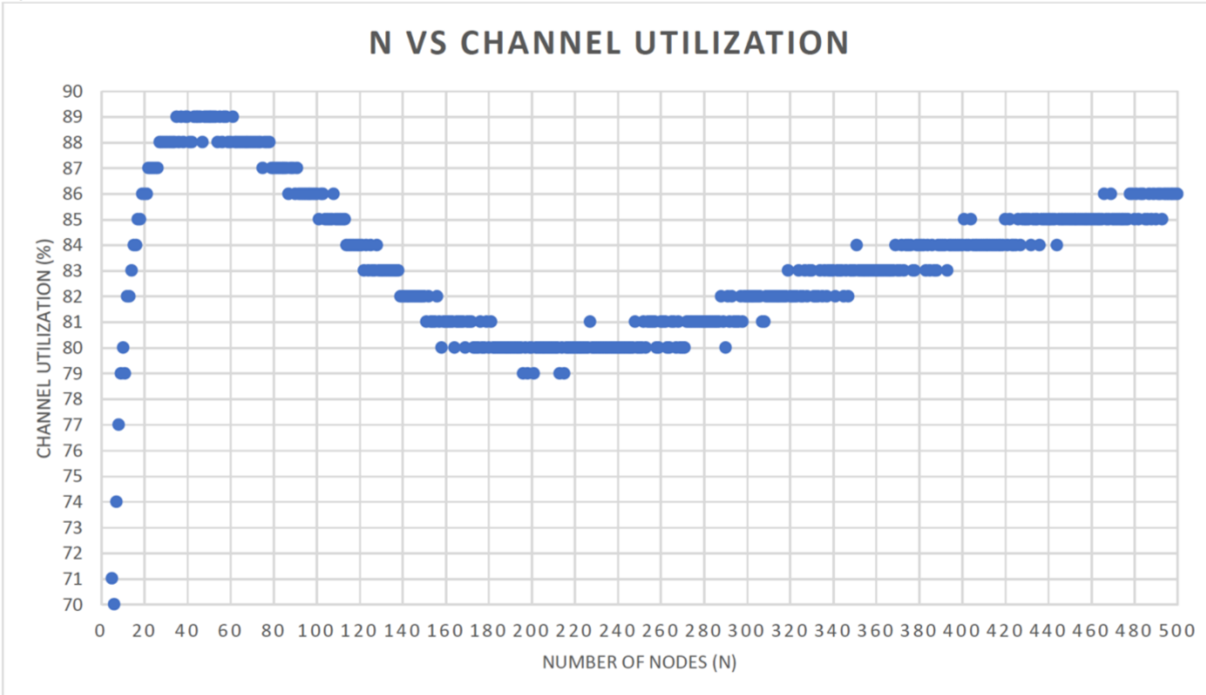
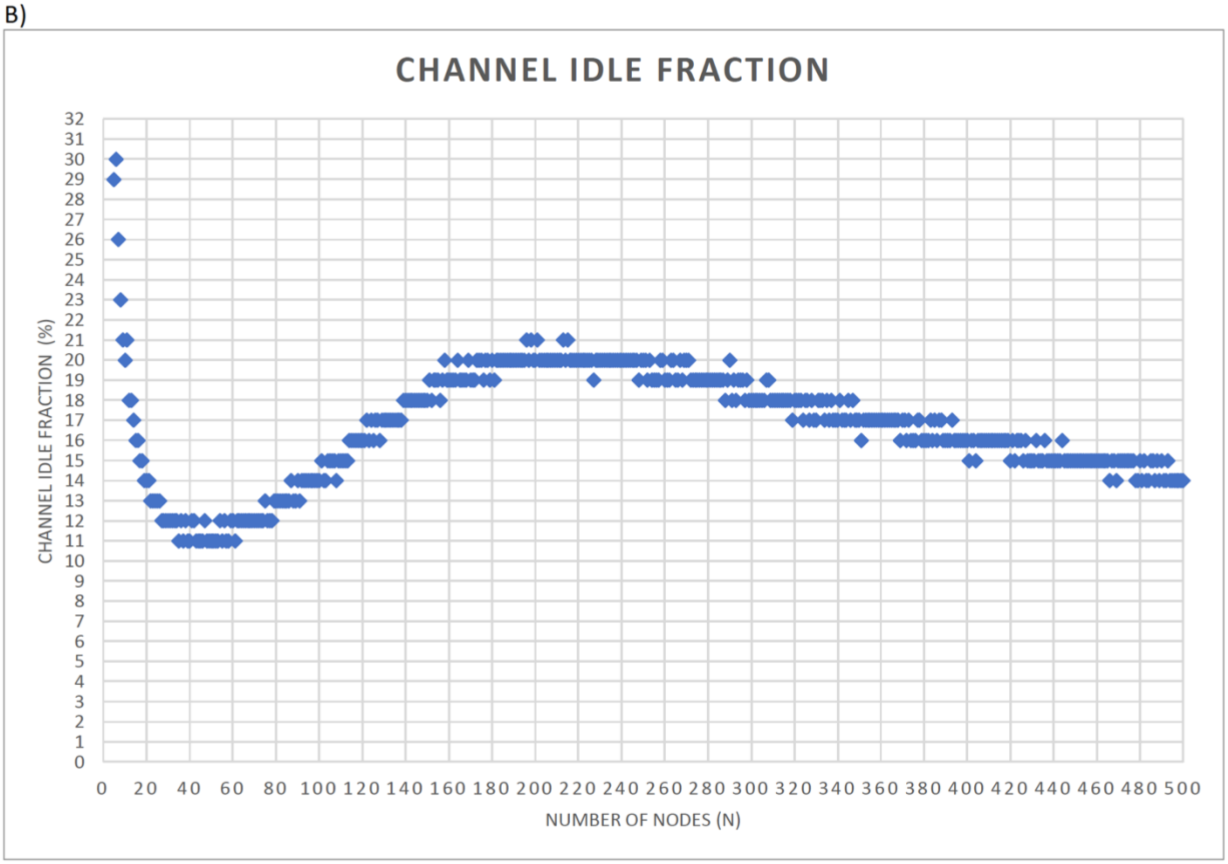
A)



