EE 122 **Spring 2016**

HW4

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1. Since A is actively communicating with B, E has received A's RTS towards B, and knows not to transmit, or else it will disturb A. Similalrly, C knows not to broadcast as well. So that just leaves:

$$D \to E$$

and

$$D \to C$$

2. Without RTS/CTS, the total time should be:

$$\text{DIFS + backoff + overhead/payload + SIFS + ACK}$$

And with RTS/CTS, the total time should be:

$$\text{DIFS + backoff + RTS + SIFS + CTS + SIFTS + overhead/payload + SIFS + ACK}$$

Actually plugging in the numbers, we know that :

$$\text{DIFS } = 2.5(20\mu s) = 50\mu s$$

$$\text{SIFS } = 0.5(20\mu s) = 10\mu s$$

$$\text{RTS = CTS = ACK } = 10(20\mu s) = 200\mu s$$

The transmission time of just the actual payload is:

$$= \text{overhead + payload transmission time } = 9(20\mu s) + X \text{ bytes} * \frac{1 \text{ bit}}{8 \text{ bytes}} * \frac{1s}{11,000,000 \text{ bits}} * \frac{1000000\mu s}{1s}$$

$$= (180 + \frac{X}{88})\mu s$$

That means that the first (without RTS/CTS) backoff time should be $1.5(180 + \frac{X}{88})\mu s$, and the second backoff time should be $1.5(200\mu s) = 300\mu s$.

So the transmission time without RTS/CTS is:

$$50 + 1.5(180 + \frac{X}{88}) + (180 + \frac{X}{88}) + 10 + 200 = 2.5(180 + \frac{X}{88}) + 260$$

And the transmission time with RTS/CTS is:

$$50 + 300 + 200 + 10 + 200 + 10 + (180 + \frac{X}{88}) + 10 + 200 = \frac{X}{88} + 1160$$

So solving:

$$\frac{X}{88} + 1160 < 2.5(180 + \frac{X}{88}) + 260$$

We get $X > 26,400$ Bytes.

3. For each packet we send, the time to transmit is:

$$\text{DIFS} + \text{backoff} + \text{propagation delay} + \text{RTS} + \text{SIFS} + \text{propagation delay} + \text{CTS} + \text{SIFS} +$$

$$\text{propagation delay} + \text{preamble} + \text{payload} + \text{SIFS} + \text{propagation delay} + \text{ACK}$$

First, we find $CW = (CW_{\text{min}} + 1) * 2^0 - 1 = CW_{\text{min}} = 31$. Since the source node is sending a large amount of data (call it X bytes), we'll assume that $X >> 1$, and so from the Law of Large Numbers, our average backoff time should be $\frac{31+0}{2} = 15.5$ slots, or $310\mu s$. The propagation delay is:

$$750m(\frac{1s}{3 * 10^8 m})(\frac{1,000,000\mu s}{1s}) = 2.5\mu s$$

And the time to actually transmit a packet is:

$$1100B(\frac{1b}{8B})(\frac{1s}{11,000,000b})(\frac{1,000,000\mu s}{1s}) = 12.5\mu s$$

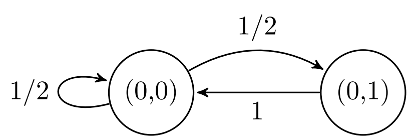
So the time to transmit a packet is:

$$50 + 310 + 2.5 + 200 + 10 + 2.5 + 200 + 10 + 2.5 + 200 + 12.5 + 10 + 2.5 + 200 = 1212.5\mu s = .0012125s$$

That means our throughput is:

$$1100B(\frac{1b}{8B})(\frac{1b}{1,000,000Mb})(\frac{1}{.0012125s}) \approx 0.11Mbps$$

4. (a) Since $2^m(CW_{\text{min}} + 1) = CW_{\text{max}} + 1$, then we know $2^m = 2^0$, so $m = 0$. Then $W_0 = 2^0(2) = 2$.



(b) We have a system of equations:

$$0.5x + y = x$$

$$0.5x + 0y = y$$

$$x + y = 1$$

We can easily solve this, giving us $x = \frac{2}{3}$, $y = \frac{1}{3}$, so:

$$\pi = [\frac{2}{3}, \frac{1}{3}]$$

5. (a) The number of devices in a Wi-Fi Direct group network is expected to be smaller than the number supported by traditional Wi-Fi access points.
   (b) Wi-Fi Direct has speeds similar to traditional Wi-Fi, which can be as fast as 250 Mbps.
   (c) Wi-Fi Direct can connect as far as 200 meters (but of course it varies, as it does with traditional Wi-Fi).
   (d) Yes it can – by creating simulataneous infrastructure and Wi-Fi Direct connections.