1.1 Telecommunication is defined by the International Telecommunication Union as the transmission, emission, or reception of any signals by electromagnetic systems. In 1876, Bell patented the telephone. The invention of diode in 1904 made possible rapid development of long-distance telephony. 1G is the first generation cellular network, which was designed purely for voice calls without any data services. 2G was first commercially began for Mobile Communications. 3G has enabled faster data transmission speeds, greater network capacity and more advanced network services. 4G is expected to provide a comprehensive and secure all-IP based mobile broadband solution to laptop computers wireless modems. The 5G can be a complete wireless communication without limitation.

1.2 cellular system, mobility management, mobile IP. Wi-Fi, WLAN. etc.

2.1 wired media requires copper wires to connect to devices while wireless media is connected via electromagnetic waves.

2.2 The licensed band is not free. But instead it guarantees no interference and provides a long-time window. The unlicensed band is not free. Usually it includes 2.4 GHz and 5GHz.

2.3 It is affected by the phenomena of reflection, refraction, diffraction, absorption, polarization and scattering.

2.4 reflection and transmission: When reflection occurs, the ~~signal~~ angle of incidence is equal to the angle of reflection. Also some loss of the signal will come along with this process.

diffraction: When signals encounter an obstacle, they intend to travel around them. Each point on a spherical wave front can be considered as a source of a secondary wave front.

scattering: Radiation is forced to deviate from a straight trajectory by one or more paths due to localized non-uniformities in the medium through what they pass.

2.5 There is more reflection in indoor environment while more diffraction and scattering in outdoor environment.

2.6 path loss $= A + B + \log(d) + C$; $A = 69.55 + 26.16\log(f_c) - 13.82\log(h_b) - a(h_m)$; $B = 44.9 - 6.55\log(h_b)$ where d refers to the distance between transmitters and receivers, and h_m, h_b refer to height of stations.

2.7 Free Space Model: $PL(dB) = 10\log\frac{P_t}{P_r} = -10\log\left[\frac{G_t G_r \lambda^2}{(4\pi)^2 d^2}\right]$; Receiving Power $P_r(d) = P_r(d_0)\left(\frac{d_0}{d}\right)^2$; Transmission delay: $t = \frac{x+x'-l}{c}$

Two-Ray Model: $PL(dB) = 40\log d - (10\log G_t + 10\log G_r + 20\log h_t + 20\log h_r) = -10\log\left[\frac{G_t G_r h_t^2 h_r^2}{d^4}\right]$;

Receiving Power: $P_t G_t G_r \frac{h_r^2 h_t^2}{d^4}$; Transmission delay: $t = \frac{x+x'-l}{c}$

2.8 Slow fading can be caused by shadowing where a large obstacle obscures the main signal path between the transmitter and receiver. It arises when the coherence time of the channel is large relative to the delay requirement.

2.9 $EIFM = RSL - T + (C/I) - (C/I)$ where EIFM refers to External Interference Fade Margin, RSL: unfaded received signal level in dBm. T refers to the receiver threshold. T/I: the threshold to interference ratio, C/I: carrier to inteference ratio.

2.10 macro-cell: $PL(dB) = A + B\log_{10}R - C$, micro-cell: $PL(dB) = 10n_1\log r + L_1$, for $r \le r_b$

2.11 multiple/small-scale fading: rapid changes in signal strength over a small travel distance, random frequency modulation.
Doppler shift: change the frequency or wavelength of a wave.
spectrum: spectrum refers to the full range of all frequencies of electromagnetic radiation.

2.12 the function of Rayleigh distribution is: $f(x;\sigma) = \frac{x}{\sigma^2}e^{-x^2/2\sigma^2}$, $x \ge 0$, Ricean distribution, $f(x|v,\sigma) = \frac{x}{\sigma^2}\exp\left(\frac{-(x^2+v^2)}{2\sigma^2}\right)I_0\left(\frac{xv}{\sigma^2}\right)$

2.13 Doppler shift: $f = \left(\frac{c+v_r}{c+v_s}\right)f_0$, where the speeds of source and the receiver are lower than the velocity of waves.
spectrum: U-shaped power spectrum for isotropic scattering: $S(f) = \frac{1}{4\pi f_m}\cdot\frac{1}{\sqrt{1-\left(\frac{f-f_c}{f_m}\right)^2}}$

2.14 Estimated received signal strength: $dBm_e = -113.0 - 10.0\gamma\log_{10}(r/R)$. where r is the distance, R is mean radius.

