Wireless Communication and Mobile Internet Midterm Exam

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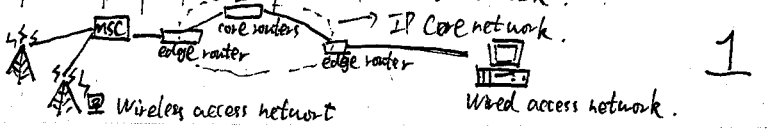
Over view of wireless networks (Chapter 1)

- Dicribe the history and development of wireless communication networks.
pre-industrial epoch - fire in Beacon tower and floags. 1876 - telephone (Bell) 1894 - Shortwave wireless communication (Maxwell). 1895 - radio (Marconi). 1906 - AM radio. 1927 - TV broadcast. 1946 - mobile phone system. 1958 - Communication satellite. 1981 - NMT. 1988 - GSM. 1997 - wireless LAN.
- List the foundational techniques used in wireless communication networks.
1. Cellular system. 2. Mobile management. 3. Mobile IP. 4. Wi-Fi: 802.11 5. WiMax 6. Self-organizing network. 7. Wireless Network security. 8. Wireless Personal Areanetwork 9. Sensor network. 10. Internet of Things. 11. Software defined network.
- List the difference between the wired and wireless media.
Wired media: more reliable, signal is transfered from a terminal to another terminal. Wireless media: relatively unstable, low bandwidth and Broadcast characteristics, no Guidence
- List at least three factors that affect radio propagation.
1. terrain 2. Operating frequency 3. speed of mobile terminal.
- Explain three radio propagation mechanisms.
Reflection: appears when the size of obstacle is larger than to wave length.
Diffraction: appears when the size of object is blocked by sharp edge.
Scattering: appears when the size of object is smaller or equal to wave length and the number of these obstacles is very large in unit volume.
- Explain the difference between licensed band and unlicensed band.
Licensed band means that individual company pays a licensing fee for channels, and unlicensed techniques don't require any permission.
- Explain the effect of each propagation mechanisms in indoor and outdoor environment.
On indoor environment, through scattering, reflection and diffraction, radio can be transfereed in certain range. On outdoor environment, through reflection, diffraction and LOS path, radio can arrive at certain terminal.
- Explain the relationship between path loss and other factors.
$L_p \propto \frac{1}{d^a}$, $L_p = \frac{P_r}{P_t}$, $L_p \propto G_t G_r$, $L_p \propto h_b^2 h_m^2$
- Calculate L_p, P_r and τ using different models.
1. free space: $10\lg P_r = 10\lg P_0 - 20\lg d$. $P_0 = P_t G_t G_r (\frac{\lambda}{4\pi})^2$. $L_p = 32.45 + 20\lg f_c + 20\lg d$. 2. two-ray: $10\lg P_r = 10\lg P_0 - 10\lg d$. $P_0 = P_t G_t G_r h_b^2 h_m^2$
