

April 29th, 2017

Chapter 1. Overview of Wireless Networks

1. The earliest wireless communication in human history started in Pre-Industrialized Period. Communication came into existence as a telecommunication in 1930s, Marconi invented radio in 1895, a new era of modern wireless communications began since then. A communication satellite named SCORE was launched, which opened a new era of wireless communication prelude in 1958. The first digital cellular system was established in Europe in 1988, The first WLAN was released in 1997.

2. Cellular System, Mobility Management, Mobile IP, Wi-Fi, WiMAX, Ad-Hoc Networks, Security, Internet of Things, SDN, etc.

Chapter 2. Radio Propagation.

1. wired: directed, limited transmission rate, interference. wireless: atmosphere, unstable; broadcast, indirected.
 2. Licensed bands are used in cellular system, PCS, WLAN, LANS and optical communication, unlicensed bands are used in ISM
 3. terrain, operation frequency, speed, interference.
 4. Reflection: the size of barrier is larger than the wavelength. Diffraction: transmission routing is obstructed by sharp edges. Scattering: the size of the object is far smaller than wavelength.
 5. Reflection happens on the surface of objects, it's not the main mechanism in outdoor environment. Diffraction appears in the shadowy region, it's weaker than reflection in indoor environment. Scattering appears in rough surfaces.

6. Path loss is the ratio of transmitting power and receiving power. In free space, $\frac{P_r}{P_t} = (\frac{\lambda}{4\pi r})^2$, in two-ray model, $\frac{P_r}{P_t} = (\frac{h_t h_r}{d^2})^2$

7. free space: $L_p[dB] = 32.44 + 20\lg f_c [MHz] + 20\lg d [km]$, $10\lg P_r = 10\lg P_t - 20\lg d$
 two-ray: $L_p[dB] = L_0 + 20\lg f_c + 40\lg d$, $10\lg P_r = 10\lg P_t - 40\lg d$; $T = \frac{P}{c} = 3\mu s$

8. Slow fading is the change of signal strength due to the change of location. Considering slow fading, a random variable is added into the Path loss formula.

9. Fade margin is a design allowance that provides for sufficient system gain to accommodate expected fading.

10. macro-cell: urban area: $A+B\lg d$, suburb: $A+B\lg d-C$, open area: $A+B\lg d-D$; micro-cell: $\overline{L_p} + X_{\sigma}$

11. fast fluctuation of wireless signal in short time or distance

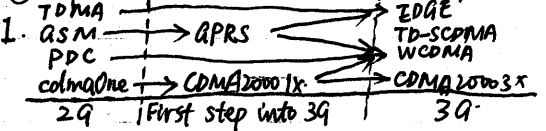
12. Rayleigh: superposition of several i.i.d Gaussian Distributions.

Ricean: a predominant signal component over others.
 13. Doppler shift exists due to the relative movement between the sender and the observer. $v(t) = \frac{V}{c} \cos(\theta(t))$

14. $f_{ray}(r) = \frac{r}{\sigma^2} \exp(-\frac{r^2}{2\sigma^2})$, $f_{ric}(r) = \frac{r}{\sigma^2} \exp(-\frac{r^2}{2\sigma^2}) I_0(\frac{r}{\sigma})$; $P = \int f(r) dr$

15. LCR: $N_R = \sqrt{2\pi} f_m(\frac{R}{\sigma}) \exp(-\frac{R^2}{2\sigma^2})$
 AFD: $X_R = [1 - \exp(-\frac{R^2}{2\sigma^2})] / [\sqrt{2\pi} f_m(\frac{R}{\sigma}) \exp(-\frac{R^2}{2\sigma^2})]$ (I)

Chapter 3&4 Cellular System



2. As the cell radius becomes larger, the transmitting power becomes stronger and the system capacity becomes smaller.

3. $N = \frac{1}{3} (6 \frac{r}{\lambda})^2 k$

4. Base station: a land station in land mobile service. uplink: link from mobile station to base station downlink: link from base station to mobile station. cells: functional units in the cellular system. Location area is a public land mobile network. Mobile switching centre is a control centre for switching management and location management.

5. VLR is a database maintained by a cellular service provider used to track users who are roaming in that mobile service area. HLR is a central database containing details of each mobile phone subscriber.

6. Handoff: base-station recognition, channel allocation. location: identification, registration.

7. higher QoS, higher speed

8. Call admission control prevents over-subscription of VoIP networks. CDMA has better security and higher transmission quality because of the spread spectrum technology it uses.