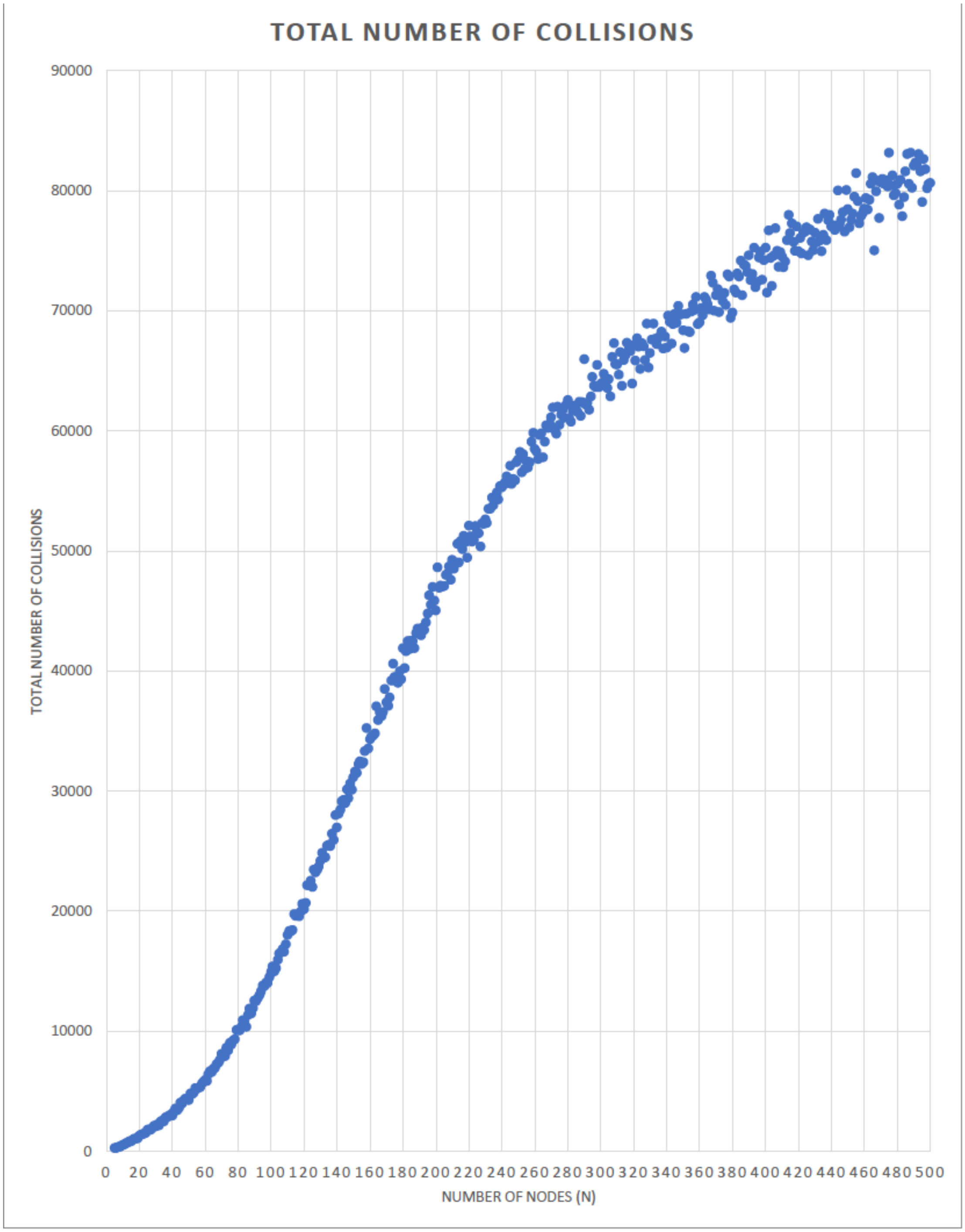
N VS CHANNEL UTILIZATION
CHANNEL UTILIZATION (%)
90
89
88
87
86
85
84
83
82
81
80
79
78
77
76
75
74
73
72
71
70
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
NUMBER OF NODES (N)