$L_p = 40\lg d - 10\lg(G_t G_r h_b^2 h_m^2)$. $\tau = \frac{D}{C} = 30ns$.
- Explain the concept and effect of shadowing/slow fading on path loss.
Concept: Change of signal strength due to change of position.
Effect: not all positions in a given distance are able to receive enough signal strength to detect correct information.
- Compute fade margin to overcome shadowing effect.
fade margin $P(dB) = NORMSINV \times \sigma$. for $\sigma = 8dB$, $NORMSINV(90\%)$: $P = 10.3dB$.
- Compute path loss based on different models.
marco-cell system:
$L_p(d) = \begin{cases} A + B\lg d, & \text{Urban area} \\ A + B\lg d + C, & \text{suburbs} \\ A + B\lg d - D, & \text{open environment} \end{cases}$
$A = 69.55 + 26.16\lg f_c - 13.82\lg h_b - a(h_m)$
$B = 44.9 - 6.55\lg h_b$
$C = 5.4 + 2\lg^2(f_c/28)$
$D = 40.94 + 4.78\lg^2 f_c - 18.33\lg f_c$.
micro cell system: n_i
$L_p(d) = \begin{cases} L_0(d_0 = 1m) + 10\log(\frac{d}{d_0}), & 1 < d < d_f \\ L_0(d_0 = 1m) + 10n_1\log(\frac{d_f}{d_0}) + 10n_2\log(\frac{d}{d_f}), & d_f < d \end{cases}$ (Visual)
$\bar{L}_p = L_0(d_0 = 1m) + 10n\log(\frac{d}{d_0})$ (Non-visual)
- Explain the effect of multi path fading and Doplar shift and spectrum.
Multi-path fading: constructive and destructive interference, phase shifting of signal.
Doplar shift: The wavelength becomes shorter and frequency becomes higher.
- Understand Rayleigh and Ricean distribution.
$f_{Ray}(r) = \frac{r}{\sigma^2}\exp(-\frac{(r^2+A^2)}{2\sigma^2})$, $r \geq 0$ no direct wave path, the angle of reflected wave is random.
$f_{Ric}(r) = \frac{r}{\sigma^2}\exp(-\frac{(r^2+A^2)}{2\sigma^2}) I_0(\frac{Ar}{\sigma^2})$, $r \geq 0$, $A \geq 0$ a strong dominant incident wave signal amplitude is Gaussian
- Explain and compute Doplar shift and spectrum.
$v(t) = \frac{df}{c}\cos\theta(t)$. Doplar effect is the change of frequency or wavelength for an observer moving relative to its source.
- Calculate signaling strength, desired cell radius for Rayleigh and Ricean distribution.
$P_R = (a^2/\sigma^2)S(d) P_t G_t G_r$, Ricean: $P_R(x) = \frac{x}{\sigma^2}\exp(-\frac{(x^2+s^2)^2}{2\sigma^2}) I_0(\frac{xs}{\sigma^2})$
$R_R = \frac{a}{c_2} e^{-a^2/2\sigma^2}$, Rayleigh. $x \geq 0$, $s^2 = m_I^2(t) + m_R^2(t)$
- Compute the level of crossing rate and average fade duration.
$LCR = f_{rms} \rho e^{-\rho^2}$; $\rho = \frac{Rthresh}{R_{rms}}$; $AFD = \frac{e^{\rho^2}-1}{\rho f_d f_{rms}}$

