CSCE 464 Wireless and Mobile Systems Fall 2019

Homework 2
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Remove all highlights before typing your answer.

1 Signals

(a) Transmitted Power: P_t
Received Power: P_r
$P_t/P_r = (4\pi d/\lambda)^2$
$P_t/P_r = (4\pi df/c)^2$

Case 1: $f = 2f$ (doubling the frequency)
$P_t/P_{r2} = (4\pi d(2f)/c)^2$
$= 4(4\pi df/c)^2$
$P_t/P_r = 4$

Doubling the transmission frequency between transmitting antenna and receiving antenna is $10log(P_t/P_r)dB = 10log(4) = 6dB$

Case 2: $d = 2d$ (doubling the distance)
$P_t/P_{r2} = (4\pi(2d)f/c)^2$
$= 4(4\pi df/c)^2$
$P_t/P_r = 4$

Doubling the distance between transmitting antenna and receiving antenna is $10log(P_t/P_r)dB = 10log(4) = 6dB$

(b) that will satisfy the following requirements: Transmit power = 2

(i) $P_{dbW} = 10log(P_w/1W) = 10log(50) \approx 17dBW$

$P_{dbM} = 10log(P_{mW}/1mW) = 10log(50000) \approx 47dBm$

(ii) $L_{dB} = 10log(P_t/P_r) = 20log(4\pi d/\lambda) = -20log(\lambda) + 20log(d) + 21.98$

$L_{dB} = 20log(4\pi fd/c) = 20log(f) + 20log(d) - 147.56dB$

$L_{dB} = 20log(900x10^6) + 20log(100) - 147.56 = 20log(900) + 20log(10^6) + 20log(100) - 147.56 = 59.08 + 120 + 40 - 147.56 = 71.52$

Received Power in dBm = 47 − 71.52 = **-24.52dBm**

(iii) $L_{dB} = 20log(f) + 20log(d) - 147.56dB$

$L_{dB} = 20log(900x10^6) + 20log(10x1000) - 147.56$
$= 20log(900) + 20log(10^6) + 20log(10000) - 147.56$
$= 59.08 + 120 + 80 + 147.56 = 111.52$

Received Power in dBm = $47 - 111.52 =$ **-64.52dBm**

(iv) (Receiver antenna gains of 2) Power in dBm = $47 - 111.52 + 3 =$ **61.52**

(c) $2W = 33.01dBm$
Path Loss: $L_p = P_t - P_r$
$= 33.01 - (-105)log_{10}(5.2km) = 108.19$

2 OFDM

(a) OFDM is a modulation technique that uses many carriers that are orthogonal to each other. Having lower rate subcarriers is helpful because it allows transmission of more symbols per second. This means the data rate is increased and the serial data is processed in parallel.

3 Spread Spectrum

(a) $W_s = 400MHz$
$bw = 100Hz$

Total number of channels:
$W_s/bw = 400MHz/100 = 4x10^6$

Minimum number of PN bits required:
$= log_2(4x10^6) =$ **21.93**

4 Aloha

(a) The window of vulnerability is the time in which the packet is being transmitted that it can suffer a collision. The window is directly related to the throughput because the window determines when you can/can't transmit packets. The larger the window, the smaller the throughput because there is more downtime when packets can't be sent.

(b) No, the slot size should not be larger than L. There will be wasted time in sending data if the slot size is too long because a packet would be sent in L time but the slot itself would still be 'reserved' for the remaining time. This would prevent other nodes from using this channel.

(c) (A) Let probability p be no success in slots 1 and 2, but success in slot 3. The probability of success is $P(A)$ and no success is $1 - P(A)$

$P(A) = AtransmitsandBdoesnotandCdoesnot$
$P(A) = P(1-P)(1-P) = P(1-P)^2$
$P(Asucceedsinslot3) = (1-P(A))^2 P(A)$
$P(Asucceedsinslot3) = (1-P(1-P)^2)^2 * P(1-P)^2$

(B) Add probabilities of all three nodes together:
$= P(A_3) + P(B_3) + P(C_3)$
$= P(1-P) + P(1-P) + P(1-P)$
$= 3P(1-P)$

(C) Probability of any node succeeding in a given slot is $3p(1-p)^2$
Probability that no node succeeds during a slot is $1 - 3p(1-p)^2$

Thus, the probability that there is no success the first two slots, but any of the three nodes succeeds in the third slot is:
$= (1 - 3p(1-p)^2 + 1 - 3p(1-p)^2) + 3p(1-p)^2$
$= (1 - 3p(1-p)^2)^2 * 3p(1-p)^2$

5 CSMA

(a) A higher CS threshold will allow for more spatial re-use but will result in more interference. The inverse happens if the CS threshold is lowered. There would be less interference but also less spatial re-use.

(b) An example scenario would be three nodes, equidistance apart from each other. Nodes: A, B, C. In the example the signal can propagate only slightly more than the distance of separation between the nodes. So A and B can communication and B and C can communicate.

The hidden terminal problem occurs when when A and C both send something to B without being able to see that the other is already transmitting to B because they are out of each other's range. This ultimately ends up resulting in a collision.

For the exposed terminal problem assume B is sending some data to A and C wants to send data to some node D which is outside the range of both A and B. Since B is in the range of C, C thinks that the carrier is busy and unnecessarily waits for B to finish its transmission before sending the data to D

(c) The main reason is the CAMA/CD listens whether the medium is free before transmitting any packets which would be cumbersome on WiFi. In WiFi the sender isn't able to sense data moving about in the medium therefore it wouldn't be able to detect collisions. Additionally, if a collision is detected all the users would have to wait to re-transmit their data. In wireless networks CAMA/CA is used instead to avoid rather than detect collisions.

