MP 4 – CSMA/CD Simulation

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ECE 438: Communication Networks, Fall 2018

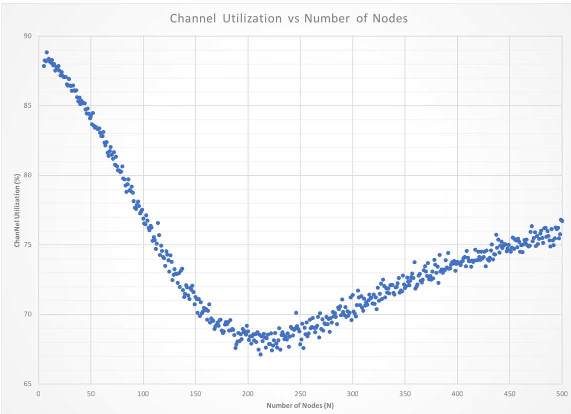

Figure 1: Channel utilization as a percentage of clock ticks used for successful transmission, shown for increasing number of nodes.

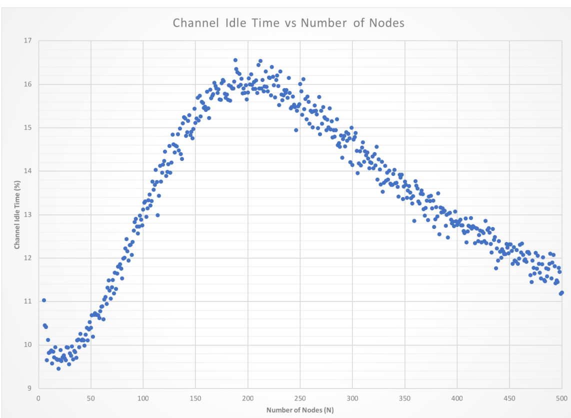

Figure 2: Channel idle time as percentage of clock ticks where channel was not used by any node, shown for increasing number of nodes.

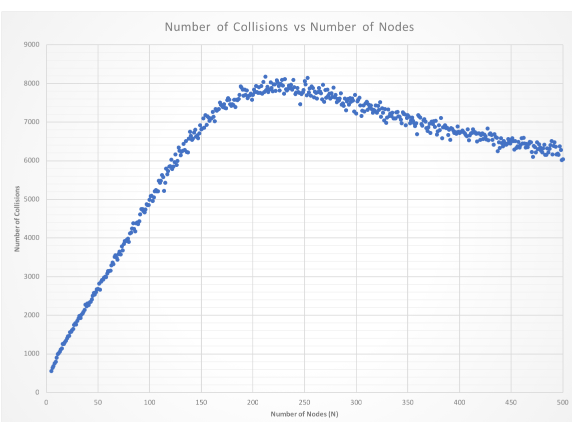

Figure 3: Total number of collisions in the network, shown for increasing number of nodes.

Note: full size charts and raw data are available in GitHub repository, in the mp4/out directory.

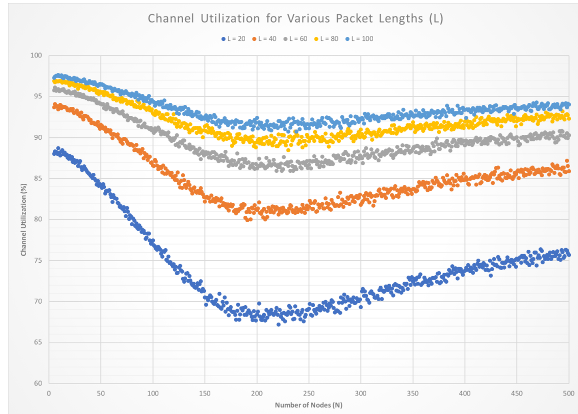

Figure 4: Channel utilization for various packet lengths (time to send).