Cellular System (Chapter 3 and 4)

- Explain the evolution from 2G to 3G systems.
1996-1997: GSM and CDMA(2G) added receiving data function. 2008, ITU announced 3G standards: TD-SCDMA. WCDMA and CDMA2000.
- Explain the relationship between the transmitting power, cell radius and capacity.
$P_{t1} R^{-k} = P_{t2}(\frac{R}{2})^{-k}$; $C = MJN$
- Explain the cluster size based on co-channel interference and system capacity.
$\frac{S}{I} = \frac{r^{-k}}{\sum_{i=1}^{N_i} D_i^{-k}} \xrightarrow{N_i = 6,\ r = R} \frac{S}{I} = \frac{(\sqrt{3}N)^k}{N_I}$
- Explain the concept of base station, up/downlinks, cells, locations and MSC.
base station: a relay located in the center of any of the cells of cellular system.
uplink: the transmission path from the mobile station to a base station.
downlink: the transmission path from a cell site to the cell phone.
cells: cellular telephone site where antennae and electronic equipment are placed.
location areas: service area of a mobile services switching center.
Mobile switching center: the centerpiece of a network switching system associated with communications switching functions.
- Explain the current wireless network architecture, with VLR and HLR.

HLR is the reference data base for subscriber parameters.
VLR contains a copy of most of the data stored in HLR.
- List the objective of handoff management and location management.
handoff management: When mobile station enter different distinct, the call have to be transfered to a new channel of the new distinct. location management: when MH leaves home network, it enters a field network. MH have to register to home home agent through field agent to announce current position.
- List the advantages of 3G over 2G systems.
Improment of the speed of transferring data. better in wireless roaming, processing multi-media, provide more services, support different transfer speed.
- Explain the purpose and difference of call admission control in 2G and 3G.
purpose: preventing over subscription of VOIP networks.
difference: TDMA, the number of traffic channels are fixed and determined by the number of time slots. CDMA, not fixed channels and limited by the inference it tolerate.
- List the function of SGSN/GGSN for packet switching domain and MSC/GMSC/HLR for circuit-switching domain in 3G wireless system.
SGSN relays the data between SGSN and relevant GGSN. GGSN forwards the data to SGSN serving the mobile user with verification. MSC: call setup, release and routing. GMSC is used to route calls outside the mobile network. HLR is the reference data base for subscriber parameters.
- List at least 3 standards of 3G wireless systems.
1. WCDMA 2. CDMA2000 3. TD-SCDMA.
- List key features of 3G wireless systems.
1. Global roaming 2. High speed data transmission. 3. Broadbend multi-media services.
- List the potential transmission rate, bandwidth, operating frequency of 2.5G.
transmission rate: 56~115 kbps. bandwidth: 25MHz operating frequency: 200kHz.
- Explain application services of different access techniques.
1. Broadband Internet access 2. Mobile bussiness 3. video call 4. Mobile TV 5. Wireless search 6. Mobilephone music 7. Mobilephone office 8. Mobile terminal.
- Explain a posiple features of all-IP wireless network.


Future Technologies (Chapter 5)

- List at least 3 techniques that will be used in future mobile communications.

1. Mobile cloud computing. 2. Mobile web pages. 3. Pervasive computing.

Mobility Management (Chapter 6)

- Explain the difference phases of handoff operation.

First generation: the test of the energy of signal is accomplished by base station, no participation of mobile station. Second generation: the occasion of handoff is determined by mobile station (MAHO). third/forth generation: handoff management varies due to different system model.

- Explain intra- and inter-switch handoff for avoide dropping of calls

intra-switch handoff: occurs when the mobile terminal moves from one terminal to another, and both stations are connected to the same switch. inter-switch handoff: the new station is connected to another switch. → same MTSO (different MTSO)

- Explain three handoff strategies: MCHO, NCHO and MAHO.

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

- Describe the advantages and disadvantages of hard and soft handoffs.

Hard handoff: mobile station have to change the communication frequency to use new resouse of new channel. Soft hand off can better utilize the information provided by different base station and allow MSC to decide new BS.

- Explain feedback-based handoff scheme, compute feedback interval.

Feedback based scheme makes use of information feedback from the mobile.

$\log\frac{R_{2i}}{R_{2i-1}} = g\log\frac{R_{2i-1}}{R_{2i-2}} + \log k$.

- Explain straight-line and fluid flow model.

Straight-line model can capture trajectories where mobiles typically tend to move in roughly a straight line. Fluid flow model used to describe the fluid level in a reservoir subject to randomly determined periods of filling and emptying.

- Compute handoff rate based on different mobility models.

$E[H] = \frac{1-P_0}{2\pi j}\int_{\sigma-j\infty}^{\sigma+j\infty}\frac{\gamma[1-f^*(s)]}{s^2[1-\frac{1}{\rho}f^*(s)]}\frac{f^*(s)}{c}(\frac{1}{s}-\frac{1}{s+c})ds$. $\lambda_H = (N_1\cos\theta+N_2\sin\theta)R_1 + (N_1\sin\theta-N_2\cos\theta)R_2$

- Explain the signaling and procedure of intra- and inter-handoff.

intra-switch handoff: during ongoing call mobile unit moves from one cellular system to a different system which is controled by different MTSO

inter-switch handoff: during ongoing call mobile unit moves from one cellular system to adjacent system which is controled by same MTSO.

- Compute intra-cluster and inter-cluster handoff rate.

inter-cluster: $P_{E,1}(N) = \frac{2N-1}{3N^2-N+1}$ $H_{intra\text{-}cluster} = (N\times M_{cell} - M_{cluster})\times\beta\times 2\times\lambda$

$H = M_{cluster}\times\beta\times 2\times\lambda$

- Evaluate the effect of cell splitting on handoff rate.

