NET3900 Midterm EXAM
November 2, 2016

Instructions:

1. Please leave all your books and bags at the front of the class. This is a closed book exam.
2. This exam has 10 questions on 5 pages. Please ensure that you have all the pages.
3. Please use the answer-books for your answers.
4. You may use your scientific, non-programmable calculator. Cell phone calculators are not permitted.
5. The questions do not necessarily provide you with all the information you need to answer them. Additional information may be provided on the **INFORMATION SHEET**.
6. Note that the prefix m is used to denote milli as in mW=milliWatt, u is used to denote micro as in usec=microsecond and n is used to denote nano as in nsec=nanosecond.
7. Show all your calculations and explain any assumptions that you need to make.
8. Each question shows the number of marks. This exam has 50 marks in total.
9. Please write neatly.
10. You have from 1:00 pm to 2:50 pm to complete this midterm exam.

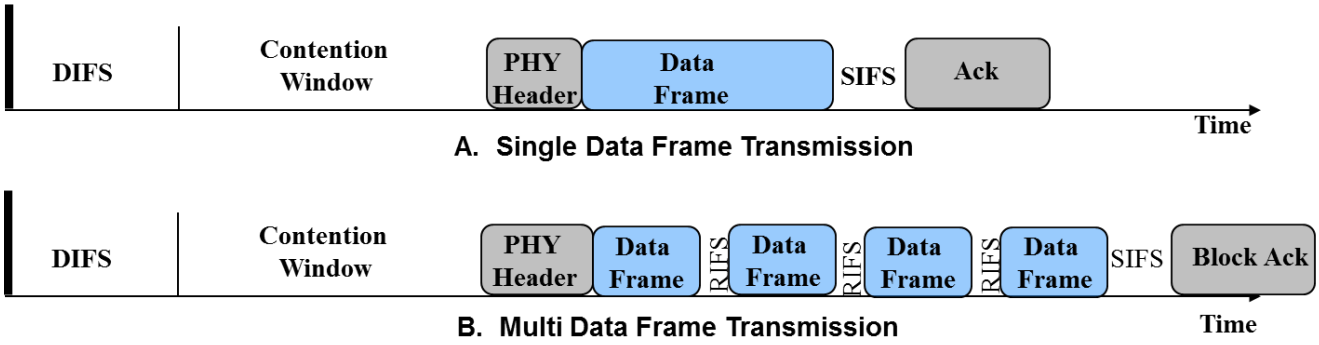
INFORMATION SHEET

TABLE 1: Wi-Fi Standards Transmission Options

Standard	Modulation	Number Bonded Channels	Channel Bandwidth (MHz)	Number of Data Subcarriers	Coding Rates	Guard Intervals	Spatial Streams
802.11a 802.11g	2,4,16,64-QAM	1	20	48	1/2, 2/3, 3/4	800ns	1
802.11n	2,4,16,64-QAM	1, 2	20, 40	52 @ 20 MHz, 108 @ 40 MHz	1/2, 2/3, 3/4, 5/6	400ns, 800ns	1 to 2
802.11ac	2,4,16,64,256-QAM	1, 2, 4, 8	20, 40, 80, 160	52 @ 20 MHz, 108 @ 40 MHz 234 @ 80 MHz, 468 @ 160 MHz	1/2, 2/3, 3/4, 5/6	400ns, 800ns	1 to 8

Base Symbol Duration: 3.2us

TABLE 2: Wi-Fi Transmission Timing Specs



Parameter	Duration
DIFS (DCF Interframe Spacing)	34 us
RIFS (Reduced Interframe Spacing	5 us
SIFS (Short Interframe Spacing)	16 us
Average Contention Window	67 us
PHY Header	25 us
Ack, Block Ack	24 us

1/3. Which organization performs the following functions?
a) Develops 802.11 standards
IEEE (ref module 1, slide 3)
b) Develops compliance standards and certifies compliance to 802.11 standards
Wi-Fi Alliance
c) Regulates use of Wi-Fi spectrum in Canada
Industry Canada

2/3. What is the 802.11 standards definition for the following?
a) Wireless Station
Device which has an 802.11 conformant protocol stack (ref module 1, slide 8)
b) Access Point
Device which has an 802.11 conformant protocol stack and a connection to the Distribution System
c) Distribution System
The network which joins the Access Points to each other

3/3. Consider a wireless network with two interconnected Access Points operating as follows. Note: A Virtual Access Point is considered as a Physical Access Point.