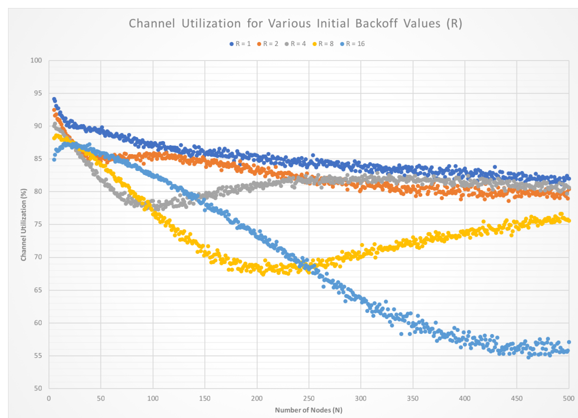

Figure 5: Channel utilization shown for various initial values of the Random Backoff Range (R).

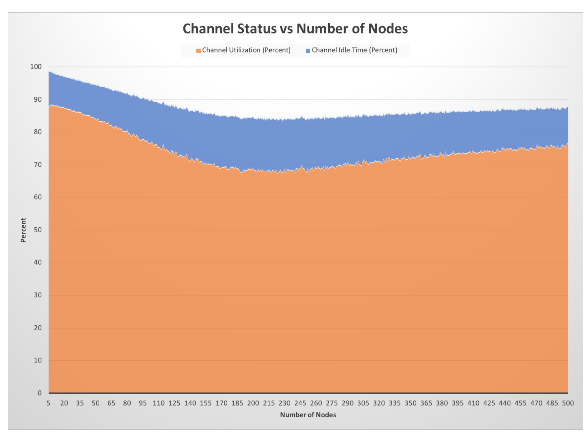

Figure 6: Cumulative channel status vs number of nodes, using default packet length (L) and random backoff (R) values. Remaining space indicates time wasted due to collisions during transmission.

Analysis:

In figure 4, we see that increasing the length of the data packets while maintaining the other parameters increases the overall channel utilization, especially as the network becomes larger. This is because there are fewer total packets transmitted for a given time interval (50000 ticks in our case), and each one takes longer to transmit. Therefore, even if the same ratio of packets collides, the number of clock ticks in which a successful transmission happens increases. If the nodes were not carrier sensing before transmission, and only checking for collisions after starting to transmit, increasing the packet length would have the opposite effect since each packet occupies more time and has a higher chance of being interrupted.

Figure 4 also shows the relationship between the network size and the channel utilization. Peak utilization is achieved by small networks having approximately 25 nodes. Worst case utilization happens in mid-sized networks of approximately 200 nodes. Increasing the number of nodes beyond 200 brings the channel utilization back up. This is due to the competing effects of additional nodes causing more collisions and additional nodes occupying the channel more frequently. For $N < 200$, we can see that the dominant effect is more frequent collisions, while for $N > 200$ the increased traffic wins out. Initially, as more nodes are added to the network, it becomes increasingly likely that any two nodes will be ready to transmit at the same time, due to the pigeon hole principle and how random backoff works. If all nodes must pick a number between 0 and 8, many nodes will end up selecting the same number. As collisions occur, each of the matching nodes will tend to diverge as they pick new random numbers, and the set of nodes in lockstep will reduce, eventually allowing each node to transmit. For medium values of N, this takes time and therefore reduces the overall channel utilization. For large values of N, this effect is dominated as more nodes attempt transmission and the low random numbers are picked more frequently.

Figure 5 shows the channel utilization for various initial backoff values. The yellow data series indicates the set with default parameters. We can see that smaller initial backoff ranges tend to have higher channel utilization, especially for midsize networks. This is because nodes are not waiting unnecessarily for their backoff counter to reach zero while the channel is idle. As N increases, initial values of 1, 2, and 4 converge to about 80% utilization with 500 nodes, while R = 8 reaches 75% and R = 16 falls to 55% at 500 nodes. The reason for this convergence in the R = 1,2,4 plots is due to the increased number of collisions from all the nodes being pigeon-holed into these smaller ranges, as compared to smaller networks where the differences in the random ranges produce variation in the plots.

In the R = 16 case, we see a slight peak near N = 25 nodes, then a dramatic drop off as the network grows. This is due to excessive waiting for transmission while the channel is idle. Larger backoff ranges help reduce chances of two nodes picking the same number, but also increase wait time and therefore reduce utilization.

Note: Since we did not look at the number of dropped vs successful packets in these situations, it is important to note that a marginally higher channel utilization may not equate to higher throughput.