Since sectoring reduces the coverage area of a particular group of channels, handoff rate will increase.

- Describe the two-tier network architetcure.

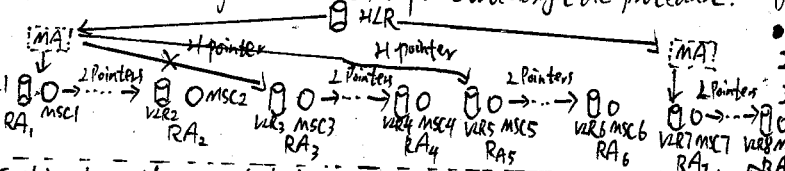
A presentation layer or interface runs on a client, and a data layer or structure gets stored on a server.

- Explain the implementation procedure for location update and service delivery. location update: allows a mobile device to inform the cellular network, whenever it moves from one location area to the next. service delivery: (it concentrates on the proactive services the ICT must deliver to provide adequate support to business users) cellular system search the position of user and using network search to get the position information

- Compare and evaluate the pros and cons of three location update schemes.

Distance based: better for the users moveless and within specific distance. and low paging cost. Time based: easy to manage, benifit to periodic signaling drawback: increase location update cost. Movement based: drawback: when user travels around the boundry, unnecessary updates may happen.

- Given a location management scheme, explain and design the procedure.



- Explain why would you want to have a permanent IP address.

1. good for creating or hosting computer services. 2. better for dedicated services (mail).

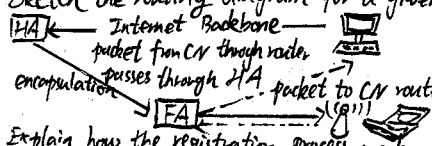
- Explain each term (MN, HA, FA, CoA, CN) used in Mobile IP lingo.

MN: Nodes whose location changes frequently. HA: ~~Permanent address of MN~~. the router in home circuit, which preserve position info of MN. FA: routers in field circuit, which informs the HA of MN the change of address. COA: a related IP address, when MN switches to field circuit. CN: Communication object of MN.

- Explain how routing takes place in Mobile IP with and w/o reserve tunneling.

with: ensure a topologically correct source address for the IP data packet. A mobile node can request a reverse tunnel between its foreign and home agent when the MN registers. Without: 1). data was sent by IP. 2) HA get packet, send it to transfer address 3) In FA, packet was depackaged and sent to MN, 4) Package from MN was sent to destination over standard IP router.

- Sketch the routing diagram for a given example.



- Explain how the registration process works.

1. MN sends a registration request to FA to begin registration. 2. FA processes it and relay it to HA. 3. HA sends a reply to FA to grant or deny the request. 4. FA reply it to MN to inform it of the disposition of its request.

- Explain why the registration has limited life time.

Since the MN occasionaly switch to other circuit, if there is no limited life time of registration, there will be several registration info on different agent.

- Explain the functions of the fields in the agent advertisement.

On the connected network, HA and FA frequently broadcast agent advertisement. From agent advertisement, MN knowns whether it is out of home network or not.

- Explain the functions of the fields in the registration request.

By using registration request, a MN's home agent can create or modify a mobility binding for that mobile node.

- Explain how registration may fail.

1. MN failed authentication. 2. MN failed in processing netmask.

- Explain how do 3 types of encapsulation work, when should you prefer for one of them.

IP in IP encapsulates on IP packet in another IP packet. Minimal encapsulation: new IP header is inserted between original IP header and IP load. general routing encapsulation encapsulates a wide variety of network layer protocols inside virtual point to point links. It is preferred when there are many network protocols. Minimal encapsulation is preferred when the saving of byte is needed.

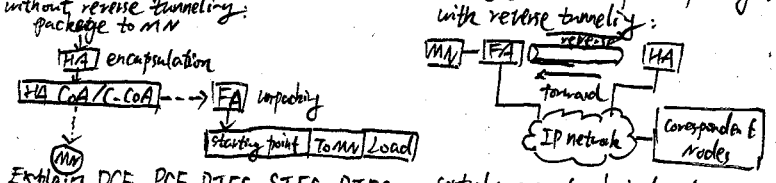
- Explain how reverse tunneling works.