2.15 $LCR = \sqrt{2\pi}f_d\rho e^{-\rho^2}$, $\rho = \frac{R_{thresh}}{R_{rms}}$; $AFD = \frac{e^{\rho^2}-1}{\rho f_d\sqrt{2\pi}}$, where $AFD \times LCR = 1 - e^{-\rho^2}$

3.1 2G introduced a new variant of communication, as SMS text messaging became possible, initially on GSM networks and eventually on all digital networks. The benefits of 2G include less power, higher voice quality. As it becomes more widespread, it became clear that demand for data services was growing. Then 3G came. The difference is the use of packet switching rather than circuit switching for data transmission.

3.2 power ↑, cell radius ↑, capacity ↓

3.3 Formula: $C = MJN$, C: system capacity, M: communities, J: channels, N: cluster size.
$D = \sqrt{3NR}$, R: radius of cell, D: distance between two cells.
$q = \frac{D}{R} = \sqrt{3N}R = \left(6\times\frac{S}{I}\right)^{1/k}$.

樊炳华
5140309386

3.4 Base Station: transceiver connecting a number of devices to one another to a wider area
Uplink: path from mobile station to a base station.
Downlink: path from base station to mobile station
cell: the area covered by a cellular transmitter.
location area: LA refers to the service areas which are created with each area.
MSC: MSC refers to the centerpiece of a network switching subsystem.

3.5 A wireless network consists of several components that support communications using radio or light waves propagating through an air medium. Some of these elements overlap with those of wired networks, but special consideration is necessary for all of these components when deploying a wireless network. VLR is a database in a network associated to a MSC. The VLR contains the exact location of all mobile subscribers currently present in the area. HLR is a database of permanent subscribers information in the network.

3.6 Handoff Management: When an MS moves from one BS into another, handoff is performed to maintain service continuity.
Location Management: keep track of the user's current location.

3.7 advantages: Larger capacity through improved spectral efficiency; higher transmission speed and rates; provides more kinds of services including calls, data transmission; higher security.

3.8 The purpose of Call Admission Control is to ensure a certain level of audio quality in voice communication.
TDMA in 2G CAC is single-class CAC, while multiple-class CAC is used in 3G service.

3.9 SGSN keeps track of the location of an individual MS/UE and performs security functions and access control.
GGSN converts the GPRS packets coming from SGSN into the appropriate packet data protocol format and sends them out. MSC controls the network switching subsystem elements. GMSC is a kind of MSC that is used to route calls outside the network. HLR is a database of permanent subscribers information.

3.10 TD-SCDMA, W-CDMA, HSPA+, CMMA2000

3.11 high transmission rates, large capacity, high security, multiple applications.

3.12

	transmission rate	bandwidth	operation frequencies
2.5G	171.2kbit/s (theoretical)	200kHz	890-915MHz (upstream), 935-960MHz (downstream)
3G	14.7Mbit/s	1.25MHz, CDMA2000	1920-1935MHz (upstream), 2110-2125MHz (downstream), CDMA2000

3.13 Since each technique improves the older one, I just list the new-added scenarios:
1G. voice call. 2G: SMS. 2.5G: web view. 3G: GPS. mobile TV. 4G: Internet of things. hd video.

3.14 The architecture may consists of several domains: Radio Access Network, General Packet Data Service network, IPT core network, Gateways and Databases.

5.1 Mobile Compute Cloud. Mobile Web. Ubiquitous Computing

6.1 handoff detection: use WEI and RSSI to make handoff decision accurately and quickly.
handoff preparation: the handoff entity requests for the other networks resource availability information.
handoff execution: a handoff execution message is responsible for triggering the handoff to another network

6.2 Intra-switch handoff refers to the case that the source and the target are the same, only the used channel is changed. Inter-switch handoff refers to the case that the source and the target are different.

