

100 Wireless Midterm

1. Explain operations of FDMA, TDMA, CDMA, and OFDM. (2*4= 8%)

Ans:

FDMA: the allocated frequency band is divided into a number of subbands, called channels, and one channel is allocated by the BS to each user (2%)

TDMA: one channel is used by several users, with BS assigning time slots for different users, and each user is served in a round-robin method.

CDMA: one unique code is assigned by the BS to each user and distinct codes are used for different users.

OFDM: Orthogonal multicarrier modulation

2. List two kinds of channels between the MS and the BS (a) according to the channel type (b) according to the channel direction (要寫出方向) . (10%)

Ans: (a) Control Channel, Traffic Channel (2%)

(b) Reverse channels (Uplink) (2%): from MS to BS; (1%)

Forward channels (Downlink): from BS to MS

3. List characteristics of (a) ad hoc network (b) sensor network (3*2*2=12%)

Ans:

(a)

- A autonomous system of mobile nodes connected by wireless links.
- Network topology dynamically changes in an unpredictable manner.
- No fixed infrastructure and information is forwarded in peer-to-peer mode using multihop routing.

(b)

- A special class of wireless ad hoc network.
- A large number of tiny immobile sensors are planted on an ad hoc basis and transmit some physical characteristics of the environment.
- An associated BS collects the information gathered by the sensors on a data-centric basis.

4. Explain the following terms: (a) Cell Splitting (b) Cell Sectoring (c) Co-channel Interference (d) Doppler Effect (e) delay spread (f) Inter-Symbol Interference (ISI) (g) Multiple access (h) spread spectrum (2*8=16%)

Ans:

(a) Splitting a cell into several smaller cells can cope with increased traffic.

(b) Use multiple directional antennas to serve sectorized cells. It requires coverage of a smaller area by each antenna and hence lower power to transmit radio signals. It also helps in decreasing interference between co-channels

(c) Interference for all the cells using the same channel though they are physically located apart.

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- (d) Doppler Effect: When a wave source and a receiver are moving towards each other, the frequency of the received signal will not be the same as the source.
- (e) When a signal propagates from a transmitter to a receiver, signal suffers one or more reflections. This forces signal to follow different paths with different path length, so the time of arrival for each path is different. This effect which spreads out the signal is called "Delay Spread".
- (f) ISI is caused by time delayed multipath signals. It has impact on burst error rate of channel. Second multipath is delayed and is received during next symbol
- (g) Multiple access
If more than one MS transmit at a time on the control channel to BS, a collision occurs. It has to determine which MS can transmit to BS.
- (h) spread spectrum: Spreading of data signal $s(t)$ by the code signal $c(t)$ to result in message signal $m(t)$ as $m(t) = s(t) \otimes c(t)$

5. (a) How do CSMA (2%), CSMA/CD (2%), CSMA/CA (2%) and CSMA/CA with RTS/CTS (6%) work? Suppose the propagation delay is α , SIFS is α , DIFS is 3α , and RTS and CTS are 5α , respectively, for CSMA/CA with RTS/CTS. (b) What is the earliest time for the receiver to send the CTS message? (過程2%, 答案1%) (c) If the data packet is 100α long, what is the shortest time for the receiver to send the ACK signal? (過程2%, 答案1%)

Ans:

(a)

CSMA (Carrier Sense Multiple Access) (2%)

- Start transmission only if no transmission is ongoing

CSMA/CD (CSMA with Collision Detection) (2%)

- Stop ongoing transmission if a collision is detected

CSMA/CA (CSMA with Collision Avoidance) (2%)

- Wait a random time and try again when carrier is quiet. If still quiet, then transmit

CSMA/CA with RTS/CTS

- Transmitter sends an RTS (request to send) after medium has been idle for time interval more than DIFS (2%)
- Receiver responds with CTS (clear to send) after medium has been idle for SIFS (2%)
- Then Data is exchanged (2%)

- (b) If a terminal has a packet ready to transmit, it will sense the medium first. If the medium is idle for DIFS, it will transmit RTS, then wait for the CTS from the receiver. Therefore, the earliest time for the receiver to send CTS message is:

$$3\alpha + 5\alpha + \alpha + \alpha = 10\alpha. \text{ (過程2\%, 答案1\%)}$$

- (c) When the sender receives the CTS from the receiver, it waits for SIFS, and then sends its data

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packet. Therefore, the shortest time for the receiver to send the ACK signal is:

$$3\alpha + 5\alpha + \alpha + \alpha + 5\alpha + \alpha + \alpha + 100\alpha + \alpha + \alpha = 119\alpha. \text{ (過程2\%, 答案1\%)}$$

Note that we should include the propagation delay also.

6. Compare Nonpersistent CSMA Protocol (4%), 1-persistent CSMA Protocol (4%) and p-persistent CSMA Protocol (6%).

Ans:

Nonpersistent CSMA Protocol

Step 1: If the medium is idle, transmit immediately (same as p=1) (2%)

Step 2: If the medium is busy, wait a random amount of time and repeat Step 1 (2%)

- Random backoff reduces probability of collisions
- Waste idle time if the backoff time is too long

1-persistent CSMA Protocol:

Step 1: If the medium is idle, transmit immediately (2%)

Step 2: If the medium is busy, continue to listen until medium becomes idle, and then transmit immediately (2%)

- There will always be a collision if two nodes want to retransmit

p-persistent CSMA Protocol:

Step 1: If the medium is idle, transmit with probability p (2%), and delay for worst case propagation delay by one packet with probability (1-p) (2%)

Step 2: If the medium is busy, continue to listen until medium becomes idle, then go to Step 1 (2%)

Step 3: If transmission is delayed by one time slot, continue with Step 1

- A good tradeoff between nonpersistent and 1-persistent CSMA

7. List the throughput of ALOHA, slotted ALOHA, 0.5-persistent CSMA Protocol and 1-persistent CSMA Protocol in descending order. (8%)

Ans: 0.5-persistent CSMA Protocol > 1-persistent CSMA Protocol > slotted ALOHA > ALOHA

8. A TDMA system uses 270.833 kbps data rate to support 8 users per frame.

(a) What is the raw data rate provided for each user? (2%)

(b) What is the guard time in TDMA? (2%)

(c) If guard time and synchronization occupy 10.1 kbps, determine the traffic efficiency? (4%)

Ans:

(a) Since 8 users are supported per frame the raw data rate is $\frac{270.833}{8} = 33.85$ kbps (2%)

(b) “guard time” is used in TDMA to reduce interference between adjacent time slots in TDMA.

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(2%)

(c) If 10.1 kbps is for guard and synchronization information the traffic efficiency is given by

$$\frac{33.85 - 10.1}{33.85} \times 100 = 70.16\% \quad (4\%)$$

9. Why does the power control become one of the main issues for the efficient operation of CDMA? (6%)

Ans:

- Because the sender's transmission power level determines the signal quality at the receiver.
- Need to conserve the limited battery power of the MS for quality signal.
- Since interference is converted to noise, a strong interference implies a strong noise and degrades the channel for all other users.