9. SGSN/GGSN: transmit protocol packets, mobile management, billing. MSC/ANMSC/HLR: channel management, call processing, handoff and roaming control, authentication.

10. WCDMA, CDMA 2000, TD-SCDMA.

11. spread spectrum, global roaming, high speed, broadband. 12. 17.12 Kbit/s; 1.25MHz; 1920-1935MHz (up), 2110-2125MHz (down). 13. broadband internet access/mobile business/video call/mobile TV/wireless search.

14. IP/MPLS runs in the transmission mode on the core network interface. Iu and Gi, protocol frame is assembled into IP packets, RNC determines the destination address of the IP packets in the uplink, while the address of downlink is determined by the Ap serving the host.

Chapter 5 Future Technologies

1. mobile cloud computing/mobile webpage/mobile access

Chapter 6 Mobility Management

1. ① detect the signal strength from different BS. ② determine whether to change the connection with BS. ③ switch to a different BS if the condition is met.

2. Inter: ongoing call mobile unit moves from one cellular system to a different system which is controlled by a different MTSO.

Intra: during ongoing call, mobile unit moves from

one cellular system to adjacent cellular system which is controlled by the same MTSO, handoff happens in order to avoid dropping of call.

3. Under NCHO or MAHO, the network generates a new connection, finds new resources for the handoff and performs any additional routing operations. For MCHO, the MN finds the new resources and the networks approves. NCHO: network-controlled handoff, MAHO: mobile-assisted handoff. MCHO: mobile-controlled.

4. hard handoffs: severe interference degrades capacity. soft handoffs: reduce interference, improve performance, by using macro diversity, extend coverage area.

5. The decision as to which access network to handoff is formulated from the movement tracking mechanism based on a synchronized feedback, which is capable of providing zero-packet loss handoff.

6. Straight-line model describes an object moving in a straight line between two places; fluid flow model describes an object moving under resistance by the surface.

7. It is determined by the processing time of MS, BTS, BSC and MSC.

8. When mobile signal becomes weak and MTSO can find other cells in the system, it uses intra system handoff. When other cells are not available in the system, then it uses inter system handoff.

9. Inter-cluster: determined by the connection between clusters

10. Intra-cluster: determined by the connection within the cluster.

10. BS with larger coverage can provide service to users whose speeds are faster, which helps to reduce the use of resources when handoff happens. So handoff rate can be improved.

11. In two-tier network, there are two tiers of network infrastructure.

12. Location update: Authentication, Database update. service delivery: First the calling user looks for an access interface to the user it is calling through the network, if it was found, the calling user will send a signal to end this call.

13. In the movement-based scheme, each mobile terminal only keeps a counter of the number of cells visited. In the distance-based scheme, no movement counter is required but the mobile terminal keeps in its local memory the identification of all cells with a specific distance.

14. In FPBR, six types of route management messages are used: RANN, PREB, PREP, PCA, ACK & NACK. PCA messages are used for canceling the old route to an external STA. ACK and NACK messages are used to send acknowledgment from a mesh STA to its sibling mesh STA.

Chapter 7 Mobile IP

1. In order to enjoy stable network service when my computer has to move frequently.

2. MN: a node which often switches from one link to another link HA: A router in the MN's home link

FA: A router in the MN's foreign link.

COA: An IP address related to a MN when it switches to a foreign link. CN: MN's communication object.

3. MN packs the message sent from CN to MN, at the terminal of tunnel, the package is unpacked and sent to MN.

4. Message → [HA] pack → [FA] unpack → MN

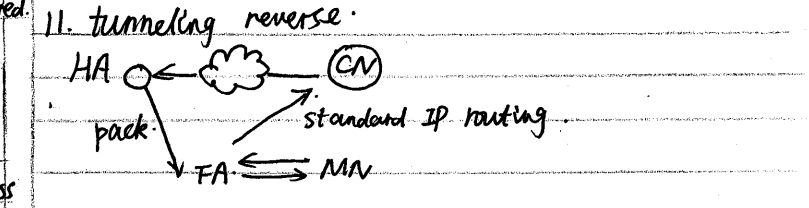
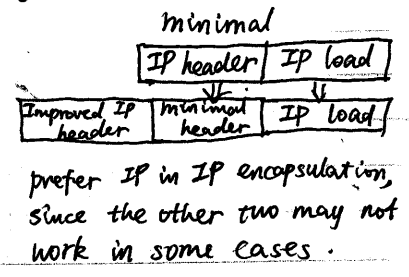
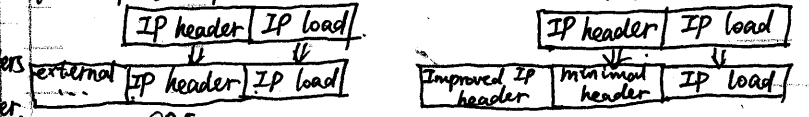
5. MN register in its home network through registration request and registration response, FA generates transfer address for MN and inform its HA, when the MN returns home network, it sends registration request to its HA and HA update MN's binding records.

