F15 NET3900

Modules 1,2 Assignment

Instructions:

Please show all your calculations for numerical answers.

The grade for each question is shown next to the question number.

Please submit this assignment via Bb, email or via paper to me at a lecture or lab.

The solutions will be posted to Bb following the due date.

This assignment is due by 3:00pm Friday Sept. 18.

1/1. What is an OFDM subcarrier.

A Wi-Fi/OFDM channel is partitioned into carriers called sub-carriers.
Each carrier is independently modulated to carry data.

2/1. Each carrier is modulated using QAM. Briefly explain QAM?

QAM modulates a signal by varying the phase and amplitude. In practice, the same effect can be created by Amplitude Modulating (AM) two orthogonal carriers (cos, sin) and summing the result. The number of AM levels is determined by how many bits per symbol are needed.

3/4. Briefly explain the following concepts in terms of purpose and basic operation:

- channel bonding

> combining neighbouring channels (i.e. 1,6) to create a single "superchannel".
802.11n permits bonding of 2 x 20MHz channels to create a 40 MHz channel.
802.11ac permits higher levels of bonding.
> this increases the channel bandwidth, hence increases the number of subcarriers and channel throughput

- MIMO

> uses multiple antennas to create multiple transmission streams.
> each transmission stream is called a spatial stream
> the purpose is to increase channel bandwidth and throughput

- adaptive rate control

> automatically adjusting the PHY rate to match the conditions for signal strength (RSSI), SNR and error rate
>if the error rate (determined by FEC errors or NAK (negative ack) is too high the radios negotiate a lower PHY rate.
- guard interval
> Lengthening of the symbol time to protect against interference due to signal reflections. When a reflected signal arrives long after the direct path signal, it can cause inter-symbol interference.

4/3. Your 802.11ag Wi-Fi radio tells you that it is operating at a PHY rate of 300 Mbps. You also determine that it is operating using 64-QAM. You configured the GI to be 400 ns, and the channel width to be 40 MHz which uses 108 subcarriers. Your Wi-Fi radio uses 2 MIMO spatial streams. The formula for the PHY rate is PHY = (NxBxRxS)/(Ts+GI) where Ts=3.2us, N=number of subcarriers, B=bits per symbol, R=FEC coding rate, S=number of spatial streams. Answer the following questions.

a) Calculate the bits per symbol "B", in other words, how many bits are supported by a 64 point constellation.
A 64 point constellation will support 6 bits of information. (ie $2^6 = 64$).
This means that each symbol is equal to 6 bits of info.
The 6 bits are coded into 3 in-phase bits (i.e. 8 levels) and 3 quad-phase bits (i.e. 8 levels).

b) Using the result from a) calculate the FEC Rate "R".
R = PHY x (Ts+GI) /(NxBxS)
R = 300 Mbps x 3.6us / (108 x 6 x 2)
R = 0.833 = 5/6

c) For every block of 6 FEC-coded bits, how many are data bits?
For a FEC rate of 5/6, every block of 6 bits includes 5 data bits (i.e. 6 x 5/6) and 1 redundancy bit.

5/3. Identify three mechanisms that the AP uses to learn the IP address of its controller.

1. Broadcast/Multicast using ADP (Aruba Discovery Protocol)
2. DNS query
3. DHCP using option 43

6/5. Answer the following questions regarding Tunneling protocols.

a) What is the principle of network tunneling?

- tunneling embeds/encapsulates a frame into the data field of another frame/packet which carries the embedded frame across the network.
- I will call the embedded frame the inner frame which has an inner header
- I will call the carrier frame/packet the outer frame which has an outer header

b) Identify two uses for tunneling.

1. used to carry frames across networks with incompatible addressing (ie private addresses across a public network)
2. used to carry frames across networks with incompatible protocols
3. used for VPNs by encrypting the carried/inner frame for privacy

c) An AP is connected to VLAN 101. However the wireless client associated to that AP is connected to VLAN 14. How is this accomplished?

The AP routes its packets to the controller using the outer frame which is connected to VLAN 101. The user frame is carried as the inner frame to the controller. The controller removes the frame and switches it on user VLAN 14.

e) What are the tunnel end-points for the AP in an Aruba wireless topology?

- AP and Controller (independent of network topology that connects the AP to the controller)
- Both the AP and the Wireless Controller encapsulate/de-encapsulate the 802.11 user frame to/from the tunnel.

7/1. What is an Aruba Networks Layer 2 topology?

The Controller is acting is a L2 switch and switches user frames to the upstream router, on which the user's default gateway is configured.

8/2. What does it mean when channels are non-overlapping? How many non-overlapping channels are available in the following bands?
- non-overlapping channels can operate independently and simultaneously without interference.

a) ISM: 3 channels (chnl 1, 6, 11)

b) UNII-1: 4 channels (chnl 36, 40, 44, 48)

c) UNII-2: 4 channels (chnl 52, 56, 60, 64)

d) UNII-2e: 11 channels (chnls 100-140 in steps of 4; in practice channels 120, 124, 128 are not used due to the risk for weather-radar interference)

e) UNII-3: 4 channels (chnl 149, 153, 157, 161)

FYI:
ISM band: Industrial, Scientific and Medical
Microwave ovens, cordless phones, Bluetooth and many other devices also use this band which creates RF noise for Wi-Fi users.

UNII band: Unlicensed National Information Infrastructure
Because of the lower risk for RF noise and the larger number of channels, these bands are generally preferred in industrial applications especially for VoIP over Wi-Fi.