6.3 Mobile-controlled handoff (MCHO): MS monitors the signal of the surrounding BSs and initiates the handoff
Network-controlled handoff (NCHO): Surrounding BSs measure the signal and the network initiates the handoff
Mobile-Assisted handoff (MAHO): The network asks the MS to measure the signal, and makes the handoff decision.

6.4 Hard Handoff: an advantage is that at any time one cell only uses one channel. Another is the phone's hardware doesn't need to be capable of receiving two or more channels in parallel. A disadvantage is that if a handover fails the call may be temporarily disrupted or even terminated abnormally.
Soft Handoff: an advantage is that the connection to the source cell is broken only when a reliable connection to the target cell has been established. A disadvantage is that the cost of the more complex hardware is high.

6.5-6.10 I really don't know and can't find something suitable to learn.

6.11 The two-tier architecture is like client server application. The direct communication takes place between client and server. There is no intermediate between client and server.

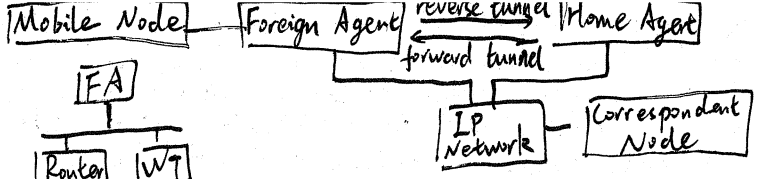
6.12 Location Update: the mobile device needs to upload its location information every time it's turned on/off, or periodically. Plus, each time it crosses different routing area, it should upload information.

6.13 Time-based: cost is low but there are unnecessary updates by stationary users.
Movement-based: may suffer from ping-pong effect.
Distance-based: high computational overhead on MT side

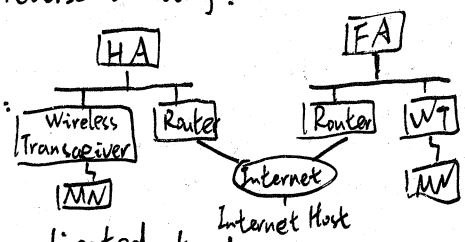
7.1 Stable, hosting, convenient remote access and preferred address for servers.

7.2 MN: mobile node, with unstable location. HA: home agent, a router at home chain.
FA: foreign agent. CoA: care-of address. a related IP address when mobile node switch to foreign chain.
CN: communication node: an objective of mobile node's communication.

7.3 with reverse tunneling:



without:



张xxx
5140309386

7.4 too complicated to draw

7.5 The mobile node registers through the FA whe the MN receives an agent advertisement.

7.6 Because mobile IP exists within a certain period. And the registration is based on the exchange of information.

7.7 Agent Advertisement: to determine their current point of attachment to the Internet or organization's network

7.8 Registration Request: to begin the registration process with MN to send and FA to receive.

7.9 transmission (UDP) fails, connection between home agent and other nodes reach the limit.

7.10 ip-in-ip: one IP packet encapsulated inside another. cost little but limit protocal.
minimal: an IP datagram is encapsulated with an outer minimal forwarding IP header. cost less than ip-in-ip.
GRE: add on additional header of its own between the inside and outside IP headers. support more protocals.

7.11 If an intermediate router check for a topologically correct source address, you should set up a reverse tunnel. Therefore, you ensure a topologically correct source address for the IP data packet.

7.12 Mobile nodes that have private addresses which are not globaly routable through the Internet require reverse tunnel.