6. To update registration information regularly.

7. HA and FA broadcast AD to announce their existence.

8. MN register new forward address to its home network.

9. MN didn't renew its binding information before expiration.



Chapter 8 IEEE 802.11 WLAN

1. DCF: distributed coordination function PCF: point coordination function DIFS: distributed inter-frame spacing. SIFS: Short inter-frame spacing. PIFS: Poll inter-frame spacing.

2. RTS/CTS is the optional mechanism used by the 802.11 wireless networking protocol to reduce frame collisions introduced by the hidden node problem.

3. With EDCA, high-priority traffic has a higher chance of being sent than low-priority traffic. 802.11e enhances the DCF and the PCF through HCF.

4. In infrastructure mode network, the WNIC needs

- a wireless access point: all data is transferred using the AP as the central hub. In ad hoc mode network the WNIC does not require an access point, but rather can interface with other nodes directly.
- 5. Infrastructure network: STA & AP. Ad hoc network only has STA. In infrastructure network, STA communicates with AP, AP forwards data to the corresponding network. In ad hoc network, nodes communicate with each other directly.
- 6. Network protocols running on IEEE 802.11 standard.
- 7. LLC: logic link control. MAC: medium access control. PLCP: physical layer convergence protocol. PMD: Physical medium dependent sublayer.
- 8. Infrared radio can't pass through walls, but it is more private.
- 9. 802.11: frequency hopping, direct sequence. 802.11a: OFDM 802.11b: data rate extension of the initial 802.11 DSSS.
- 10. polling coordination function is used
- 11. CSMA/CA: network multiple access method where carrier sensing is used. Nodes transmit only when the channel is sensed to be idle. IEEE 802.11b is based on FDMA and DS-SS to avoid interference.
- 12. 802.11 or 802.11e access, one or some of the MAC methods.
- 13. Unicast: sent from only one sender to only one receiver. multicast: more than one senders, a set of receivers.
- 14. NAV limits the need for physical carrier-sensing at the air interface in order to save power.
- 15. QoS is supported in 802.11, it ensures the delivery of key features and interoperation through their certification programs.
- 16. It is required for Frequency Hopping Spread Spectrum, QoS, Multi-Channel MAC protocols, etc.
- 17. Synchronization is achieved by stations periodically exchanging timing information through beacon frames. In BSS, AP sends the TSF information in the beacons. In IBSS, each station competes to send the beacon.
- 18. Because beaconing allows a network to self-repair network problems. The stations on the network notify the other stations on the ring when they are not receiving them.
- 19. No. The problem is addressed by using local averaging at overlapping subsets of the nodes to achieve synchronization.

- 20. Without it, energy required to keep devices connected to the network quickly dissipates.
- 21. PSM is built into 802.11 standard. PSM is based on a synchronized sleep scheduling policy, in which wireless nodes are able to alternate between two modes.
- 22. A client device chooses to sleep for one or more beacon intervals waking for beacon frames that include ATIM/DTIMS.
- 23. handover within the same network type / handover across subnets of different types of networks.
- 24. packets can pass through a link with a smaller maximum transmission unit.
- 25. define the type of 802.11 MAC frame / provide information necessary for the following fields.
- 26. Because a network node may have multiple NICs and each NIC must have a unique MAC address.
- 27. 802.11a is an amendment to 802.11 that defined requirements for an OFDM communication system.
- 28. protect Wi-Fi network just like Ethernet.
- 29. seed \rightarrow RC4 \rightarrow keystream \oplus Plain Text Cipher text.
- 30. the WEP code will be changed.
- 31. ① The client sends an authentication request to AP. ② AP replies with a clear-text challenge ③ client encrypts the challenge-text using WEP key and sends it back. ④ AP decrypts the response.
- 32. Captive portal: have Wi-Fi and TCP/IP stack but don't have a web browser. MAC filtering: may lead to a false sense of security, attackers can eavesdrop transmission.
- 33. Passive: less sensitive; lighter touch. Active: powerful, high cost.
- 34. Add priority information on the frame.
- 35. throughput \leq $RWLN/RTT$.

