ECE356 Lab 3: Part 2 Link Layer Problems

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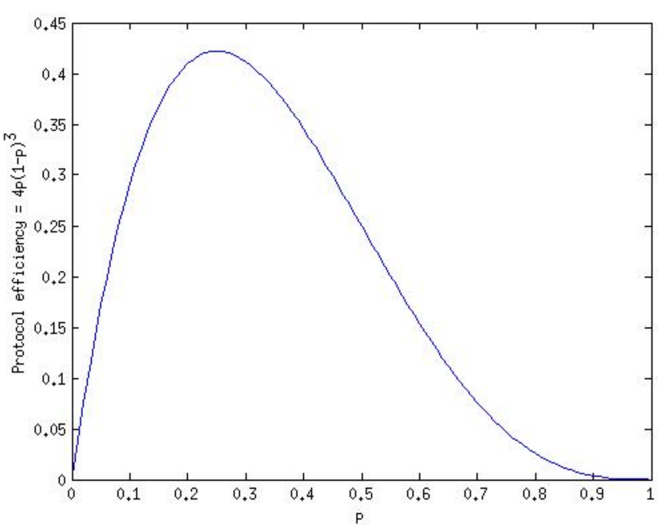
1.1

Protocol efficiency e:

$$
\begin{aligned}
p &= 0.25 \\
N &= 4 \\
e &= Np(1-p)^{N-1} \\
&= 4(0.25)(0.75)^{(}3) \\
&= 0.421875
\end{aligned}
$$

1.2

Figure 1: Protocol Efficiency for N = 4



Using the same fixed value for N = 4 from part 1.1 we observe the graph of Figure 1. Let's first examine the end points of the graph; if p = 0 or p = 1, then the nodes either never or always transmit packets. In the first case, it is easy to see why when p = 0, the protocol efficiency is also 0. In the second case, if nodes are always transmitting packets, there will always be collisions and no successful transmissions will be possible, thus protocol efficiency is 0. The protocol efficiency increases from p = 0 to p ≈ .25 because this signifies nodes transmitting more frequently, thus it makes sense that protocol efficiency increases. However, after a certain point (after p ≈ .25), the nodes begin to transmit so frequently that more collisions occur and protocol efficiency is reduced.

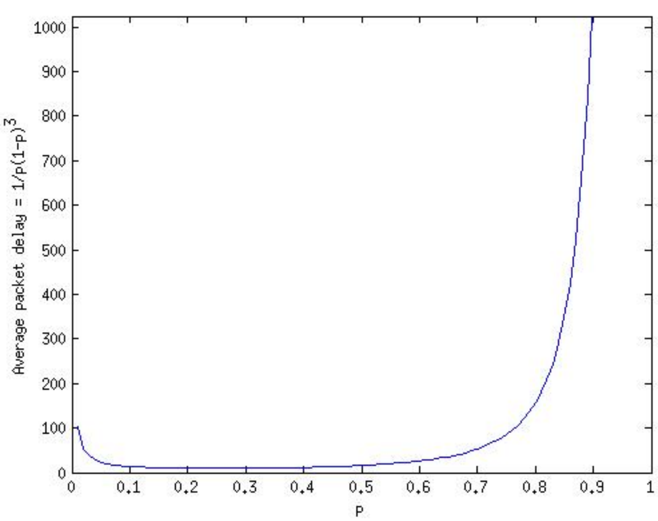
1.3

The average packet delay d is related to the probability involved in the protocol efficiency:

$$d = \frac{1}{p(1-p)^{N-1}}$$

The reasoning behind this is that for any one node, the probably that the node will successfully transmit a packet is $p(1-p)^{N-1}$. Thus, on average, any node will need to experience $\frac{1}{p(1-p)^{N-1}}$ slots for a successful transmission.

