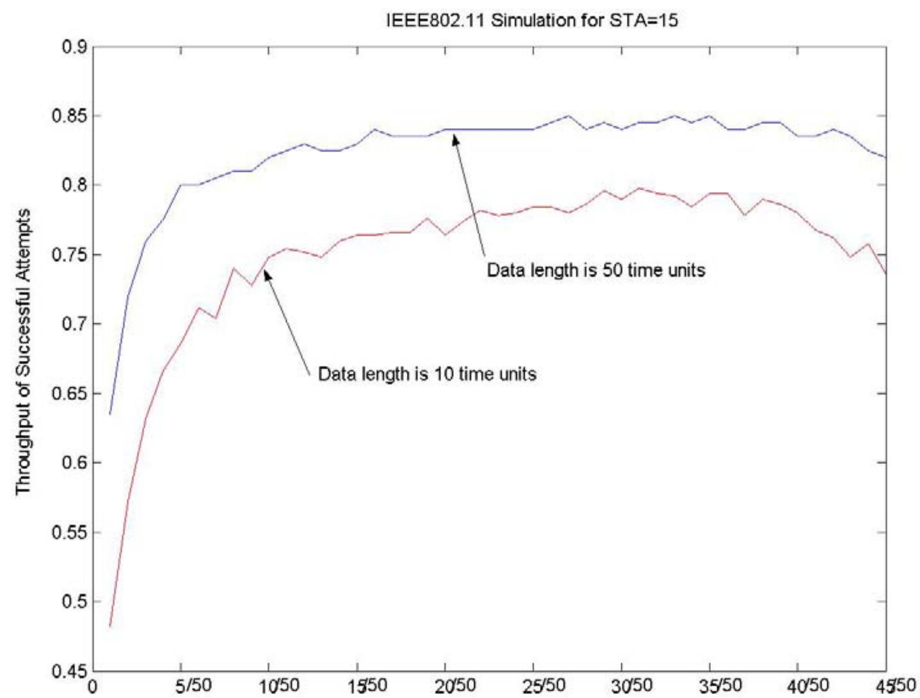

Figure 7

From figure 7 we can notice the following:

a. at probability (25/50 = 0.5) the throughput for data length 50 is almost about 84%, which is almost the same value in figure 6 for STA=15
b. the throughput improves as the data length increases which is logic due to the fact that more time slots will be occupied by the successful stations