7.13 I don't know.

8.1 DCF: Distributed coordination function. is the fundamental MAC technique based on WLAN standard.
PCF: Point Coordination function. It resides in an Access Pointer to coordinate the communication.
DIFS: DCF Interframe Space, usually it's calculated by: DIFS = SIFS + (2* slot time)
SIFS: Short Interframe Space: is the amount of time in microseconds required for a wireless interface.
PIFS: PCF Interframe Space: PIFS = SIFS + slot time

8.2 RTS and CTS are two virtual carrier sense mechanism of DCF exchange between source and destination. frames that

8.3 EDCA: Enhanced distribution channel access. high priority traffic has a higher chance of being sent.
HCF: Hybrid Coordination function. It includes two methods of channel access: HCCA, EDCA

8.4 In infrastructure mode, devices communicate through a ringle access point while in Ad-hoc they connect directly.

8.5 Infrastructure: STA: communicate with each other via AP. AP: receive and pass message
Ac-hoc: STA: communicate with each other directly.

8.6 physical layer and data link layer.

8.7 LLC: Logical Link Control Layer - for identifying network layer protocals
MAC: Media Access Control - for controling how devices gain access to a medium and permission to transmit data.
PLCP: Physical Layer Convergence Procedure. PMD: Physical Medium Dependent.

8.8 Infrastructure: it's simple, cheap and available in many devices. But its bandwidth is low.
Radio: cover large areas. but very limited licenses are free, and it interference with other devices.

8.10 management frame > control frame > data frame

8.11 CSMA/CA is a network multiple access method in which carrier sensing is used but nodes attempt to avoid collisions.
Binary Exponential Backoff is used to space out repeated retransmissions of the same block of data.
NAV limits the need for physical carrier sensing at the air interface to save power.

8.15 multimedia, emergency services such like network availability, group communications.

8.20 battery is limited, reduce overall energy consumption, reduce operating costs for energy.

8.21 The 802.11 provides the power savings in IBSS configuration. Essentially, all clients in an IBSS configuration must awaken each time a beacon is sent. The clients randomly alternate the task of transmitting a beacon.

8.22 In frastructure mode, broadcast/multicast frames are buffered at AP. Delivery traffic indication map (DTIM) is time when multicast frames are able to be delivered. Power Saving Stations wake up prior to expected DTIM.
In Ac-hoc mode, power management has to wake up for ATIM window after beacon. ATIM window is the time when other stations announce if they have buffered packets for a sleeping station.

8.24 because of the limit of the bandwidth.

8.25. Power Save polling Packet, Request to send, clear to send. acknowledges receipt of transmitted data.

8.26. when an 802.11 device is transmitting to a receiving device, either of these devices may not be the actual source or destination of the L2 traffic. so four addresses are needed. Transmitter address, Receiver Address
Source Address, Destination Address

8.28 WEP: Wired Equivalent Privacy is a security algorithm for 802.11 wireless networks, for providing data confidentially.

8.29 For sender, WEP encrypts the data by four operations: combine secret key and IV; use resulting key to run PRNG; the plaintext is thrown in a integrity algorithm; the result of key sequence and ICV will go to RC4 algorithm.
For receiver, there are five steps to decrypt: combine the Pre-shared key and IV; the cipher text and secret key go to RC4 algorithm; ICV and plaintext will seperate; plaintext goes to integrity algorithm to make new ICV; new ICV compare to old one.

8.30 WEP2: it extends IV and key values to 128 bit, which can eliminate the duplicate IV deficiency to stop brute force key attack.

8.31 In Open System Authentication, any client can authenticate with the AP and attempt to associate. So no authentication is needed.
In Shared key Authentication, WEP key is used in a four-step challenge-response handshake: client sends a request to AP; AP replies with a clear-text challenge; client encrypts it using WEP key and sends back another request; AP decrpts the request and check if it matches the challenge text, if so, sends back a positive reply.

8.34 from lowest to highest: background; spare; Best Effort: Excellent Effort; Controlled Load; Video; voice; network control.

9.1 WiMax, which is based on IEEE 802.16, provides higher speed broadband access. It has more substantial backhaul bandwidth requirements the legacy cellular applications. Also it's economically viable to provide last-mile broadband Internet access.

9.2 The newest version of WiMAX uses scalable orthogonal frequency-division multiple access, and brings multiple antenna support through MIMO. It includes Transport Convergence sublayer and Physical Media Dependent sublayer.

9.3 OFDM: is a frequency-division multiplexing scheme. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams and channels.

