**R1. What does it mean for a wireless network to be operating in “infrastructure mode”? If the network is not in infrastructure mode, what mode of operation is it in, and what is the difference between that mode of operation and infrastructure mode?**

In infrastructure mode of operation, each wireless host is connected to the larger network via a base station (access point). If not operating in infrastructure mode, a network operates in ad-hoc mode. In ad-hoc mode, wireless hosts have no infrastructure with which to connect. In the absence of such infrastructure, the hosts themselves must provide for services such as routing, address assignment, DNS-like name translation, and more.

**R2. What are the four types of wireless networks identified in our taxonomy in Section 7.1 ? Which of these types of wireless networks have you used?**

a) Single hop, infrastructure-based

b) Single hop, infrastructure-less

c) Multi-hop, infrastructure-based

d) Multi-hop, infrastructure-less

**R3. What are the differences between the following types of wireless channel impairments: path loss, multipath propagation, interference from other sources?**

Path loss is due to the attenuation of the electromagnetic signal when it travels through matter. Multipath propagation results in blurring of the received signal at the receiver and occurs when portions of the electromagnetic wave reflect off objects and ground, taking paths of different lengths between a sender and receiver. Interference from other sources occurs when the other source is also transmitting in the same frequency range as the wireless network.

**R4. As a mobile node gets farther and farther away from a base station, what are two actions that a base station could take to ensure that the loss probability of a transmitted frame does not increase?**

a) Increasing the transmission power

b) Reducing the transmission rate

**R5. Describe the role of the beacon frames in 802.11.**

APs transmit beacon frames. An AP’s beacon frames will be transmitted over one of the 11 channels. The beacon frames permit nearby wireless stations to discover and identify the AP.

**R6. True or false: Before an 802.11 station transmits a data frame, it must first send an RTS frame and receive a corresponding CTS frame.**

False

**R7. Why are acknowledgments used in 802.11 but not in wired Ethernet?**

APs transmit beacon frames. An AP’s beacon frames will be transmitted over one of the 11 channels. The beacon frames permit nearby wireless stations to discover and identify the AP.

**R8. True or false: Ethernet and 802.11 use the same frame structure.**

False

**R9. Describe how the RTS threshold works.**

Each wireless station can set an RTS threshold such that the RTS/CTS sequence is used only when the data frame to be transmitted is longer than the threshold. This ensures that RTS/CTS mechanism is used only for large frames.

**R10. Suppose the IEEE 802.11 RTS and CTS frames were as long as the standard DATA and ACK frames. Would there be any advantage to using the CTS and RTS frames? Why or why not?**

No, there wouldn’t be any advantage. Suppose there are two stations that want to transmit at the same time, and they both use RTS/CTS. If the RTS frame is as long as a DATA frames, the channel would be wasted for as long as it would have been wasted for two colliding DATA frames. Thus, the RTS/CTS exchange is only useful when the RTS/CTS frames are significantly smaller than the DATA frames.

**R11. Section 7.3.4 discusses 802.11 mobility, in which a wireless station moves from one BSS to another within the same subnet. When the APs are interconnected with a switch, an AP may need to send a frame with a spoofed MAC address to get the switch to forward the frame properly. Why?**

Initially the switch has an entry in its forwarding table which associates the wireless station with the earlier AP. When the wireless station associates with the new AP, the new AP creates a frame with the wireless station’s MAC address and broadcasts the frame. The frame is received by the switch. This forces the switch to update its forwarding table, so that frames destined to the wireless station are sent via the new AP.

**R12. What are the differences between a master device in a Bluetooth network and a base station in an 802.11 network?**

Any ordinary Bluetooth node can be a master node whereas access points in 802.11 networks are special devices (normal wireless devices like laptops cannot be used as access points).

**R13. What is meant by a super frame in the 802.15.4 Zigbee standard?**

Each beacon frame divides the super frame into an active period (during which devices may transmit) and an inactive period (during which all devices, including the controller, can sleep and thus conserve power).