B)

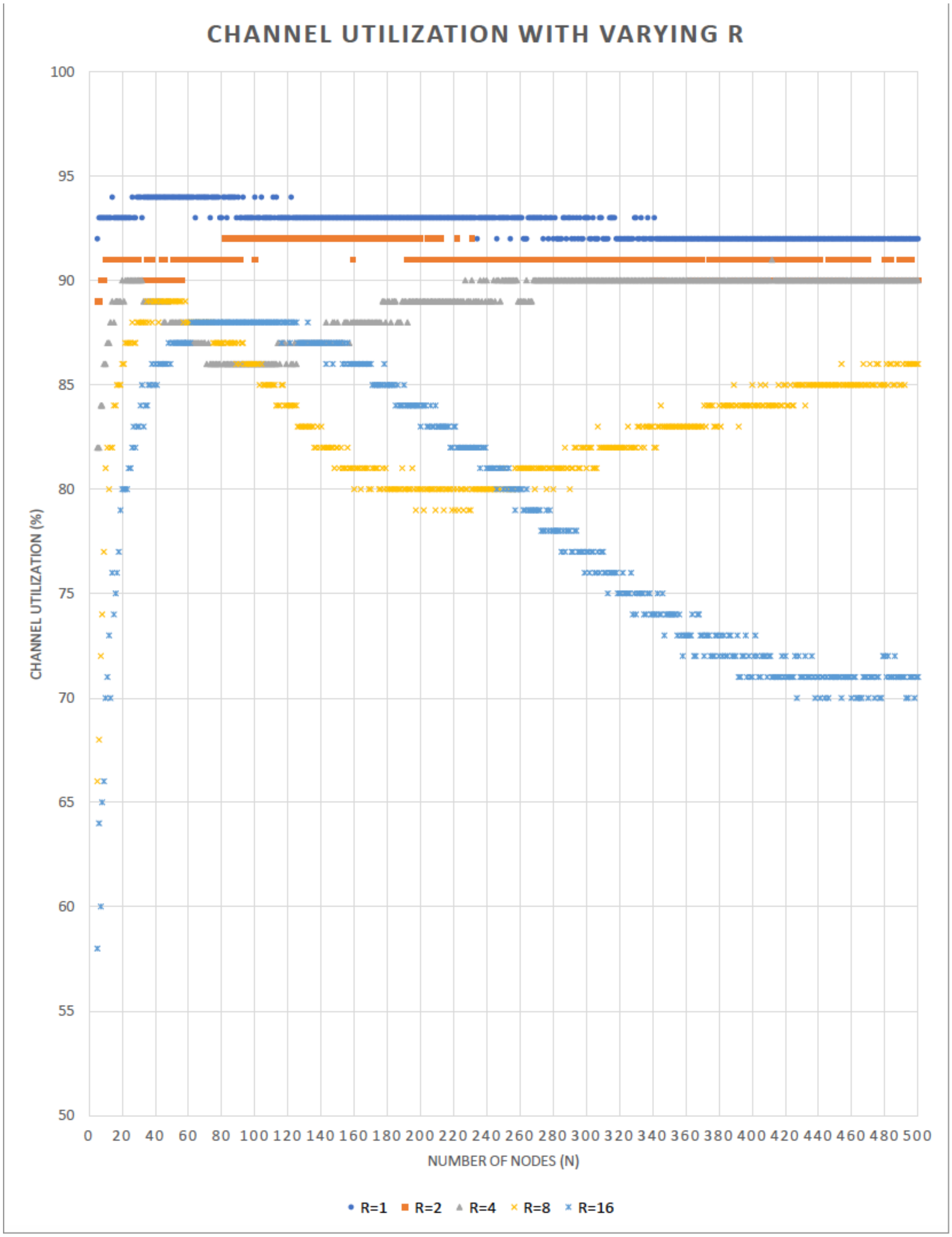


CHANNEL IDLE FRACTION
CHANNEL IDLE FRACTION (%)