(d) No it is not possible to avoid the hidden terminal problem with only physical carrier sense. Physical carrier sense listens on the channel to see if any node is transmitting on it. The node will assume the channel is clear if it doesn't sense anything on it but as we can see from the answer to part (b), if the nodes are out of each other's range they will both try to transmit and result in a collision.

(e) The virtual carrier sense is implemented with a timer that counts down signaling when a channel is clear. Each frame has a 'duration' field that is used to set/update the value of the timer.. When a client sends a frame it determines how long the channel is 'reserved' for. Without the physical carrier sense clients might miss these frames meaning the timer would expire while the channel is still busy. Additionally, if a frame sets the duration too high, then the channel would be 'reserved' for too long.

6 MAC Layer

(a) Total frame size = 28+1452 = $1480 bytes$, at 54Mbps, taking $1480 * 8 bytes/54 Mbps = 219.25 \mu s$ to transmit
Acknowledge frame takes $14 * 8 bytes/54 Mbps = 2.07 \mu s$ to transmit

Total time to transmit frame is DIFS, data, propagation, physical overhead, SIFS, the acknowledgement, propagation for the acknowledgement, and physical overhead for the acknowledgement.
$= 34 \mu s + 219.25 \mu s + 1 \mu s + 36 \mu s + 16 \mu s + 2.07 \mu s + 1 \mu s + 36 \mu s = 345.3 \mu s$ to transmit the frame.
Data throughput is $\approx 37 Mbps$

(b) Known:
$219.25 \mu s$ transmit frame of data $2.07 \mu s$ transmit acknowledge frame
$20 * 8 bytes/54 Mbps = 2.96 \mu s$ transmit RTS frame
$14 * 8 bytes/54 Mbps = 2.07 \mu s$ send CTS frame

When using RTS/CTS, the total time taken to transmit a frame is instead DIFS + RTS + propagation time + physical overhead + SIFS + CTS + propagation time + physical overhead + SIFS + data time + propagation time + physical overhead + SIFS + acknowledgement + propagation time + physical overhead:

$34 \mu s + 2.96 \mu s + 1 \mu s + 20 \mu s + 16 \mu s + 2.07 \mu s + 1 \mu s + 36 \mu s + 16 \mu s + 219.25 \mu s + 1 \mu s + 36 \mu s + 16 \mu s + 20 \mu s + 1 \mu s + 36 \mu s = 410 \mu s$

Total transmission throughput for the 1452 byte payload is $\approx 28.33 Mbps$.

7 Wireshark

(a) 30 Munroe St. & linsys_SES_24086

(b) 0.1024 seconds

(c) 00:16:b6:f7:1d:51

(d) ff:ff:ff:ff:ff:ff

(e) 00:16:b6:f7:1d:51

(f) Supported Rates:

   (a) 1.0 Mbps
   (b) 2.0 Mbps
   (c) 5.5 Mbps
   (d) 11.0 Mbps

   Extended Rates:

   (a) 6.0 Mbps
   (b) 9.0 Mbps
   (c) 12.0 Mbps
   (d) 18.0 Mbps
   (e) 24.0 Mbps
   (f) 36.0 Mbps
   (g) 48.0 Mbps
   (h) 54.0 Mbps

(g) MAC Addresses for TCP SYN:

   (a) Sender: 00:13:02:d1:b6:4f
   (b) Destination/First Hop: 00:16:b6:f4:eb:a8
   (c) BSS: 00:16:b6:f7:1d:51

   IP of Host Sending: 192.168.1.109
   Destination IP: 128.199.245.12 (corresponds to gaia.cs.umass.edu)

(h) oh MAC Addresses for TCP SYNACK:

   (a) Sender/First Hop: 00:16:b6:f4:eb:a8
   (b) Destination: 91:2a:b0:49:b6:4f
   (c) BSS: 00:16:b6:f7:1d:51

   IP of Host Sending: 128.199.245.12 (corresponds to gaia.cs.umass.edu)
   Destination IP: 192.168.1.109 (corresponds to the wireless PC)

(i) 1. A DHCP release is sent by the host to the DHCP server
   2. The host sends a de-authentication frame

   Expected to see a disassociation request but one is not visible

(j) 6 messages are sent

(k) The host is requesting that the association be open

(l) No, because AP is likely ignoring requests for open access since it is looking for a key

(m) Authentication Frame Sent: time = 63.168087
Reply Sent: time = 63.169071

(n) Associate Request: time = 63.169910 Associate Reply: time = 63.192101

(o) Rates for both Association Request/Response:

  (a) 1.0 Mbps
  (b) 2.0 Mbps
  (c) 5.5 Mbps
  (d) 6.0 Mbps
  (e) 9.0 Mbps
  (f) 11.0 Mbps
  (g) 12.0 Mbps
  (h) 18.0 Mbps
  (i) 24.0 Mbps
  (j) 32.0 Mbps
  (k) 48.0 Mbps
  (l) 54.0 Mbps

(p) MAC Addresses:

  (a) Sender: ff:ff:ff:ff:ff:ff
  (b) Sender BSSID: f:ff:ff:ff:ff:ff
  (c) Receiver: 00:16:b6:f7:1d:51
  (d) Receiver BSSID: 00:16:b6:f7:1d:51

The purpose of a probe request is for active scanning to find an access point. The purpose of a probe response is to acknowledge the request