By setting up a reverse tunnel, we can ensure a topologically correct resource address for the IP data packet. MN requests a reverse tunnel between FA and HA when MN registers.

- Explain why reverse tunneling may be the only way to go in certain situations.

Because Mobile IP assumes that the routing within the Internet is independent of the data packet's source address. so it can not go in certain situation for example, intermidiate routers might check for a topologically source address.

- Given an example with several IP nodes, determine the routes of the package.



- Explain DCF, PCF, DIFS, SIFS, PIFS (control access to physical medium)

DCF is a MAC technique that employs a CSMA/CA with binary expotential backoff algorithm. PCF resides in AP to coordinate the communication within the network. DIFS is the minimum medium idle time. SIFS is the amout of time in microseconds required for a wireless interface to process a received frame. PIFS is used by PCF during the contention free operations.

- Describe the DCF with RTS/CTS against time lene.

Prior to the to the data transmission the sending node will send a RTS packet to announce the upcomming transmission. When the destination node receives the RTS it will send a CTS packet after a SIFS interval.

- Explain IEEE 802.11e, EDCA, HCF.

IEEE 802.11e is a proposed enhancement to the 802.11a and 802.11b WLAN. it offers QoS services. EDCA supports differentiated and distributed access to the wireless medium using eight sub fields supporting 4 ACs. HCF combines enhanced DCF and PCF to simplify the QoS conformance model.

- Explain the difference between the "ad-hoc" mode and "infrastructure mode"

Infrastructure network includes STA and AP and the topological order is ESS. Ad hoc network only includes STA and its topological order is IBSS

- Explain the function of each element in the 802.11 in infrastructure and ad-hoc.

Infrastructure network: STA communicate with AP. STA communites with each other by AP. AP relays all communication. In Ad-hoc, the Host directly communicate with each other. All nodes can forward the message.

- Explain ~~the function~~ where the 802.11 standard comes in TCP/IP stack.

In Physical layer and data link layer.

- Briefly explain the functions of each sublayer.

LLC: provides multiplexing mechanisms that network protocols can coexist and be transferred to same medium. MAC provides addressing and channel access control mechanisms. PLCP defines how cells are formatted with in a datastream

for a particular type to transmission facility, PMD defines the details of transmission and reception of individual bits on a physical medium.

• Difference between infrared and radio network.

Unlike radio network, infrared network cannot pass through walls, but infrared network is more private than radio network.

• The physical layers specified in 802.11 standards so far.

802.11: FHSS and DSSS modulation. 2.4GHz / 1~2Mbps. 802.11a: OFDM with 3.8GHz / 54Mbps. 802.11b: DSSS: 2.4GHz / 5.5 and 11Mbps. 802.11g: OFDM and DSSS 2.4GHz / 22Mbps.

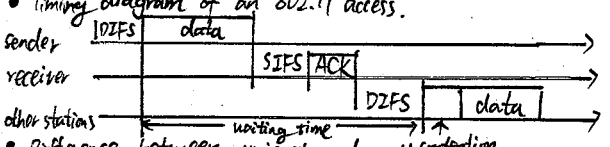
• Explain how are the prop priorities for packets implemented in 802.11.

By addressing QoS, those applications whose a high quality of service is required can tag their transmissions and take priority over the transmission.

• Three access methods for 802.11.

FDMA provides different frequency bands to different data-streams. TDMA provides different time-slots to different data-streams. CDMA: several message signal is transferred simultaneously over the same carrier frequency, utilizing different codes.

• Timing diagram of an 802.11 access.



• Difference between unicast and multicast in 802.11.

Unicast transmission sends IP packets to a single recipient on a network. Multicast transmission sends IP packets to a group of hosts on a network.

• Why both the sender and receiver must transmit the NAV.

It can limit the need for physical carrier-sensing of the air in order to save power.