Codes & M-Files

a. M-File for part 1:

```
clear all

STA=50;                          %Number of Terminals
P_Tx=0.5;
for N=1:STA
  data_Tx=50;                     %Transmitted data size
  IFS=3;                           %Interframe Space size
  %N_Success=zeros(1,N);           % Number of successful trials
  CW=5;                           %Contention Wendow
  Time_Access=zeros(1,10000);
  N_Backoff=zeros(1,N);            %Backoff Counter for each STA
  N_Count=zeros(1,N);
  IFS_Count=0;
  Idle=0;
  N_Colision=0;
  Ready_STA=0;


  % my assumption that all N station are active and ready to transmit

  for i=1:length(Time_Access)
    if (Time_Access(1,i)==0)
      %P_STA=rand(1,N);
      [min_N,indx_N]=min(N_Backoff);
      Ready_Tx=0;
      y=1;
      if (min_N ==0)    %Backoff timer is "0" if not non of the STAs are ready to transmit
        for a=1:N
          if (N_Backoff(1,a) ==0)
            %if (P_STA(1,a) >= P_Tx)
              Ready_STA(y)=a;       %To identify the STA which is ready to transmit
              y=y+1;
              Ready_Tx=Ready_Tx+1;    %To count the number of STAs ready to
                                           transmit at the same instant
              %end
          end
        end
        if (Ready_Tx ==1)
          Time_Access(1,i:i+data_Tx-1)=indx_N;
          N_Backoff(1,indx_N)=randint(1,1,[1 2^randint(1,1,CW-1)]);
          Time_Access(1,i+data_Tx:i+data_Tx+IFS-1)=-1;
        elseif (Ready_Tx >1)
          N_Colision=N_Colision+1;
          for z=1:length(Ready_STA)
            N_Backoff(1,Ready_STA(z))=randint(1,1,[1 2^randint(1,1,CW-1)]);
          end
        end
      else
        N_Backoff=N_Backoff-1;
      end
    end
  end
```

```
  for i=1:length(Time_Access)
    if (Time_Access(1,i)~=0)
      if (Time_Access(1,i)~=-1)
        N_Count(1,Time_Access(1,i))=N_Count(1,Time_Access(1,i))+1;
      else
        IFS_Count=IFS_Count+1;
      end
    else
      Idle=Idle+1;
    end
  end
  N_Sum=cumsum(N_Count);
  N_Success(N)=N_Sum(1,N);
  N_IFS_Count(N)=IFS_Count;
  NN_Colision(N)=N_Colision;
  N_Idle(N)=Idle;
  NN_Idle(N)=N_Idle(N)-NN_Colision(N);
end

subplot(2,2,1), plot(N_Success/length(Time_Access)), xlabel('Number of STA'),
ylabel('Throughput of Successful Attempts'), title('IEEE802.11 Simulation Full Load')
subplot(2,2,2), plot(NN_Colision/length(Time_Access)), xlabel('Number of STA'),
ylabel('Percentage of Collided Attempts'), title('IEEE802.11 Simulation Full Load')
subplot(2,2,3), plot(N_IFS_Count/length(Time_Access)), xlabel('Number of STA'),
ylabel('Throughput of IFS'), title('IEEE802.11 Simulation Full Load')
subplot(2,2,4), plot(NN_Idle/length(Time_Access)), xlabel('Number of STA'), ylabel('Idle
Channel'), title('IEEE802.11 Simulation Full Load')
```

b. M-File for part 2:

```
clear all

STA=50;                          %Number of Terminals
P_Tx=0.5;
for N=1:STA
   data_Tx=10;                      %Transmitted data size
   IFS=2;                            %Interframe Space size
   %N_Success=zeros(1,N);            % Number of successful trials
   CW=5;                            %Contention Wendow
   Time_Access=zeros(1,100000);
   N_Backoff=zeros(1,N);            %Backoff Counter for each STA
   N_Count=zeros(1,N);
   IFS_Count=0;
   Idle=0;
   N_Colision=0;
   Ready_STA=0;


   % my assumption that all N station are active and ready to transmit

   for i=1:length(Time_Access)
      if (Time_Access(1,i)==0)
         P_STA=rand(1,N);
         [min_N,indx_N]=min(N_Backoff);
         Ready_Tx=0;
         y=1;
         if (min_N ==0)     %Backoff timer is "0" if not non of the STAs are ready to transmit
            for a=1:N
               if (N_Backoff(1,a) ==0)
                  if (P_STA(1,a) >= P_Tx)
                     Ready_STA(y)=a;   %To identify the STA which is ready to transmit
                     y=y+1;
                     Ready_Tx=Ready_Tx+1;        %To count the number of STAs ready to
                                                    transmit at the same instant
                  end
               end
            end
            if (Ready_Tx ==1)
               Time_Access(1,i:i+data_Tx-1)=indx_N;
               N_Backoff(1,indx_N)=randint(1,1,[1 2^randint(1,1,CW-1)]);
               Time_Access(1,i+data_Tx:i+data_Tx+IFS-1)=-1;
            elseif (Ready_Tx >1)
               N_Colision=N_Colision+1;
               for z=1:length(Ready_STA)
                  N_Backoff(1,Ready_STA(z))=randint(1,1,[1 2^randint(1,1,CW-1)]);
               end
            end
         else
            N_Backoff=N_Backoff-1;
         end
      end
   end



   for i=1:length(Time_Access)
      if (Time_Access(1,i)~=0)
         if (Time_Access(1,i)~=-1)
            N_Count(1,Time_Access(1,i))=N_Count(1,Time_Access(1,i))+1;
```

```
            else
               IFS_Count=IFS_Count+1;
            end
         else
            Idle=Idle+1;
         end
      end
      N_Sum=cumsum(N_Count);
      N_Success(N)=N_Sum(1,N);
      N_IFS_Count(N)=IFS_Count;
      NN_Colision(N)=N_Colision;
      N_Idle(N)=Idle;
      NN_Idle(N)=N_Idle(N)-NN_Colision(N);
   end

subplot(2,2,1), plot(N_Success/length(Time_Access)), xlabel('Number of STA'),
ylabel('Throughput of Successful Attempts'), title('IEEE802.11 Simulation for P_Tx=0.5')
subplot(2,2,2), plot(NN_Colision/length(Time_Access)), xlabel('Number of STA'),
ylabel('Percentage of Collided Attempts'), title('IEEE802.11 Simulation for P_Tx=0.5')
subplot(2,2,3), plot(N_IFS_Count/length(Time_Access)), xlabel('Number of STA'),
ylabel('Throughput of IFS'), title('IEEE802.11 Simulation for P_Tx=0.5')
subplot(2,2,4), plot(NN_Idle/length(Time_Access)), xlabel('Number of STA'), ylabel('Idle
Channel'), title('IEEE802.11 Simulation for P_Tx=0.5')
```

