**Question 1:** 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.

**Solution**

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.

**Question 2:** What are the purposes of the HLR and VLR in GSM networks? What elements of mobile IP are similar to the HLR and VLR?

**Solution**

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.

**Question 3:** Consider the following idealised LTE scenario. The downstream channel is slotted in time, across *F* frequencies. There are four nodes, A, B, C, and D, reachable from the base station at rates of 10 Mbps, 5 Mbps, 2.5 Mbps, and 1 Mbps, respectively, on the downstream channel. These rates assume that the base station utilises all time slots available on all *F* frequencies to send to just one station. The base station has an infinite amount of data to send to each of the nodes, and can send to any one of these four nodes using any of the *F* frequencies during any time slot in the downstream sub-frame.

a. What is the maximum rate at which the base station can send to the nodes, assuming it can send to any node it chooses during each time slot? Is this protocol fair? Explain and define what you mean by “fair.”

b. If there is a fairness requirement that each node must receive an equal amount of data during each one second interval, what is the average transmission rate by the base station (to all nodes) during the downstream sub-frame? Explain how you arrived at your answer.

**Solution**

1. 10 Mbps if it only transmits to node A. This solution is not fair since only A is getting served. By “fair” it means that each of the four nodes should be allotted equal number of slots.
2. For the fairness requirement such that each node receives an equal amount of data during each downstream sub-frame, let n1, n2, n3, and n4 respectively represent the number of slots that A, B, C and D get.

Now, data transmitted to A in 1 slot = 10t Mbits

(assuming the duration of each slot to be t)

Hence, Total amount of data transmitted to A (in n1 slots) = 10t n1

Similarly total amounts of data transmitted to B, C, and D equal to 5t n2, 2.5t n3, and t n4 respectively.

Now, to fulfill the given fairness requirement, we have the following condition:

10t n1 = 5t n2 = 2.5t n3 = t n4

Hence,

n2 = 2 n1

n3 = 4 n1

n4 = 10 n1

Now, the total number of slots is N. Hence,

n1+ n2+ n3+ n4 = N

i.e. n1+ 2 n1 + 4 n1 + 10 n1 = N

i.e. n1 = N/17

Hence,

n2 = 2N/17

n3 = 4N/17

n4 = 10N/17

The average transmission rate is given by:

(10t n1+5t n2+ 2.5t n3+t n4)/tN

= (10N/17 + 5 \* 2N/17 + 2.5 \* 4N/17 + 1 \* 10N/17)/N

= 40/17 = 2.35 Mbps

**Question 4:** One proposed solution to allow mobile users to maintain their IP addresses as they moved among foreign networks was to have a foreign network advertise a highly specific route to the mobile user and use the existing routing infrastructure to propagate this information throughout the network. We identified scalability as one concern. Suppose that when a mobile user moves from one network to another, the new foreign network advertises a specific route to the mobile user, and the old foreign network withdraws its route. Consider how routing information propagates in a distance-vector algorithm (particularly for the case of interdomain routing among networks that span the globe).

a. Will other routers be able to route datagrams immediately to the new foreign network as soon as the foreign network begins advertising its route?

b. Is it possible for different routers to believe that different foreign networks contain the mobile user?

c. Discuss the timescale over which other routers in the network will eventually learn the path to the mobile users.

**Solution**

1. No. All the routers might not be able to route the datagram immediately. This is because the Distance Vector algorithm (as well as the inter-AS routing protocols like BGP) is decentralised and takes some time to terminate. So, during the time when the algorithm is still running as a result of advertisements from the new foreign network, some of the routers may not be able to route datagrams destined to the mobile node.

1. Yes. This might happen when one of the nodes has just left a foreign network and joined a new foreign network. In this situation, the routing entries from the old foreign network might not have been completely withdrawn when the entries from the new network are being propagated.
2. The time it takes for a router to learn a path to the mobile node depends on the number of hops between the router and the edge router of the foreign network for the node.



**Question 5:** Suppose the correspondent in Figure 1 were mobile. Sketch the additional network-layer infrastructure that would be needed to route the datagram from the original mobile user to the (now mobile) correspondent. Show the structure of the datagram(s) between the original mobile user and the (now mobile) correspondent.

**Solution**

If the correspondent is mobile, then any datagrams destined to the correspondent would have to pass through the correspondent’s home agent. The foreign agent in the network being visited would also need to be involved, since it is this foreign agent that notifies the correspondent’s home agent of the location of the correspondent. Datagrams received by the correspondent’s home agent would need to be encapsulated/tunneled between the correspondent’s home agent and foreign agent.



**Question 6:** In mobile IP, what effect will mobility have on end-to-end delays of datagrams between the source and destination?

**Solution**

Because datagrams must be first forward to the home agent, and from there to the mobile, the delays will generally be longer than via direct routing. Note that it *is* possible, however, that the direct delay from the correspondent to the mobile (i.e., if the datagram is not routed through the home agent) could actually be smaller than the sum of the delay from the correspondent to the home agent and from there to the mobile. It would depend on the delays on these various path segments. Note that indirect routing also adds a home agent processing (e.g., encapsulation) delay.

**Question 7:** Consider two mobile nodes in a foreign network having a foreign agent. Is it possible for the two mobile nodes to use the same care-of address in mobile IP? Explain your answer.

**Solution**

Two mobiles could certainly have the same care-of-address in the same visited network. Indeed, if the care-of-address is the address of the foreign agent, then this address would be the same. Once the foreign agent decapsulates the tunneled datagram and determines the address of the mobile, then separate addresses would need to be used to send the datagrams separately to their different destinations (mobiles) within the visited network.