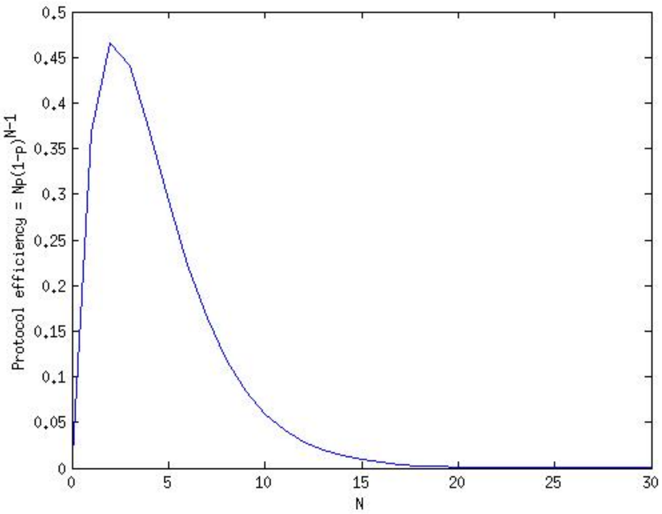
Figure 2: Average Packet Delay for N = 4



Observing Figure 2 we see that the average packet delay goes to infinity at p = 0 and p = 1, and this is based on similar reasoning from part 1.2. Again, as we move to p = 0 to p ≈ 0.25, we observe that the average packet delay reaches a minimum, at the same point that protocol efficiency reaches its maximum. This makes intuitive sense because it says that if the link is operating efficiently then average packet delay is low. Again, we see that as nodes begin to transmit packets more frequently (after p ≈ 0.25), the average packet delay increases because there are more collisions.

1.4

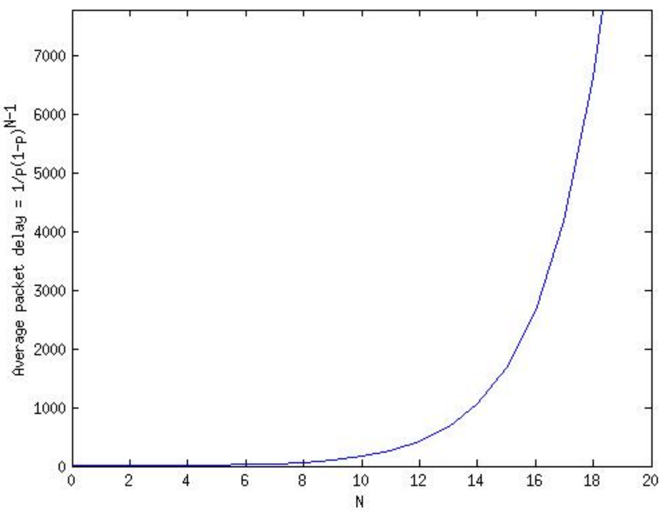
Figure 3: Protocol Efficiency for p = 1/e



This time varying N and using a fixed $p = 1/e$, we observe from Figure 3 that the protocol efficiency follows the same trend as that demonstrated in part 1.1. Thus, if all nodes transmit with some fixed probability, there will be a certain number of nodes that maximizes the protocol efficiency. This makes sense because as more nodes are added past the optimal value, more packets will be likely to enter the channel, so more collisions will occur and efficiency will drop. As too many nodes get added, the channel will be constantly flooded with packets and there will be no successful transmissions. On the other hand, if there are no nodes then there can be no efficiency because no packets will be transmitted. Thus, we need to have a certain number of nodes ($N \approx 3$ when $p = 1/e$) such that enough packets are being sent to fully utilize the channel but not so much that the number of collisions hinder efficiency.

1.5

Figure 4: Average Packet Delay for p = 1/e



Observing Figure 4, we see that the average packet delay demonstrates the same behavior as that demonstrated in part 1.3. As more nodes are added, there will be more packets transmitted at the same time and more collisions will occur, thereby increasing delay and decreasing efficiency (as shown in part 1.4).