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
NUMBER OF NODES (N)

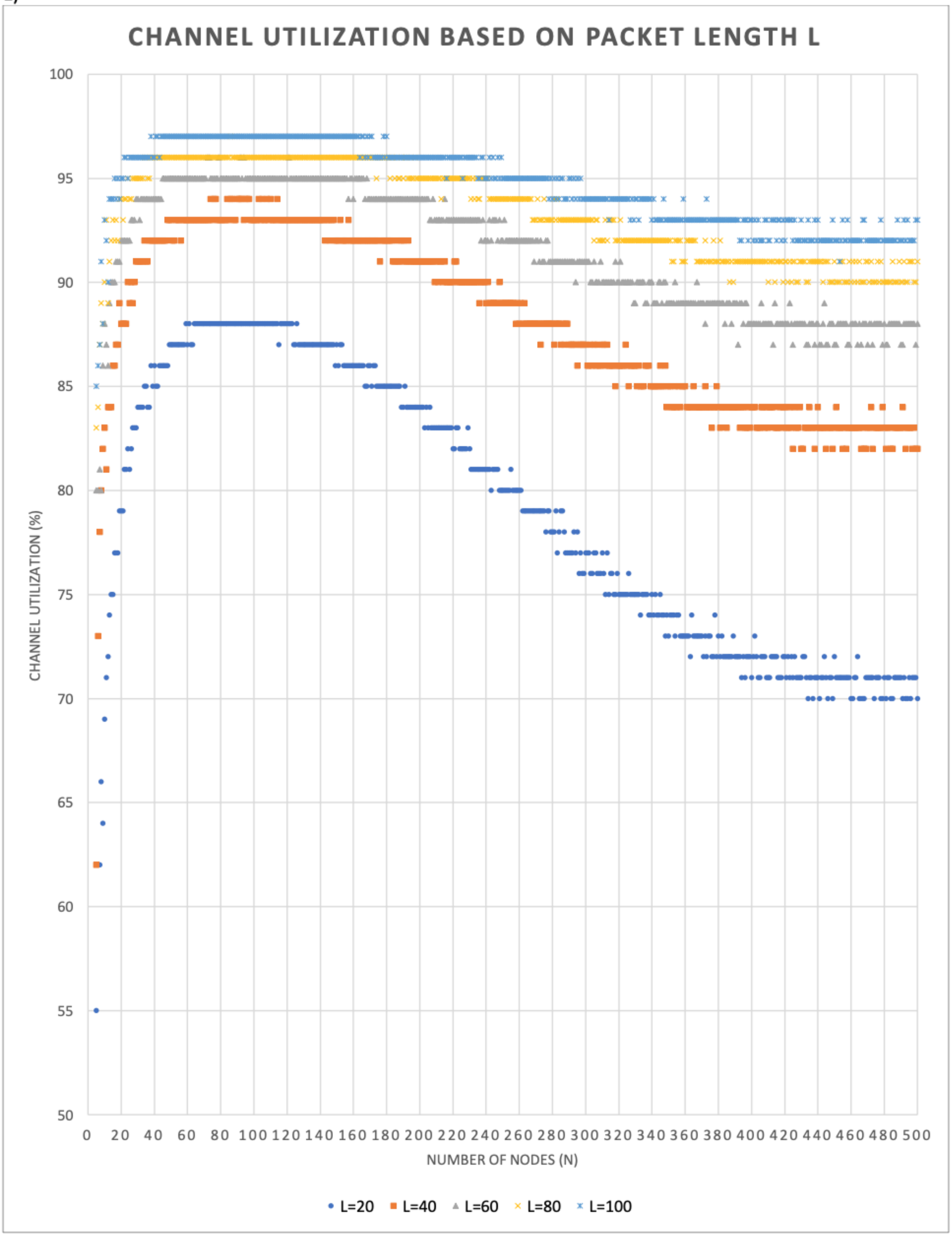
C)


