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## Chapter 1

1. Wireless communication appeared in preindustrial age, when people use smoke or flags to pass information.

Communication using telecommunication began at 1930s. Faraday discovered electro magnetic, Morse invented telegraph, Maxwell gave electro magnetic field theory. After all those discoveries, telephone, radio, satellite, wireless network are invented with the development of wireless communication.

2. Cellular system, Mobile management, Mobile IP, Wi-Fi, WiMAX, Ad Hoc Network, Wireless network security, WPAN, Sensor Network, Internet of Things, SDN

## Chapter 2

1. Wired media includes twisted-pair cable, coaxial cable, optical cable, and is stable. Wireless media includes microwave, satellite, laser, etc, and is less stable. Wireless communication passes information through air.

2. Using licensed band requires permission, and the wireless operators will not interfere with each other's transmissions. And using unlicensed band doesn't need permission, and may interfere.

3. Topography, operation frequency, interference source

4. Reflection: When the obstacle size is greater than the wavelength, the wave will reflect.

Diffraction: The transmission is blocked by a sharp edge, and the diffraction occurs.

Scattering: When the obstacle size is less than wavelength and there are many obstacles, scattering occurs.

5. Indoor: Reflection and scattering are strong. Diffraction is weaker than reflection.

Outdoor: Diffraction and scattering are strong.

Reflection is weaker.

$$6. \frac{P_r}{P_t} = G_r G_t \frac{h_p^2 h_m^2}{d^4}$$

7. Free space modeling:

$$\text{path loss: } L_p[dB] = 32.44 + 20 \lg f_c [MHz] + 20 \lg d [km]$$

$$\text{receiving power: } P_r = \frac{G_r G_t P_t}{L}$$

$$\text{transmission delay: } \tau = 3d/c$$

Two-ray modeling:

$$\text{path loss: } L_p[dB] = 10 \lg (G_r G_t h_r^2 h_t^2) - 40 \lg d$$

$$\text{receiving power: } P_r = P_t d^{-\alpha}, \alpha = 4$$

transmission delay: /

8. In wireless communications, shadowing fading is deviation of the power caused by the obstacles affecting the wave propagation. Even at the same distance from the source, the received power may differ. The long-term deviation from an average value is called slow fading.

9.  $L_p = L_0 + 10\alpha \lg D + X$ ,  $X$  is a random variable.

10. Macro-cell systems:

$$L_p(d) = \begin{cases} A + B \lg d & \text{city} \\ A + B \lg d - C & \text{country side} \\ A + B \lg d - D & \text{open area} \end{cases}$$

$$A = 69.55 + 26.16 \lg f_c - 13.82 \lg h_b - a(h_m)$$

$$B = 44.9 - 6.55 \lg h_b, C = 5.4 + 2 \lg(f_c / 28)$$

$$D = 2.94 + 7.78 \lg f_c - 18.33 \lg h_b$$

Medium, small city

$$a(h_m) = (1.1 \lg f_c - 0.7) h_m - (1.6 \lg f_c - 0.8)$$

$$\text{Big city } a(h_m) = \begin{cases} 8.29 [ \lg(1.54 h_m) ]^2 - 1.1, f_c \leq 200 \text{ MHz} \\ 3.2 [ \lg(1.75 h_m) ]^2 - 4.97, f_c \geq 200 \text{ MHz} \end{cases}$$

Micro-cell systems:

The propagation attributes are complicated.

11. In wireless communication, the sent wave passes different paths, and their propagation time and phases are different, it causes the received signal changes sharply in a short time, which is multipath fading.

Doppler shift: The source or the receiver is moving, which causes the received frequency changing.

12. The distribution describes the envelop of an individual multipath component.

13. Doppler shift: The source or the receiver is moving, which causes the received frequency changing.  $f_r = f_t v(t)$ ,  $v(t) = \frac{v}{c} \cos \theta(t)$

14. /

15. /

## Chapter 3 & 4

1. Qualcomm developed a new communication tech CDMA, which is the fundamental of 3G. It can transmit voice and data over 100kb/s, much faster than 2G.

