INFORMATION SHEETS

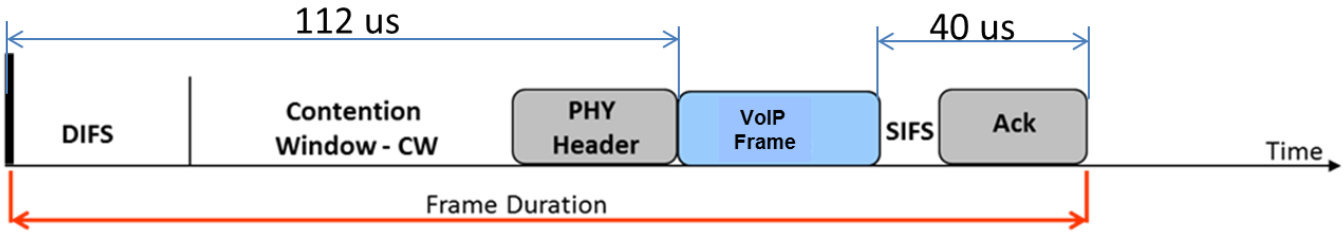


Figure1: Wi-Fi Frame for VoIP

Protocol	Channel Bandwidth (MHz)	Bonded Channels	Number of Data Subcarriers	Guard Intervals (nsec)
802.11a or g	20	1	48	800
802.11n	20	1	52	400, 800
802.11n	40	2	108	400, 800
802.11ac	80	4	234	400, 800
802.11ac	160	8	468	400, 800

Table 1: Wi-Fi Protocol Parameters

Minimum Received Signal Strength (dBm)	Modulation	Number of points in constellation	Coding Rate (R)
-82	BPSK	2	1/2
-81	BPSK	2	3/4
-79	QPSK	4	1/2
-77	QPSK	4	3/4
-75	16-QAM	16	1/2
-70	16-QAM	16	3/4
-66	64-QAM	64	1/2
-65	64-QAM	64	3/4

Table 2: Receiver Sensitivity Table

PART A: Wireless Systems

Q1/Q9/5. Briefly explain the following terms.
a) BSSID:
- The Identifier for the BSS which is the MAC address of the radio for the BSS
b) OFDM:
- modulation system of multiple orthogonal subcarriers
- each subcarrier is modulated and demodulated independently of the others using QAM
c) BSS:
- Basic Service Set
- includes AP and associated wireless stations
d) QAM:
- Quadrature Amplitude Modulation
- Amplitude modulation of two orthogonal signals (in-phase and quadrature phase) and summing the result
e) Spatial Stream:
- independent wireless data stream used in MIMO
- all data streams are transmitted simultaneously within the same channel

PART B: Modulation and Wi-Fi Protocol

Q2/Q10/6. You are setting up an 802.11n Wi-Fi system in a large conference hall as shown in the diagram. The room is 80 meters long and 60 meters wide. You need to ensure that an Access Point placed at one end of the room can send a signal to a wireless station at the other end of the room without distortion. An object, placed against one wall (see diagram), is causing reflection. Assume that there are no other reflections. An RF signal travels at 3×10^8 meters/second. Answer the following questions pertaining to the Guard Interval.

a) What is the value of Delay Spread in nanoseconds?
Direct Path Delay = distance / c (speed of light)
Direct Path Delay = $80m/3x10^8$ = 267 nanoseconds

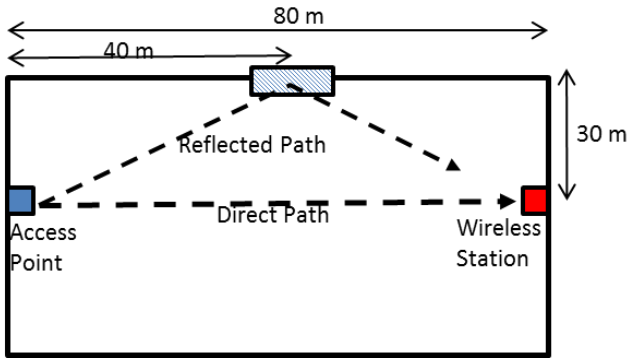
Reflected Path distance = $2 \times SQRT(40^2 + 30^2) = 100$
Reflected Path Delay = $100/3x10^8$ = 333 nanoseconds

The Delay Spread is the difference between the two delays.
Therefore Delay Spread = 333-267 = 66 nanoseconds

b) What is the minimum Guard Interval that you can use based on the options provided by 802.11n?
GI = 400 nanoseconds

c) What would be the impact of using a Guard Interval which exceeds the calculated minimum?
- reduces capacity

d) What would be the impact of using a Guard Interval which is below the calculated minimum?
- increases Inter Symbol Interference which may lead to increased errors



Q3/Q11/5. An 802.11ac radio is operating at a PHY rate of 702 Mbps. It is configured for long GI, 2 spatial streams, 80 MHz channel and 1 added redundancy bit per 3 data bits. How many amplitude modulation levels are needed for the quadrature carrier?
1. Use PHY rate formula to calculate the bits/symbol
PHY = NBRS/Ts
therefore B = PHY x Ts / NRS
Note: N=234 from Protocol Parameters in info sheet
Note: R = 3 / (1+3) = 3/4
B = 702Mbps x (3.2+.8)us / 234 x (3/4) x 2
B = 8 bits/symbol