TOTAL NUMBER OF COLLISIONS
TOTAL NUMBER OF COLLISIONS
NUMBER OF NODES (N)
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500

D)


CHANNEL UTILIZATION WITH VARYING R
CHANNEL UTILIZATION (%)
100
95
90
85
80
75
70
65
60
55
50
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
NUMBER OF NODES (N)
R=1 R=2 R=4 R=8 R=16

E)


CHANNEL UTILIZATION BASED ON PACKET LENGTH L
CHANNEL UTILIZATION (%)
100
95
90
85
80
75
70
65
60
55
50
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
NUMBER OF NODES (N)
L=20 L=40 L=60 L=80 L=100

Channel Utilization is being assumed as the ratio of time the **network is being utilized for packet transmission** to the global time (T = 50000 clicks). Therefore, it is not an outright representation of the throughput of the network.

ANALYSIS

In graph (D), we observe that the channel utilization of the network gradually decreases with increasing value of R. The nodes back off after a collision for a random value in the range of [0,R]. Therefore, for each collision the nodes back off for a smaller amount of time in average when R = 1 compared to R = 8 so the nodes are more active when R=1 compared to R=8, as evidenced in the graph. For N = 180, channel utilization is 85% for R = 8 compared to 80% utilization for R = 16. Therefore, as the starting value of R increases, there will be a compounded effect on the network as the R value doubles after every collision. This may cause the network to wait longer times to start transmitting packets as compared to a network with an R value of 1, which will increment the R values to [2,4,8,16,32] (considering M = 6). A network with a starting R value of 16 will increment to R values of [32,64,128,256,512]. Therefore, there is a 16-fold increase in the maximum back off value which is amplified by larger networks waiting longer to transmit packets. This causes the utilization rate to significantly decrease with increase in the starting value of R.

In graph (E), the channel utilization increases with increasing values of Packet Length (L). As packet length increases, the network utilizes more time in transmitting the packet and takes up more clicks as a packet with L = 80 will take 80 clicks to transmit while a packet with L = 20 will take 20 clicks to transmit. This ensures that each packet transmission is a larger ratio of the global clock (T) thereby increasing channel utilization. As each transmission utilizes more clicks, the network is idle for a shorter duration resulting in fewer chances of collision. For packets of smaller lengths (L = 20), the channel is idle for a shorter duration resulting in more chances of collision between nodes.

The channel utilization has an interesting trend with N (number of nodes in the channel). The channel utilization increases exponentially with increase in N till N reaches the value of 50. As the network size gets larger, the channel utilization rate decreases and reaches a low at N = 220. However, as nodes increase beyond 250 the utilization rate increases again as nodes start to diverge and the increased traffic causes fewer collisions, causing the channel to be idle for a shorter period of time. From 50 – 200 nodes, the channel utilization rate drops as more nodes collide and the back-off time for each node is low as it is either the first or second collision for each node so a certain value of R is more likely to be chosen by multiple nodes, leading to further collisions and the network not being utilized. With increasing number of nodes (N > 300), most of the nodes have had either more than 6 collisions (causing the node to drop the packet and reset the back-off time to 0) or are nearing 6 collisions (high value of R, as R doubles after every collision). This diverges the back-off time for the nodes resulting in fewer collisions and increased transmission of packets and utilization rate.