2. radius ↓, MT, capacity ↑

$$3. C = M \lg N, \frac{S}{I} = \frac{r^{-k}}{\sum_{i=1}^M P_i^{-k}}$$

4. Base station is a transceiver connecting a number of other devices to one another to a wider area. Uplink is the transmission path from the mobile station to a base station. Downlink is the transmission path from a cell site to the cell phone. Cells are area of radio coverage. Location areas are sets of base stations that are grouped together to optimize signalling. Mobile switching centers are network elements which control the network switching subsystems elements.

5. When sending out an SMS messages, the operator initially checks whether the number is sending and receiving signals from the home network. If it's not in the home network, the VLR sends a request for information about its current status and location by network via HLR. The VLR sends routing information back to the MSC which allows it to locate the network it's currently roaming to deliver the message. The main difference between HLR and VLR is the data that is stored in them. HLR has more permanent data while VLR's data changes all the time.

6. Handoff management: To switch the communication to a new channel belonging to a new cluster.

Location management: Register the location to ensure the home agent knowing its location to pass information.

7. Overcrowding is relieved; Bandwidth, security and reliability; Provide interoperability among service providers; Available of fixed and variable rates; Support to devices with backward compatibility with existing networks; Always online devices; Rich multi-media services.

8. A call admission control algorithm is designed that maximizes the throughput in multicell networks. 3G use a QoS-Aware CAC algorithm.

9. GPRS is responsible for the internetworking between the GPRS network and external packet switched networks. SGSN is the node that is serving the MS/UE. MSC is responsible for routing voice calls and SMS. HLR is a central database that contains details of each mobile phone subscriber that is authorized to use the GSM core network.

10. WCDMA/CDMA2000/TD-SCDMA

11. The speed in transferring voice and data.

12. 3G potential transmission rate: 3.6 Mb/s. Bandwidth: 5 MHz. Operation frequencies: 1710-1955 MHz (cup), 2170-2345 MHz (down)

13. 2G network uses TDMA, 3G network uses CDMA

14. In 3GPP network the GPRS network hides mobility from all IP core and Gateways. In 3GPP2 the MIP is adopted as integral part of the architecture.

## Chapter 5

1. Mobile cloud computing, Mobile webpage, Ubiquitous computing

## Chapter 6

1. First the mobile station detects the signal strength. If the signal strength is less than the threshold, the cellular network will start the switching process.
2. If during any ongoing call, mobile unit moves from one cellular system which is controlled by different MTSC — Inter



If during ongoing call mobile unit moves from one cellular system to adjacent cellular system which is controlled by same MTSO — Intra

3. MCHO: The mobile decides for itself
- NCHO: The network makes the decision
- MAHO: The mobile provides data for the network to make the decision

4. Hard handoff
  - Advantage: At any moment in time one call uses only one channel.
  - The phone's hardware does not need to be capable of receiving two or more channels in parallel.
  - Disadvantage: If a handoff fails the call may be temporarily disrupted or terminated abnormally.

Soft handoff

Advantage: The chances that the call will be terminated abnormally due to failed handovers are lower.

Disadvantage: The cost of more complex hardware in the phone.

5. Feed back-based handoff scheme makes use of information fed back from the mobile. The interval is the time from base station to mobile station and mobile station feeds back to the network.

6. Straight-line model: People's move is a straight line.

Fluid Flow model: The fluid level in a reservoir subject to randomly determined periods of filling and emptying.

7. ✓

8. Inter-switch handoff: A MTSO engages in this handoff system. When a mobile signal becomes weak in a given cell and MTSO can not find other cell within its system to which it can transfer the call then

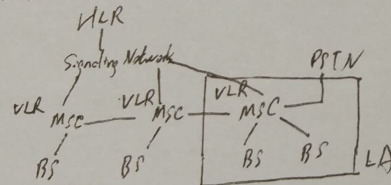
Before implementation of Inter System handoff MTSO compatibility must be checked and in Inter System handoff local call may become long distance call.