• Is QoS supported in 802.11? in infrastructure mode? in ad-hoc mode? how?

QoS is supported in 802.11e but only in infrastructure not in ad-hoc mode, while Bluetooth only has an ad-hoc mode and can accept reservation for transmission.

• Explain why synchronization is needed in 802.11

Synchronization is needed because it can achieve better efficiency in wireless network.

• Explain how is synchronization achieved in 802.11 with infra and ad-hoc.

It is achieved by stations periodically exchanging information through beacon frames. In infrastructure mode, AP sends TSF information in the beacons. In ad-hoc, each station competes to send the beacon.

• Why the other form of synchronization is needed while we having 128bit DSSS

Because beacons use battery friendly - low energy Bluetooth connections to transmit messages or prompts directly to a smartphone or tablet.

• Does synchronization work in a multi-hop environment? how well?

Yes, it does. Synchronization allows the nodes in a 3-hop deep network to maintain synchronization within 76us, a 83% reduction of sending time.

• Explain why do we need power management?

Because Mobile devices are battery powered and enhancement of battery life enhances network lifetime.

• Explain how the paver management works in 802.11. (Infrastructure and ad-hoc)

Infrastructure: 1. Allow idle station go to sleep. 2. AP buffers packets for sleeping nodes 3. Power saving stations wake up periodically. 4. TSF ensures AP and PSS are synchronized. Ad-hoc: 1. Has to wake up for every Beacon transmission. 2. If it hears an ATIM frame, it must acknowledge the frame. 3. Has to estimate the power saving state of the intended destination.

• Explain the role of ATIM and DTIM in paver management.

ATIM: to prevent entering power saving mode and to indicate there is data to flow. DTIM informs the clients about the presence of buffered multicast data on the access point.

• Explain how is the handover performed in 802.11?

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

• Explain why would you fragment a message.

Packets may be formed that can pass through a link with a smaller maximum transmission unit than the original datagram size.

• Explain briefly what are the functions of the control fields in the MAC header.

Sequence control: detect duplicate packets, Block ACK and fragmentation support long packets. Frame control: 1. Protocol version 2. Type field 3. Address fields ordering.

• Explain why do you need two or three or even 4 addresses in MAC header.

Depending on how the To/From DS flags are set, this determines which of the four fields are required and what information each provides.

• Explain what is 802.11a and how it differs from 802.11b and 802.11

802.11a is an amendment to 802.11 wireless network specifications. It has higher bandwidth and transmission rate than 802.11 and 802.11b. 802.11a is modulated by OFDM while 802.11b is by DSSS.

• Explain what is the goal of WEP.

Provide data confidentiality comparable to that of a traditional wired network.

• Explain how does WEP work.

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

• Given a modification of any part of the WEP encryption explain what happens.

IV + key (seed) → RC4 → 0101 (keystream) ⊕ 1100 (Plain text) = 1001 (Cipher text) →

• Explain how does the WEP authentication mechanism work.

1. Client sends an authentication request to AP. 2. AP replies with a clear text challenge. 3. The client encrypts it using WEP key and send it back. 4. AP decrypts the response. If it meches the challenge, AP sends positive reply.

• Explain various options with their pros and cons.

MAC filtering allows you to define on your WiFi network. But this protection is tedious to set up and easy to breach. Captive portal is a Web page that a user of a public-access network is obliged to view and interact with before access is granted. Its implementation can be exploitable with a simple packet sniffer. The authentication mechanisms of WEP are weak.

• Explain the difference between active and passive scanning

A passive scan generally takes more time, and if the client does not wait long enough on a channel, then the client may miss an AP beacon.

• Explain how are the priorities implemented in 802.11

EDCA is effective DCF with 4 priorities. By setting different min and max back-off slots, one stream has an advantages over another.

• Determine the throughput available for various stations in the system.

$$S = \frac{D}{t_{DIFS} + t_{backoff} + t_{data} + t_{SIFS} + t_{ACK}}$$

• Summarize the characterizations of WiMax.

