COMP4336/9336 Mobile data networking
Quiz-2: WiFi Basics + Mainstream WiFi

Q1. What would be the percentage increase in the maximum data rate of a WiFi version if it upgrades its maximum modulation from 256 QAM to 1024 QAM while keeping all other parameters unchanged?

Sol.

Data rate increases linearly with the number of bits per symbol.

256 QAM has $\log_2(256) = 8$ bits per symbol.
1024 QAM has $\log_2(1024) = 10$ bits per symbol

Therefore, increasing QAM from 256 to 1024 yields 2 extra bits per symbol.

Percentage increase in data rate due to increasing QAM from 256 to 1024 = (2/8) x100 = **25**

Q2. You are tasked with designing a new WiFi system that increases the maximum data rate by at least 25%. However, you are only permitted to adjust the QAM levels and coding rates. Given that the current WiFi system uses 1024-QAM with a 3/4 coding rate, which of the following modulation and coding combinations would achieve the required data rate increase?

(a) 2048-QAM with a 5/6 coding rate.
(b) 2048-QAM with a 7/8 coding rate.
(c) 2048-QAM with a 3/4 coding rate.
(d) 1024-QAM with a 7/8 coding rate.
(e) None of these

Sol.

(a) 11/10 x (5/6)/(3/4) = 1.22 (22% increase)
(b) 11/10 x (7/8)/(3/4) = 1.1 x 1.16 = 1.276 (**27% increase**)
(c) 11/10 = 1.1 (10% increase)
(d) (7/8)/(3/4) = 1.16 (16% increase)
(e) 11/10

Therefore, (b) is the correct answer.

Q3. A WiFi standard supports a maximum data rate of 16 Gbps using 8 MIMO streams, 1024-QAM modulation, and a 5/6 coding rate. However, you have a special Internet of Things (IoT) device, which is equipped with only 3 antennas, uses 256-QAM modulation, and operates with a 3/4 coding rate. Given these conditions, what is the maximum data rate your device can achieve, assuming the channel bandwidth remains constant and each spatial stream supports the same modulation and coding scheme?

Sol.

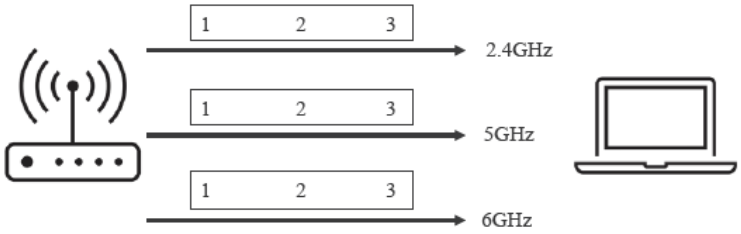
It can only use a maximum of 3 streams with 3 antennas.

256 QAM = 8 bits per symbol
1024 QAM = 10 bits per symbol

Combined reduction factor: 3/8 x 8/10 x (3/4)/(5/6) = 0.27

Data rate = 16 x 0.27 = 4.32 Gbps

Q4.



The above figure is probably referring to

a) 802.11n
b) 802.11ac
c) 802.11ax
d) **802.11be**
e) 802.11a

Sol.

Refer to Fig 10 in Chapter 5. This is the use of multiple bands simultaneously to transmit data redundantly over different bands for improved reliability, a feature that is only available in 802.11be (the upcoming WiFi 7).

Q5. Which of the following is expected to be employed to increase data rates in WiFi 7 compared to WiFi 6?

a) Use of more efficient coding rates
b) Use of more efficient modulation schemes
c) Use of GHz channels
d) Use of ultra-short guard intervals
e) None of these

Sol.

Refer to Section 11.1 and Table 10 in Chapter 5 in the text.

Data rates for 802.1be will be increased by enhancing channel bandwidth (to 320 MHz, but not GHz as suggested in one of the MCQ options), modulation (**4096 QAM, which is one of the MCQ options**), and MIMO.

Q6. What would be the maximum data rate expected from WiFi 7 (802.11be) if it's MIMO system was limited to only 8 streams?

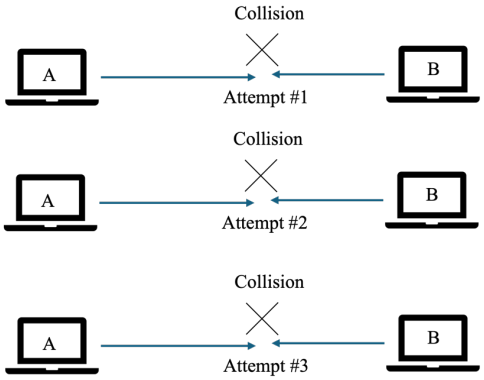
Sol.