In Intra System handoff local calls always remain local call only since after handoff also the call is handled by same MTSO.

$$9. \text{Cluster} = \text{Master} \beta \alpha \alpha$$

$$\text{Cluster} = (N \cdot \text{Master} - \text{Master}) \beta \alpha \alpha$$

10. The smaller the cells are, the higher the handoff rate will be.
11. A two-tier architecture is a software architecture in which a presentation layer or interface runs on a client, and a data layer gets stored on a server.
12. When a mobile device goes across different routing areas, it should report to the cellular network. When the mobile device is working, it will detect the code of its routing area. If the code is different from the last one, it will require the cellular network to update its location, including its position and TMSI.
13. Time based: the update scheme chooses a proper time to better renew the information.
- Movement based: the update scheme is sensitive to move and can judge whether the movement is out of the cellular.
- Distance based: makes the handoff easy to conduct.



## Chapter 7

1. Because the mobile device is always moving, it cannot afford changing its IP ~~at~~ everytime connecting to a new network.

2. MN: A node ~~is~~ often changes from one link route to another.
- HA: The IP address assigned to the device within its home network.

HA: A router on a mobile node's home network which tunnels datagrams for delivery to the mobile node when it is away from home.

FA: A router that stores information about mobile nodes visiting its network.

COA: The network-native IP address of the device when operating in a foreign network.

CN: A communication object to a mobile node.

3. An intermediate router checks for a topologically correct source address when there is a reverse tunnel.

4. ✓
5. When a mobile node finds it changes from one link route to another, it ~~initiates~~ initiates the registration. Functions: Mobile node can get service from FA, Mobile node can notify its CA to HA. Mobile node can make ~~is~~ registration which is to be expired effective.

6. Because by that mobile nodes can renew their registrations which are to be expired.

7. Mobile nodes use agent advertisements to determine their current point of attachment to the Internet or to an organization's network.

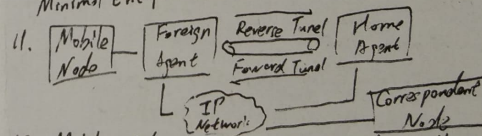
8. So that its home agent can create or modify a mobility binding for that mobile node.

9. Because the binding information may be expired. IP in IP encapsulates one IP packet in another IP packet.

Minimal Encapsulation encapsulates the new IP header ~~to the~~ between the origin IP header and data.

GRE encapsulates the packet in the data ~~with~~ using different protocols.

Minimal Encapsulation can save bits.



12. Mobile Nodes may have private address, thus cannot be globally routable.

13. ✓

## Chapter 8

1. DCF: DCF is the fundamental MAC technique of the IEEE 802.11 based WLAN standard. DCF employs a CSMA/CA with binary exponential backoff algorithm.
- PCF: PCF resides in a point coordinator to coordinate the communication within the network.

SIFS: SIFS is the amount of time in microseconds required for a wireless interface to process a received frame and to respond with a response frame.

PIFS: PIFS = SIFS + (2 \* Slot time)

2. Assume that a node has data that it needs to transmit. First it will wait a random backoff time. When the backoff

time has expired, the node will "sense" the channel to determine if there is another node transmitting. If the channel is clear, it will then wait for a short time and sense the channel again. If the channel is still free, it will transmit a request to send (RTS) to the destination. The destination will respond with a clear to send (CTS) if it is available to receive data. When the source node receives the CTS, it will transmit its data. Along with both the RTS and CTS, an NAV is transmitted. After correct reception of the data, the destination will transmit an ACK back to the sender.

7. EDCA: With EDCA, high-priority traffic has a higher chance of being sent than low-priority traffic.

UCF: UCF is a new coordinate function which enhances the DCF and the PCF.

4. Infrastructure mode requires a central access point that all devices connect to. Adhoc mode is also known as "peer to peer" mode. Ad-Hoc networks doesn't require a centralized access point. Instead, devices on the wireless network connect directly to each other.

5. Infrastructure mode: Base stations connect to mobiles.

Adhoc mode:

No base stations. Mobile can only transmit to other nodes. Nodes organize themselves into a network.

6. 802.11 is a set of data link and physical layer protocols. All Wi-Fi system use these layers to format data and control the data to conform with 802.11 standards.

