CIS 5511 02/22/2022

1. Suppose the IEEE 802.11 RTS and CTS frames were as long as the standard DATA and ACK frames. Would there be any advantage to using the CTS and RTS frames? Why or Why not?

   Ans: No, there wouldn't be any advantage. Suppose there are two stations that want to transmit at the same time, and they both use CTS/RTS. If the RTS frame is as long as it would have been wasted for two colliding DATA frames. Thus, the RTS/CTS exchange is only useful when the RTS/CTS frames are significantly smaller than the DATA frames.

2. The SIFS is the amount of time that a node waits between receiving a DATA frame and sending an ACK. The DIFS is the amount of time that a node waits (sensing the medium) before sending a new DATA frame. Why do you think that the designers of IEEE 802.11 made the SIFS shorter than the DIFS?

   Ans: SIFS = spacing between transmission and ACK, between polling and response

   PIFS = spacing after which point coordinator can take over

   DIFS = distributed inter frame spacing. a new transmission can begin after DIFS of idle time.

   Having PIFS < DIFS allows point coordinator to take over and separate contention-free and contention periods. Having SIFS smaller than both PIFS and DIFS prevents ACK and important control packets from getting killed.

3. Suppose an IEEE 802.11b station is configured to always reserve the channel with the RTS/CTS sequence. Suppose this station suddenly wants to transmit 1,000 bytes of data, and all other stations are idle at this time. As a function of SIFS and DIFS, and ignoring propagation delay and assuming no bit errors, Calculate the time required to transmit the frame and receive the acknowledgement.

(1) transmission ~~of a control frame~~ rate of 802.11b is 11 Mbps;

(2) the size of a control frame (RTS, CTS, ACK) is 256 bits;

(3) the head of a data frame is also 256 bits.

Ans: A frame without data is 32 bytes long. Assuming a transmission rate of 11 Mbps, the time to transmit a Control frame (such as an RTS frame, a CTS frame, or an ACK frame) is $\frac{256 \text{ bits}}{11 \text{ Mbps}} = 23$ u Sec. The time required to transmit the data frame is $\frac{8256 \text{ bits}}{11 \text{Mbps}} =$ u Sec.

DIFS + RTS + SIFS + CTS + SIFS + FRAME + SIFS + ACK

= DIFS + 3 SIFS + (3 * 23 + 751) u Sec

= DIFS + 3 SIFS + 820 u Sec

4. Comparing tree-based structures (Blue-Tree) and ring-based structures (Blue-Ring), what are advantages and disadvantages of using them to form the Bluetooth scatternets?

Blue-Tree, advantages include (1) A Tree Structure can be maintained (2) No master is also a bridge so the load on the master is reduced. (3) The number of links in a bridge is the minimum possible, thus making the overhead in the bridge lighter. However, the resulting scatternet has an inherent deficiency due to its treelike structure; it does not exhibit a high degree of reliability. If one parent node is lost, all the children and grandchildren nodes below it will be separated from the rest of the network and part of the tree (or even the whole tree) has to be rebuilt in order to retain connectivity. In a mobile network, this may happen quite frequently, making the scatternet very susceptible to disconnections. [Reference: Bluetooth Scatternets: Criteria, models and classification, Ad Hoc Networks] BlueRing provides an effective scheduling scheme for efficient scatternet operation as no master node is a bridge connecting two piconets (thus making it more efficient.) However the number devices is limited to less than 37. As the system grows large, the traffic delay increases linearly and multiple communications can't be well supported. [Reference: Bluetree #: An Extendable Bluetooth Scatternet Formation Using Only Slave/Slave Bridges].

5. Prove that $D = R(3N)^{1/2}$, where D is the reuse distance, R is the radius of each cell, and N is the number of cells in a cluster.

Ans: $$D^2 = (\sqrt{3}\, i\, R)^2 + (\sqrt{3}\, j\, R)^2 - 2(\sqrt{3}\, i\, R)\cdot(\sqrt{3}\, j\, R)\cos 120^\circ$$
$$= 3 \cdot N \cdot R^2$$

Hence $Q = D/R = \sqrt{3N}$.

6. If 20 MHz of total spectrum is allocated for a duplex wireless Cellular system and each simplex channel has 25 kHz RF bandwidth, find: (a) the number of duplex channels

(b) the total number of channels per cell site, if $N=4$ cell reuse is used.

Ans: (a) $\frac{20,000}{50} = 400$ channels

(b) $\frac{400}{4} = 100$ Channels

7. For the right cell pattern, find the reuse distance if the radius of each cell is 2 km.

Ans: $D = \sqrt{3N} \cdot R = 2 \times \sqrt{3 \times 12} = 2 \times 6 = 12$ km.

8. In the following figure, calculate the cochannel interference ratio in the worst case for the forward channel, given $N=7$, $R = 3$ km, and $\gamma = 2$. Notice the calculation ($D_1 = D_2 = D - R$, $D_3 = D_6 = D$, $D_4 = D_5 = D + R$) in lecture note is an approximation method, but here you need use the exact geometry to compute the values.

Ans: $C/I = \frac{1}{2}\left((q-1)^{-\gamma} + (q)^{-\gamma} + (q+1)^{-\gamma}\right)$

$D = \sqrt{3N} \cdot R = \sqrt{3 \times 7} \times 3 = 3 \times \sqrt{21} = 3\sqrt{21}$

$C/I = \frac{1}{2}\left[(\sqrt{21}-1)^{-2} + (\sqrt{21})^{-2} + (\sqrt{21}+1)^{-2}\right]$

$= 3.1981067443074 31 \ldots$

9. In the following figure (a three sectors system), calculate the co channel interference ratios at points a and b for the forward channel. Please use frequency reuse factor q to express the result.

A forward channel can be expressed as:

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{i_0} I_i}$$

$$S/I = \frac{1}{6} \times (4.583)^4 = 75.3 \quad (18.66\,dB)$$