**R14. What is the role of the “core network” in the 3G cellular data architecture?**

The core network interoperates with components of the existing cellular voice network (in particular, the MSC)

**R15. What is the role of the RNC in the 3G cellular data network architecture? What role does the RNC play in the cellular voice network?**

The Radio Network Controller (RNC) typically controls several cell base transceiver stations similar to the base stations that we encountered in 2G systems (but officially known in 3G UMTS parlance as a “Node Bs”—a rather non-descriptive name!). Each cell’s wireless link operates between the mobile nodes and a base transceiver station, just as in 2G networks. The RNC connects to both the circuit-switched cellular voice network via an MSC, and to the packet-switched Internet via an SGSN. Thus, while 3G cellular voice and cellular data services use different core networks, they share a common first/last-hop radio access network.

**R16. What is the role of the eNodeB, MME, P-GW, and S-GW in 4G architecture?**

The data plane role of eNodeB is to forward datagram between UE (over the LTE radio access network) and the P-GW. Its control plane role is to handle registration and mobility signaling traffic on behalf of the UE.

The mobility management entity (MME) performs connection and mobility management on behalf of the UEs resident in the cell it controls. It receives UE subscription information from the HHS.

The Packet Data Network Gateway (P-GW) allocates IP addresses to the UEs and performs QoS enforcement. As a tunnel endpoint it also performs datagram encapsulation/decapsulation when forwarding a datagram to/from a UE.

The Serving Gateway (S-GW) is the data-plane mobility anchor point as all UE traffic will pass through the S-GW. The S-GW also performs charging/billing functions and lawful traffic interception.

**R17. What are three important differences between the 3G and 4G cellular architectures?**

In 3G architecture, there are separate network components and paths for voice and data, i.e., voice goes through public telephone network, whereas data goes through public Internet. 4G architecture is a unified, all-IP network architecture, i.e., both voice and data are carried in IP datagrams to/from the wireless device to several gateways and then to the rest of the Internet.

The 4G network architecture clearly separates data and control plane, which is different from the 3G architecture.

The 4G architecture has an enhanced radio access network (E-UTRAN) that is different from 3G’s radio access network UTRAN.

**R18. If a node has a wireless connection to the Internet, does that node have to be mobile? Explain. Suppose that a user with a laptop walks around her house with her laptop, and always accesses the Internet through the same access point. Is this user mobile from a network standpoint? Explain.**

No. A node can remain connected to the same access point throughout its connection to the Internet (hence, not be mobile). A mobile node is the one that changes its point of attachment into the network over time. Since the user is always accessing the Internet through the same access point, she is not mobile.

**R19. What is the difference between a permanent address and a care-of address? Who assigns a care-of address?**

A permanent address for a mobile node is its IP address when it is at its home network. A care-of-address is the one its gets when it is visiting a foreign network. The COA is assigned by the foreign agent (which can be the edge router in the foreign network or the mobile node itself).

**R20. Consider a TCP connection going over Mobile IP. True or false: The TCP connection phase between the correspondent and the mobile host goes through the mobile’s home network, but the data transfer phase is directly between the correspondent and the mobile host, bypassing the home network.**

False **R21. What are the purposes of the HLR and VLR in GSM networks? What elements of mobile IP are similar to the HLR and VLR?**

The home network in GSM maintains a database called the home location register (HLR), which contains the permanent cell phone number and subscriber profile information about each of its subscribers. The HLR also contains information about the current locations of these subscribers. The visited network maintains a database known as the visitor location register (VLR) that contains an entry for each mobile user that is currently in the portion of the network served by the VLR. VLR entries thus come and go as mobile users enter and leave the network.

The edge router in home network in mobile IP is similar to the HLR in GSM and the edge router in foreign network is similar to the VLR in GSM.

**R22. What is the role of the anchor MSC in GSM networks?**

Anchor MSC is the MSC visited by the mobile when a call first begins; anchor MSC thus remains unchanged during the call. Throughout the call’s duration and regardless of the number of inter-MSC transfers performed by the mobile, the call is routed from the home MSC to the anchor MSC, and then from the anchor MSC to the visited MSC where the mobile is currently located.

**R23. What are three approaches that can be taken to avoid having a single wireless link degrade the performance of an end-to-end transport-layer TCP connection?**

a) Local recovery

b) TCP sender awareness of wireless links

c) Split-connection approaches