7. LLC: Provides multiplexing mechanisms that make it possible for several network protocols to co-exist within a multipoint network and to be transported over the same network medium.
- MAC: Access mechanisms, fragmentation, error control, encryption.
- PLCP: Clear channel assessment signal
- PMD: Modulation, coding



8. Infrared: Use IR diodes, diffuse light, multiple reflections to synchronize in multi-hop.  
Advantages: (1) simple, cheap, available in many mobile devices  
(2) no licenses needed  
(3) simple shielding possible

Disadvantages: (1) interference by sunlight, heat sources, etc.  
(2) many things shield or absorb IR light  
(3) low bandwidth

Radio: Typically using the license free ISM band at 2.4GHz

Advantages: (1) experience from wireless WTV and mobile phones can be used.  
(2) coverage of larger areas possible

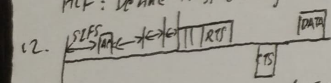
Disadvantages: (1) very limited license free frequency bands  
(2) shielding more difficult, interference with other electrical devices

9. 802.11 DSSS, FHSS 802.11a OFDM 802.11b DSSS  
802.11g DSSS, OFDM

10. BK - BE EE CL VI VO NC  
low high

11. PIFS: A station waiting to transmit to listen for the channel status for a PIFS interval.  
PCF: Resides in a point coordinator to coordinate the communication within the network.

DCF: Define Traffic Categories.



13. A unicast transmission sends IP packets to a single recipient on network. A multicast transmission sends IP packets to a group of hosts on a network.

14. Nodes should maintain the NAV to indicate the activity in its neighbourhood.

15. DoS is supported in infrastructure mode.  
But not in ad hoc mode.

16. For frequency hopping and power saving.

17. The first ad hoc station (radio NIC) active establishes an IBSS and starts sending beacons, which are needed to maintain synchronization among the stations. With infrastructure mode, only the access point sends beacons.

18. When a radio receives a beacon frame, it receives information about the capabilities and configuration of that network. This allows the device to choose to connect to the optimal network.

19. Yes. Each station competes to send the beacon

20. Because most of the WLAN clients are mobile systems. We need to save the battery.

21. There is a power management bit in the dotagram, to indicate the power management state of the sender.

22. ATIM: Transmitted in ATIM-Window by stations who want to send buffered packets.

DTIM: Transmitted less frequently, for sending buffered broadcast packets

23. The mobile device is entirely in charge of deciding when to handoff and to which access point it wishes to handoff.

24. To reduce the cost if one message is lost.

25. To provide a wealth of information about the frame transmission.

26. Four addresses are: TA, RA, SA, DA, BSSID. They are based on the type of the frame.

27. 802.11a: Operates in the 5.15GHz to 5.35GHz. Speed up to 54Mbps. Range 50 feet. Less prone to interference. More expensive.

802.11b: Operates in the 2.4GHz. Speed up to 11Mbps. Range 100 feet. Prone to interference. Less expensive.

28. Access control achieved by preventing unauthorized users from gaining access because they do not have the correct WEP key.

Privacy is obtained by using the WEP key to encrypt the WLAN data streams and only those with the correct WEP key can decrypt them.

29. WEP uses the stream cipher RC4 for confidentiality, and the CRC-32 checksum for integrity.

30. Modify the sequence number to be valid without messing with the encrypted portion on the frame.

31. In open system authentication, the WLAN client need not provide its credentials to the Access Point during authentication. Any client can authenticate with the Access Point and then attempt to associate. In effect, no authentication occurs. Subsequently, WEP keys can be used for encrypting data frames. At this point, the client must have the correct keys.

32. WEP: Ad: standard security feature  
Dis: easy to crack

MAC: Ad: No attachment cost

Dis: Easy to spoof

33. During an active scan, the client radio transmits a probe request and listens for a probe response from an AP. With a passive scan, the client radio listens on each channel for beacons sent periodically by an AP.

34. By using a Priority Code Point.

35. ✓

## Chapter 9

1. support multipath, offer high speed data rate, offer modulation and error correction, support reliability of data, support TDD and FDD, TDM scheme, MAC layer, strong encryption.

2. WiMax physical layer are of five types viz. SC, SCA, HUMAN, OFDM and OFDMA.

3. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

## Chapter 10

1. Infrastructure mode requires a central access point that all devices connect to. Ad-hoc mode is also known as "peer to peer" mode. Ad-hoc networks don't require a centralized access point. Instead, devices on the wireless network connect directly to each other.