WiMax provide multiple physical layer and Media Access options. It can provide long-distance and high-speed transmission. It have mobile, broadband and IP features and Extensibility and stability.

• Explain the protocols of WiMax and 802.16 in physical layer.

OFDM: a large number of closely spaced orthogonal sub-carrier signals are used to carry data on several data streams. OFDMA is a multi-user version of OFDM. SOFDMA is the OFDMA mode employed in Mobile WiMax outlined in 802.16e.

• Explain how OFDM works.

OFDM is based on the concept of FDD, the method of transmitting multiple data streams over a common broadband medium. Each data is modulated onto multiple adjacent carriers and transmitted simultaneously.

• Compare infrastructure and ad-hoc networks.

Infrastructure mode requires a central access point that all devices connect to. Ad-hoc mode is "peer to peer", devices connect directly to each other.

• Understand the protocol interference model in the transmitter and receiver's side.

$$\frac{P_{r,i}}{P_{r,j}} > \beta_v \Rightarrow \frac{|X_i - X_{R(i)}|^{-\delta}}{|X_j - X_{R(i)}|^{-\delta}} > \beta_v \Rightarrow |X_j - X_{R(i)}| > \beta_v^{1/\delta} |X_i - X_{R(i)}|.$$

• Describe the concept of exclusion region.

It is important to employ exclusion region in order to limit the inference caused by neighboring nodes to the receiver.

• Understand upper and lower bound of arbitrary network with protocol model.

$$\frac{W}{1+2\Delta}\frac{n\bar{A}}{\sqrt{n}+\sqrt{8\rho}} \le \lambda n\bar{l} \le \sqrt{\frac{8}{\pi\rho}}\frac{1}{\Delta} W\sqrt{n\bar{A}}$$

• Discuss hidden terminals and exposed terminals.

Hidden terminal is the nodes within the coverage of receivers and out of the coverage of transmitters. Exposed terminal is the node within the coverage of transmitters and out of the coverage of receivers.

• Describe the working schedule of WEP protocol.

WEP seeks to establish similar protection to that offered by the wired network's physical security mesures by encrypting data transmitted over the WLAN.

• How does the authentication mechanism of IEEE 802.1x protocol work?

1. Authenticator is enabled and set to the "unauthorized" state. 2. Initiation 3. Negotiation 4. Authentication.

• Compare the differences among WEP, WAPI and IEEE 802.11.

WAPI was initialed to resolve the existing security loop holes of WEP in WLAN international standard. It allows symmetric encryption, AES or SMS4. It is more secure than WEP. WPA implemented a subset of draft of 802.11i. 802.11i makes use of AES, whereas WEP and WAP use the RC4 stream cipher.

• List the improvement in Bluetooth 4.0 compared with the last version.
Bluetooth 4.0 improved transmission distance (60m), decreased the energy consumption (90%).

• List the working states in Bluetooth connecting.
1. Connection state 2. Stand-by state.

• List hardware devices of RFID and describe their functions.
1. Reader: Two-way communication with electronic tag; Receive the control demand from host system. 2. Electronic Tag: used for communication with Reader.

• List some key techniques in RFID
1. Chip technology 2. Antenna design technology 3. Packaging technology 4. Tag application technology 5. RFID anti collision technology.

• Describe at least 3 applications of RFID in Internet of Things.
1. Logestics field: Cargo tracking, Automatic information collection, Port application.
2. Retail area: Real-time statistics of sales data, Replenishment. Anti-theft.
3. Indentification: identification of personal documents.

• Explain the role of sensor networks, base station, monotoring stations and aggregation nodes in WSNs.
sensor network is spatially distributed sensors to monitor physical conditions.
base station: radio receiver/transmitter that serves as the hub of wireless network.
monotoring station: provides supervisory services to monitor the change in network.
aggregation nodes: dynamic search; positioning; restoring the connection.

• Explain the role of each element in a sensor node.
controller: performs tasks, processes data and controls the functionality of other component.
Transceiver: transmite and receive information.
External memory: storing application or personal data; programming the device.
Power source: storing energy. Sensors: capture data from their environment.