Access Point 1:

- 5 GHz radio has 2 Virtual APs (VAP) as follows:
  - VAP1 SSID = "VOIP" and has 2 wireless station associations
  - VAP2 SSID = "HQ-Data" and 1 wireless station association

- 2.4 GHz radio has 2 Virtual APs (VAP) as follows:
  - VAP1 SSID = "Employee" and has 1 wireless station association
  - VAP2 SSID = "Guest" and 1 wireless station association

Access Point 2:

- 5 GHz radio has 2 Virtual APs (VAP) as follows:
  - VAP1 SSID = "VOIP" and has 3 wireless station associations
  - VAP2 SSID = "HQ-Data" and no wireless station associations

- 2.4 GHz radio has 2 Virtual APs (VAP) as follows:
  - VAP1 SSID = "Employee" and has 3 wireless station associations
  - VAP2 SSID = "Guest" and 4 wireless station associations

Answer the following questions showing your calculations or provide a brief explanation.
a) How many BSS are operating in this network?
BSS = number VAPs with associations (ref: module 1, slides 9,10,12)
AP1: 4
AP2: 3
TOTAL: 7

b) How many BSSIDs are configured in this network?

number of BSSID = number of VAPs
number of BSSID = 8

c) How many ESS are operating in this network?
An ESS is based on unique SSID count
Unique SSID: 1: VOIP, 2:HQ-Data, 3:Employee, 4:Guest
Therefore, there are 4 ESS

4/4. A QAM modulator is encoding 8 bits per symbol. Answer the following questions.
a) What do the points represent in a QAM constellation?
They represent the amplitude modulation levels of the In-Phase and Quad-Phase carrier (ref: module 3: slide 9)

b) How many In-phase modulation levels are used?
- 4 bits are used for In-phase carrier
- bits encode 16 modulation levels.

c) How many points are there in the constellation?
Based on b) there are 16^2 points = 256 points

d) In Wi-Fi which carrier signals are QAM modulated?
OFDM subcarrier (ref: module 2: slides 6,8)

5/6. An 802.11g radio is operating at a PHY rate of 36 Mbps and a modulation of 16-QAM. How many redundancy bits are added to the bit stream for every 12 data bits?
PHY rate = NBR/Tb;
N=48, B=4 bits per symbol, Ts=4us
Therefore
R = PHY x Ts / (NB)
R = 36 x 4 / (48 x 4)
R = 3/4

Let #Redundancy Bits = Re; #Data Bits = D
R = D / (D + Re)
3/4 = 12 / (12 + Re)
36 + 3Re = 48
Re = 4
Rb = 4 Therefore, 4 bits are added for every 12 data bits.

6/6. Answer the following questions regarding DCF and basic Wi-Fi Operation.
a) Which function is used to ensure that the high priority ACK frame is transmitted before a lower priority data frame?
Interframe Spacing (ref: module 3: slide 11)
b) Which function is used to prevent a station from transmitting while RF energy is still detected?
Physical Carrier Sense or Clear Channel Assessment

c) What is used to distribute frame transmissions over an interval of time in order to prevent over the air collisions?
Contention Window
d) Why does Wi-Fi implement the “listen before talk” rule.
Due to unlicensed spectrum, adjacent Wi-Fi deployments need to cooperate
e) RTS/CTS is a solution for which problem?
Hidden Nodes
f) What is the Duration field used for?
The transmitter informs the receiver how much additional time is needed to transmit a frame. The receiver uses this to set a NAV timer for Virtual Carrier Sense.