2. Nodes in wireless networks are linked by radio signals. Two or more adjacent nodes may collaboratively transmit messages.

3. An exclusion region is a region around each receiver such that no interferers exist inside this region.

4. ✓  
5. Hidden terminal occurs when a node is visible from a wireless access point, but not from other nodes communicating with that AP.

Exposed terminal occurs when a node is prevented from sending packets to other nodes because of a neighbouring transmitter.

## Chapter 11

1. The initiating station sends an authentication request to the receiving station (AP). The AP sends back a clear text challenge message. The station uses RC4 to encrypt the message and send it back to the AP. The AP decrypts the message.

2. EAPOL communication occurs between the end-user station (supplicant) and the wireless access point (authenticator). If user is authorized, AP will open a port for user, and he can transmit the data frames through the controlled port.

3. WAPI is more secure than WEP. 802.11i is a framework for authentication.

## Chapter 12

1. Maintain the transmit rate, improve the range to 60m, reduce the energy consumption.

2. Active, Sniff, Hold, Park

3. Reader: be responsible for two-way connection between the electronic tag, receive the command from host system.

Electronic tag: communicate with reader.

4. Chip tech. Antenna design tech, Packing tech, Tag application. Standard analyzing tech

5. Logistics, Retail, Manufacturing

## Chapter 13

Base station collects information from sensors, and transmit to monitoring station.

2. Controller: performs tasks, processes data and controls the functionality of other components in the sensor node.

Transceiver: transmit and receive.

External memory: save data

Power source: gives power

Sensors: capture data from the environment

3. Smart dust, Remote health detect, Auto watering

4. A Line in the Sand uses sensors to detect moving metal objects



5. Data rate: 40 kbps Range: 1000 feet

6. Data rate, Distance, Bandwidth

Higher data rate may cost bandwidth and decrease the distance.

7. Solar energy, nuclear energy

## Chapter 14

1. RFID, BLE, SDR, Ultra Wideband

2. High transfer rates, Low power consumption.  
Immunity to external interference

3. BLE is used for applications that do not need to exchange large amounts of data, and can therefore run on battery power for year at a cheaper cost.

4. Cognitive radio is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, and instantly move into vacant channels while avoiding occupied ones.

5. A body area network is a system of devices in close proximity to person's body that cooperate for the benefit of the user.

Application: Health care, GPS, Personal entertainment  
Military or space use

## Chapter 15

1. SDN is an architecture purporting to be dynamic, manageable, cost-effective, and adaptable, seeking to be suitable for the high-bandwidth, dynamic nature of today's applications.

2. Directly programmable, Agile, Centrally managed, Programmatically configured, Open standards-based and vendor-neutral

3. SDMN, SD-WAN, SD-LAN,  
Security using the SDN paradigm

4. SDN can address the fact that the static architecture of traditional networks doesn't support the dynamic, scalable computing and storage needs of more modern computing environments such as data centers.

## Chapter 16, 17, 18

1. Control system, motors, sensors, mechanical parts

2. Indoor localization. Driveway car, Indoor exploration  
Driverless car: Using sensors to drive the car automatically.

## Chapter 19

1. In SISO system only one antenna is used at transmitter and one antenna is used at receiver ~~with~~ while MIMO uses multiple antennas.

2. In MIMO systems, a transmitter sends multiple streams by multiple antennas.

The transmit streams go through a matrix channel which consists of all  $N_t N_r$  paths between the  $N_t$  transmit antennas at the transmitter and  $N_r$  receive ~~at~~ antennas at the receiver. Then, the receiver gets the received signal vectors by the multiple

receive antennas and decodes the received signal vectors into the original information.

3. Space diversity uses two or more antennas to improve the quality and reliability of a wireless link.

Space ~~muti~~ multiplexing uses separate point-to-point electrical conductors for each transmitted channel.

4. Distributed MIMO, Multi-user MIMO, Networking MIMO

In distributed MIMO, antennas' location is not specified, ~~is~~ and can improve the communication.

## Chapter 21, 22

1. The bitcoin protocol includes several features that protect it against some of those attacks, such as unauthorized spending, double spending, forging bitcoins, and tampering with the blockchain. Other attacks, such as theft of private keys, require due care by users.

2. Storage, Error correction, Encoding