Refer to Example 9 in Chapter 5 in the text.

Example 9 calculates the maximum data rate of 802.11be as 46.08 Gbps assuming 16 MIMO streams.

For 8 streams, we will get only half of the data rates: 46.08/2 = 23.04 Gbps.

Q7. The figure shows a WiFi network with only two active transmitting stations, A and B. What is the probability that device A will successfully transmit a frame before device B in their next transmission attempt?



a. Approx. 0.15
b. Approx. 0.73
c. Greater than 0.5
d. Smaller than 0.25
e. Approx. 0.44

Sol.

Correct answer: e. Approx. 0.44

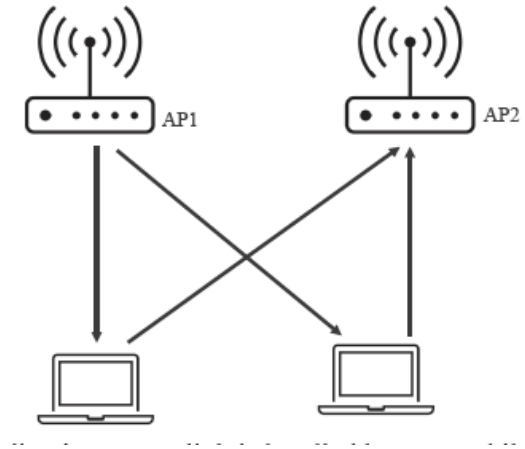
After 3 consecutive collisions, both devices will draw a random backoff from the following set {0,1,2,3,4,5,6,7}. For A to be able to transmit before B, A must draw a random back off number from this set which is smaller than the number drawn by the device B. The possibilities are as follows:

A draws 0 and B draws from 1-7: 1/8 x 7/8 = 7/64
A draws 1 and B draws from 2-7: 1/8 x 6/8 = 6/64
A draws 2 and B draws from 3-7: 1/8 x5/8 = 5/64

.
.
.
A draws 6 and B draws from 7: 1/8 x1/8 = 1/64

Therefore, the total probability = (7+6+5+4+3+2+1)/64 = 28/64 = 0.437 = approx.. 0.44

Q8.



The above figure shows that two WiFi access points (APs) are coordinating with each other to serve mobile users in the area. Which of the following statements is TRUE?

a) The mobile users need to associate with only one AP
b) Both APs can be used for downloading data from the Internet
c) Only AP1 can be used to upload data to the Internet
c) **Only AP1 can be used to download data from the Internet**
d) Only AP2 can be used to download data to the Internet

Sol.

Refer to Fig 11 Chapter 5.

AP1 handles downlink for all users in the area, while AP2 handles the uplink. This means all users in the area will have to associate with both APs (in conventional WiFi, a user associates with only one AP and there is no coordination among the APs).

Q9. A WiFi frame has the following contents in its first three address fields, ADR1 to ADR3, respectively: Mobile device MAC Address, Access Point MAC address, and Server MAC Address. Which of the following is a likely transmitter of the frame?

a) The mobile device
b) The server
c) The Access Point
d) Either the mobile device or the server
e) None of these

Sol.

Figure 12 of Chapter 4 in the text book refers to this scenario.

Q10. You have designed a new WiFi system that can dynamically adjust the guard interval to optimize performance. What is the primary benefit of this dynamic guard interval adjustment in WiFi communications?

a. It enables the WiFi system to automatically switch between different frequency bands to avoid interference from other wireless devices.

b. It reduces the frequency of collisions between WiFi packets, thereby increasing the overall network efficiency.

c. It helps balance the trade-off between data throughput and protection against multipath interference based on environmental conditions.

d. It allows the WiFi system to increase the transmission power when there are fewer users connected to the network.

Sol.

Correct answer is:

c. It helps balance the trade-off between data throughput and protection against multipath interference based on environmental conditions.

Explanation:

Guard interval (GI) protects against inter-symbol interference due to multipath delay spread.

However, GI effectively increases the symbol length and hence reduces data rate (or data throughput).

Hence, the ability to adjust the GI dynamically based on the environmental conditions (e.g., open area vs. dense obstructions/reflectors) would help use the optimal GI at all times.

End of Quiz-2 (Basic+mainstream)