c. M-File for part 3:

```
clear all

N=15;                                   %Number of Terminals

for P_Tx=1:50
   data_Tx=100;                          %Transmitted data size
   IFS=11;                                %Interframe Space size
   %N_Success=zeros(1,N);                % Number of successful trials
   CW=5;                                %Contention Wendow
   Time_Access=zeros(1,10000);
   N_Backoff=zeros(1,N);                %Backoff Counter for each STA
   N_Count=zeros(1,N);
   IFS_Count=0;
   Idle=0;
   N_Colision=0;
   Ready_STA=0;


   % my assumption that all N station are active and ready to transmit

   for i=1:length(Time_Access)
      if (Time_Access(1,i)==0)
         P_STA=rand(1,N);
         [min_N,indx_N]=min(N_Backoff);
         Ready_Tx=0;
         y=1;
         if (min_N ==0)     %Backoff timer is "0" if not non of the STAs are ready to transmit
            for a=1:N
               if (N_Backoff(1,a) ==0)
                  if (P_STA(1,a) >= P_Tx/50)
                     Ready_STA(y)=a;         %To identify the STA which is ready to transmit
                     y=y+1;
                     Ready_Tx=Ready_Tx+1;    %To count the number of STAs ready to
                                                  transmit at the same instant
                  end
               end
            end
            if (Ready_Tx ==1)
               Time_Access(1,i:i+data_Tx-1)=indx_N;
               N_Backoff(1,indx_N)=randint(1,1,[1 2^randint(1,1,CW-1)]);
               Time_Access(1,i+data_Tx:i+data_Tx+IFS-1)=-1;
            elseif (Ready_Tx >1)
               N_Colision=N_Colision+1;
               for z=1:length(Ready_STA)
                  N_Backoff(1,Ready_STA(z))=randint(1,1,[1 2^randint(1,1,CW-1)]);
               end
            end
         else
            N_Backoff=N_Backoff-1;
         end
      end
   end



   for i=1:length(Time_Access)
      if (Time_Access(1,i)~=0)
         if (Time_Access(1,i)~=-1)
```

```
            N_Count(1,Time_Access(1,i))=N_Count(1,Time_Access(1,i))+1;
         else
            IFS_Count=IFS_Count+1;
         end
      else
         Idle=Idle+1;
      end
   end
   N_Sum=cumsum(N_Count);
   N_Success(P_Tx)=N_Sum(1,N);
   N_IFS_Count(P_Tx)=IFS_Count;
   NN_Colision(P_Tx)=N_Colision;
   N_Idle(P_Tx)=Idle;
   NN_Idle(P_Tx)=N_Idle(P_Tx)-NN_Colision(P_Tx);
end

plot(N_Success/length(Time_Access)), xlabel('P_STA'), ylabel('Throughput of Successful
Attempts'), title('IEEE802.11 Simulation for STA=15')
```