• Give a few examples of WSNs applications.
1. Smart dust 2. CHISRT system. 3. Remote health monitoring 4. Automatic sprinkler system. 5. Intel home care system

• Give examples of a few ways to deploy WSNs.
Random deployment and planned deployment.

• Explain the characteristics of the radios in WSNs.
MICA2: data ~~range~~ rate - 40kb/s, communication range - 1000miles.
It can work in 868/916, 433 and 315 MHz ~~band~~ frequency band.

• Explain the fundamental trade-off of WSNs. Explain how one can trade one metric for another one.
The fundamental trade-off is between Performance and energy consumption. To achieve better performance, a large scale of energy is needed, but the energy of each node is limited.

• Give examples of a few energy sources for future WSNs.
Solar energy, wind energy, bio-energy etc.

• List at least three key techniques in Internet of Things.
1. Ultra Wideband. 2. Software defined radio. 3. Radio Frequency Identification 4. Body Area Networks.

• List the features of Ultra Wideband.
1) good security 2) high processing gain 3) strong multipath resolution capability 4) high transmission speed. 5) large system capacity. 6) strong Anti-jamming capability. 7) low power consumption.

• Explain the difference between Bluetooth Low Energy and Bluetooth.
Comparing with Bluetooth, BLE uses single-mode and dual mode to the design of chip, integrates BLE protocal to controler in order to decrease power consumption and increase transmission rate.

• Explain how does cognitive radio works
Such a radio automatically detects available channels in wireless spectrum, then accordingly changes its transmission parameters to allow more concurrent wireless communications in a given spectrum band at one location.

• Describe the features of body area networks and their applications.
features: 1) Low transmit power. 2) high transmission speed.
applications: 1) medical insurance. 2) Wireless access/cognitive system.
3) Navigation and positioning services. 4) military applications.

• Explain the concept of SDN.
SDN allows network administrators to programmatically initialize, control, change, and manage network behavior dynamically via open interfaces and abstraction of lower-level functionality.

• Describe the working principles of SDN.
its architecture decouple network control and forwarding functions, enabling network control to become directly programmable and the underlying infrastructure to be abstracted from apps and network services.

• Give a few examples of SDN applications.
1. SDMN 2. SD-WAN 3. SD-LAN. 4. Security using the SDN paradigm

• Explain how SDN could outperform traditional networks.
In SDN, the network control and physical network are seperated, so that it gets rid of the limitation of hardware to network architecture. And the control and management of network data is more efficient and stable.

• List the major hardware devices an intelligent robot should have.
1. motors. 2. Camera 3. GPS 4. Microphone 5. Infrared receiver 6. network support devices.

• List at least 3 applications of intelligent cars and explain one of them.
1. Autonomous car is a vehicle that is capable of sensing its environment and navigating without human input. Advanced control systems interpret sensory information to identify appropriate navigation paths.
2. Leap-Frog Path Design. 3. Real-Time Indoor Mapping.

• Explain the difference between MIMO and SISO systems.
SISO: only single transmission path between transmitter and receiver.
MIMO: multiple paths between transmitter and receiver.

• Give the channel model of MIMO system.
$$y = Hx + n.$$

• Describe the differences between space ~~density~~ diversity and space multiplexing.
space diversity aims at improving the reliability of the system, we may choose to send some data across the different propagation paths. Space multiplexing aims at improving the data rate of the system, we may choose to place different portions of the data on different propagation paths.

• List at least 3 applications of MIMO and explain one of them.
1. anti-shadowing effect: because the position of antenna can be determined randomly, distributed MIMO system can cover the space in a more balanced way.
2. multi-user MIMO. 3. networked MIMO.

• Describe the security of bitcoins.
1. Security of Monetary value. 2. Security of account.
3. Trasaction security 4. Privacy security

• List the major components of QR codes.
(1. Start character 2. Data character 3. Check character)
X 4. Terminate character 5. Blind-spot.
1. Coding area 2. Viewfinder graphics. 3. Seperator
4. Positioning graphics 5. Check graphics.

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