7/7. Answer the following questions regarding Aruba Wireless Architecture.
a) Identify two methods an AP uses to discover the IP address of the Master Controller.
1. DHCP Option 43: IP Address provided with IP address
2. DNS Lookup:
3. Aruba Discovery Protocol: Discovery Broadcast

b) Explain how the AP discovers the IP address of the Local Controller.
- After discovering the Master, AP queries it to get updated image and configuration.
- The Master controller then sends the AP configuration. This configuration includes the IP address of the local controller.

c) Under what conditions are layer 2 and layer 3 roaming used?
Layer 3 roaming is used when a client roams to an AP on another controller but the destination controller does not support the user VLAN. Layer 3 roaming is used to ensure connectivity to original VLAN.

Layer 2 roaming is used when a client roams to an AP on same or another controller and the destination controller does support the user VLAN.

d) Explain the basic operation of Layer 3 roaming.
This occurs when a wireless station has roamed from an AP on one controller (home) to an AP on another controller (foreign) but the second controller does not have the User VLAN. Therefore a mobility tunnel is used to bring the 802.11 frame from the foreign controller back to the origin controller. At the origin controller the frame is placed on the User VLAN.

8/4. Briefly explain the following security terms.
a) What is 1-way encryption?
The data is encrypted to a hash. The hash cannot be unencrypted back to the original data. (ref: module 5: slides 16,19)
b) What is 2-way encryption?
The data is encrypted with an encryption key and the encrypted data can be decrypted back to the original data using a key. (ref: module 5: slides 16,17)
c) What is symmetric key encryption?
The same key is used for encryption and decryption

d) What is asymmetric key encryption?
Different keys are used for encryption and decryption.

9/6. Answer the following question regarding 802.1X with PEAP.
a) PEAP negotiation occurs between which two elements? Use the 802.1X terminology.
Supplicant and Authentication Server (module 5, slide 36)
b) How does the wireless station use the CA's public key certificate to validate the Enterprise Server's signed public key certificate?
step 1: Use CA public key to decrypt Enterprise Server's certificate signature. The leaves the HASH.
step 2: Create a new HASH of the certificate.
step 3: If the HASHes are equal, the Enterprise certificate is validated.
c) Identify three features of 802.1X/PEAP that make it more secure than PSK?
a) per user username and password
b) encrypted tunnel to pass credentials
c) dynamic encryption-key creation

10/8. Frame aggregation is a feature to improve the protocol efficiency of Wi-Fi. Answer the following questions concerning frame aggregation.
a) An 802.11ac Access Point is operating with a 20 MHz channel and a FEC coding rate of 3/4. It is transmitting at the maximum PHY rate for these parameters. What is this PHY rate?
Max PHY rate occurs at 256 QAM, 52 carriers, Coding Rate=3/4, GI=400ns and SS=8.
N=52, B=8, Rmax=3/4, GImin=400ns
PHY rate = NBRS/Ts, Ts=Tb+Tgi
PHY rate = (52x8x3/4x8)/3.6us = 693 Mbps

b) If wireless stations are transmitting 1000 Byte frames what is the effective channel throughput if 4 frames are aggregated with each transmission?
Data Frame Transmission Time = 1000B x 8 / 693 Mbps = 11.5 us
Total Frame Time
= DIFS + CW + PHY + 4xDataFrame + 3xRIFS + SIFS + ACK
= 34 + 67 + 25 + 4 x11.5 + 3 x 5 + 16+24
= 126 + 46 + 15 + 40 us
= 227 us

Effective Throughput = 4 x 1000B x 8 / 227 us = 140 Mbps

c) What effective throughput is required to achieve a protocol efficiency of 40%?
Protocol Efficiency = Effective / PHY
PHY rate = 693; Efficiency = 40%
Therefore Effective Throughput = PHY rate x Efficiency
= 693 x 0.4 = 277