10.1 Infrastructure requires communication should be through AP, while Ac-hoc allows devices to connect directly. So Ac-hoc doesn't need high security ensurance. Usually it's slower than Infrastructure.

10.3 Exclusion Region is a zone established by a sanctioning body to prohibit specific activities in a specific geographic area.

10.5 Hidden Terminals: If A and C want to transmit to B at the same time, but they can't communicate with each other, which may cause interference, so we use RTS/CTS mechanism to solve this. A broadcast a request, if B is free, it replies with a clear to send which makes other nodes enter a back off period where they don't transmit. This is called Exposed Terminal.

11.1 It's answered at 8.29.

11.2 It's answered at 8.31

11.3 WEP is wired equivalent privacy, using 64-or 128-bit keys and RC4 stream cipher. It's easily to be hacked because of weak authentication.
WPA is Wi-Fi Protected Access, which is an interim standard to address major WEP flaws. It uses RC4 and 256-bit keys.
IEEE 802.11i is WPA2. It's the current standard, replacing RC4 and TKIP with CCMP and AES algorithm for stronger authentication.

12.1 Low-energy consumption, more secure, more reliable on multi-point connections.

12.2 Inquiry. Paging and Connection

12.3 Transponder: uniquely indentifies itself. Transceiver: handles radio communication through antennas. Antenna: attached to the reader to communicate with transponders. Reader Interface Layer: compress tag signals into a single identification.

12.4 Label Application ~~tag~~ Technique. Collision Detection Technique. Chip Technique.

12.5 ID badging. Supply chain management. Assert Tracking

13.2 Controller performs tasks, controling the functionality of other elements. Transceiver makes use of ISM band, which gives free radio availability. Extern Memory stores necessary information. Power Source supplys power energy to it. Sensors capture data from the environment.

13.3 Natural Disaster Prevention. Data logging. Area Monitoring. Air pollution Monitoring.

13.4 Static Deployment depends on the optimization strategy, and the nodes don't change.
Dynamic Deployment may be backed to the deployment of the robot. It requires movement of nodes automatically to get maximum performance.

13.5 IFE: Medium data rate, range: 3-5m, medium reliability. Video Streaming: High data rate, range: 3-10m, high reliability.

13.7 solar cells, vibration energy harvesters, batteries.

14.1 Sense Technology. RFID Label. Embedded System. Cloud Computing

14.2 high security, high process gain, high transmission rate. large system capacity.

14.3 They are used for different purposes. Bluetooth can deal with large scale data, but consumes battery life quickly. BLE is used for applications that don't need to exchange large amounts of data.

14.4 cR is a radio that can be programmed and configured dynamically to use the best channels in the vicinity.

14.5 features: wireless communication protocol, frequency band, transmission distance. Application: Sports, Military, security.

15.1 SDN is an approach to computer networking that allows network administrators to programmatically initialize, control and change.

15.2 Directly Programmable, Agile, Centrally managed, Programmatically configured, Open Standards-based and vendor-neutral.

15.3 SDMN. SD-WAN. SD-LAN. Security using the SDN paradigm

15.4 Centralized network provisioning. More granular security. Cloud Abstraction. Guaranteed Content delivery.

16.1 It contains intelligent devices, chips, robotic systems, and brain-inspired computing systems.

16.2 Auto-Mobile. Environment Monitoring. Navigation Robots. Vision Navigation.

19.1 MIMO refers to multiple input multiple output. Outputs can be controlled for next loop. SISO refers to single input single output.

19.2 Channel Model. $\vec{y} = H\vec{x} + \vec{n}$. $\vec{y}$ is the output signal vector, $\vec{x}$ is input signal vector. $\vec{n}$ is noise vector. H is transfer function.

19.4 3G, 4G, Wi-Fi. In 4G, MIMO has become an essential element of wireless communication standards including WiMAX and LTE.

21.1 Bitcoin's most common vulnerability is in user error. It's security lies in one of its fundamental characteristics, the transaction blockchain.

21.2 Major components: three distinctive squares at the corners to locate; a small square to normalize the size, angle small dots which can be converted to binary numbers.