2. Calculate the constellation size and AM levels per carrier
Number of constellation points = 2^8 = 256
Number of AM levels = SQRT (256) = 16

Q4/Q/12/5. The Distributed Coordination Function (DCF) is the algorithm used to determine when a station can transmit. A Wi-Fi wireless station has a message to transmit, but the channel is currently busy.

a) First, the wireless station waits for a clear channel. What two mechanisms does DCF use to determine that the channel is clear and explain their basic operation?
i) Physical Carrier Sense/Clear Channel Assessment: detects RF energy in the channel
ii) Virtual Carrier Sense/NAV Timer: wait for expiry of NAV timer. NAV timer is included in the frame transmitted by a station.

b) Next, the wireless station must wait until its turn to transmit its message. What two mechanisms does DCF use to determine when it's the station's turn to transmit and explain their basic operation?
i: Interframe Spacing: Used to distinguish message priority. Higher priority messages have shorter IFS.
ii) Contention Window: Random time slot selected by the station from within a time window called the contention window. The station waits for this time slot to arrive before sending its message.

c) The wireless station determines that its last transmission collided because it did not receive an ACK. What does the station do differently when retransmitting the message?
The station doubles the size of the Contention Window and selects a new time slot from within this new Contention Window at the next transmission attempt. Since the CW is wider, the stations will be distributed in a wider range of timeslots thereby reducing the probability of collision.

Q5/Q13/2. When a Wi-Fi wireless station needs to associate to an access point, it uses a scanning process to select an AP. What are the two scanning methods and briefly describe them?
i) Passive Scanning: Wireless station listens for Beacons broadcast from the AP. Beacon contains sufficient information to permit the station to decide to which AP it will connect.
ii) Active Scanning: Wireless station sends probe request frame per channel. APs reply with Probe Response. Probe response is similar to Beacon and contains sufficient information to permit the station to decide to which AP it will connect.

Q6/Q14/5.You are deploying one 802.11a Access Point in an open area for use by Polycom voice over IP (VoIP) over Wi-Fi phones. Calculate how many VoIP phones in active conversation the Access Point will support. Use the following specifications?

- 5GHz operation only
- Wi-Fi frame shown in information sheet
- Operate RF channel at 70% throughput capacity to minimize collisions
- VoIP Frame size is 240 Bytes
- Throughput per VoIP phone while in an active conversation: 192 Kbps per second for both directions of speech
- PHY rate: 48 Mpbs
- All VoIP phones are operating within close enough range of the AP to permit bi-directional speech with the above PHY rate

1. Calculate the AP channel capacity for the conditions:
- Voice Frame Duration = bits/PHY = 240 x 8 / 48 Mpbs = 40 us
- Total Frame Duration = 112 + 40 + 40 = 192 us
- Calculate the Channel Capacity = bits/Total Frame Duration = 8x240/192us = 10 Mbps

- Max channel capacity = 70% of 10 Mpbs = 7 Mbps

2. Calculate the number of phones
- Number of Phones = AP Capacity / Phone Throughput = 7 Mpbs / 0.192 Mpbs = 36 phones

PART C: Wireless Security

Q7/Q1/3. Complete the following chart with the required/default (not optional) Encryption Protocol and Encryption Algorithm. In your answer identify the contents for A to H.

Wi-Fi Alliance Security	Encryption Protocol	Encryption Algorithm
WPA-Personal	A	B
WPA-Enterprise	C	D
WPA2-Personal	E	F
WPA2-Enterprise	G	H

A/C=TKIP; B/D=RC4; E/G=CCMP; F/H=AES

Q8/Q2/2. Clearly identify the 2 cryptographic steps that are needed to create a digital signature for a certificate.
Step 1: Make a HASH of the certificate
Step 2: Encrypt the HASH using the private key of the Certificate Authority

Q9/Q3/3. Clearly identify the 3 cryptographic steps that are taken by a wireless station to validate the digital signature of a certificate.
Step 1: Decrypt the digital signature using the public key of the Certificate Authority to get the original HASH of the certificate.
Step 2: Create a local HASH of the certificate
Step 3: Compare the original HASH to the local HASH. If they are the same then the signature is verified.

Q10/Q4/3. Identify the three distinct features of 802.1X/PEAP that make it more secure than PSK.
1. Bidirectional authentication using server certificate, and user credentials
2. Encrypted TLS tunnel to securely pass user credentials
3. Dynamic Key Creation
4. Unique user credentials: username and password

Q11/Q5/5. Use the standard 802.1X device names to answer the following questions.
a) EAP negotiation normally occurs between which two devices?
supplicant and authentication server

b) When using PSK, which device sends a digital certificate as its security credential?
none. digital certs are not used.

c) Which device blocks the user port until successful authentication?
authenticator

d) Which two devices negotiate the PTK following successful authentication?
supplicant and authenticator

e) Which device stores the user database used to authenticate the user credentials?
authentication server

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