Chapter 9 WiMAX

- 1. high-speed, mobile broadband, IP.
- 2. TCL: transport convergence sublayer. PMD: physical media dependent sublayer.
- 3. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams. Each is modulated at a low symbol rate, which achieves a total data rate similar to the conventional scheme.

Chapter 10 Ad Hoc Networks

- 1. Infrastructure: has pre-deploy infrastructure for mobile networks. Ad Hoc Network: consists of a group of mobile nodes with wireless transceivers.
- 2. Under the protocol interference model, a successful transmission occurs when a node falls inside the transmission range of its intended transmitter and falls outside the interference of non-intended transmitters.

- Nodes inside the exclusion region are not allowed to transmit, which can limit the interference.
- Through calculation and deduction under protocol model.
- Hidden terminals are nodes within the coverage of receiver and beyond the coverage of transmitter. Exposed terminals are nodes within the coverage of transmitter and beyond the coverage of receiver.

Chapter 11. Security

- encryption: data confidentiality, access control, data integrity. authentication: open system authentication and shared key authentication.
- ① SS sends start frame to AS ② AS request identity information ③ SS sends its information to AS ④ AS packs the information into RADIUS Access Request frame and sends it to ASS ⑤ ASS verify ⑥ inform AS the result ⑦ AS gets the results and finishes authentication.
- WAPI uses WAI to implement authentication. IEEE 802.11i introduces IEEE 802.1X protocol to WLAN security, enhancing the security of the network.

Chapter 12 Bluetooth and RFID

- improved transmission distance, lower energy-consumption.
- active state, sniff state, hold state, park state.
- Reader: bidirectional communication with electronic tags. Electronic tag: communication with reader, modulate and demodulate.
- chip techniques, antenna design, packaging, anti-collision, security, etc.
- logistics, manufacturing, identification.

Chapter 13. Wireless Sensor Networks.

- sensor acts like the end device; base station acts like the router; monitoring station acts like the coordinator.
- processing unit, sensor, communication.
- smart dust, a line in the sand. remote health monitoring
- dynamic topology, multihop routing, ad-hoc network.
- The coverage area of sensing is increased because of a large amount of nodes.
- increase its reliability will affect its performance.
- wind energy, solar energy, heat.

Chapter 14 Internet of Things.

- SPR, RFID, BLE.
- low cost, secure, high transmission rate. high capacity, anti-interference.
- BLE has lower energy-consumption, higher reliability, higher transmission rate.
- power control, spectrum sensing and management.
- BAN is a wireless network of wearable computing devices, it is centered on human body. It can be used in medical insurance, wireless access system, navigation, multimedia, etc.


Chapter 15 Software-Defined Networking.

- An architecture purporting to be dynamic, manageable, cost-effective, adaptable, seeking to be suitable for high-bandwidth, dynamic nature of applications.
- directly programmable, agile, centrally managed, programmatically configured, and vendor-neutral.
- SDMN, SD-WAN, SD-LAN, Security.
- make the network more flexible, reduce resource consumption, improve link utilization.

Chapter 16 & 17 & 18 Intelligent Robots, ~

- motor, sensor, communication module.
 - Leap-frog path design: three cars travel in a particular pace, and requires some algorithms to minimize the deviation error.
- Other applications include: real-time indoor mapping, fully distributed scalable smoothing and mapping.

Chapter 19 MIMO

- In SISO system, there's only one transmission path between transmitter and receiver, while in MIMO system, there are multiple paths.
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- space-diversity: transmitter encodes data stream and transmit it to the receiver, the receiver decodes it and it helps to reduce BER.
 - space-multiplexing: transmitter divides data stream into multiple sub data streams and transmit them using different antennas, it improves transmission rate.
 - Distributed MIMO system: the location of antennas are arbitrarily distributed in a given space, which guarantees perfect communication quality.
- ### Chapter 21 & 22. Bitcoin and Graphic Code.
- monetary value security / account security / transaction security / privacy security.
 - version information / format information / parity bit / identifier / silent area.