P4. For the two-sender, two-receiver example, give an example of two CDMA codes containing 1 and 21 values that do not allow the two receivers to extract the original transmitted bits from the two CDMA senders.

Sender 1: (1, 1, 1, -1, 1, -1, -1, -1)

Sender 2: (1, -1, 1, 1, 1, 1, 1, 1)

P5. Suppose there are two ISPs providing WiFi access in a particular café, with each ISP operating its own AP and having its own IP address block.

a. Further suppose that by accident, each ISP has configured its AP to operate over channel 11. Will the 802.11 protocol completely break down in this situation? Discuss what happens when two stations, each associated with a different ISP, attempt to transmit at the same time.

b. Now suppose that one AP operates over channel 1 and the other over channel 11. How do your answers change?

a) The SSIDs and MAC addresses of the two APs are usually different. When a wireless station arrives in the café, it will connect to one of the SSIDs (that is, one of the APs). There is a virtual link between the new station and the AP after association. The APs should be labeled as AP1 and AP2. Assume the new station is linked to AP1. A frame sent by the new station will be sent to AP1. AP2 will receive the frame as well, but it will not handle it because it is not directed to it. As a result, the two ISPs can operate simultaneously on the same channel. The two ISPs will, however, share the same wireless bandwidth. There will be a collision if wireless stations from different ISPs transmit at the same time. The two ISPs' highest aggregate transmission rate for 802.11b is 11 Mbps.

b) There will no longer be a collision if two wireless stations from different ISPs and thus distinct channels transmit at the same time. As a result, with 802.11b, the maximum combined transmission rate for the two ISPs is 22 Mbps.

P8. Consider the scenario shown in Figure 7.31, in which there are four wireless nodes, A, B, C, and D. The radio coverage of the four nodes is shown via the shaded ovals; all nodes share the same frequency. When A transmits, it can only be heard/received by B; when B transmits, both A and C can hear/ receive from B; when C transmits, both B and D can hear/receive from C; when D transmits, only C can hear/receive from D.

Suppose now that each node has an infinite supply of messages that it wants to send to each of the other nodes. If a message's destination is not an immediate neighbor, then the message must be relayed. For example, if A wants to send to D, a message from A must first be sent to B, which then sends the message to C, which then sends the message to D. Time is slotted, with a message transmission time taking exactly one time slot, e.g., as in slotted Aloha. During a slot, a node can do one of the following: (i) send a message, (ii) receive a message (if exactly one message is being sent to it), (iii) remain silent. As always, if a node hears two or more simultaneous transmissions, a collision occurs and none of the transmitted messages are received successfully. You can assume here that there are no bit-level errors, and thus if exactly one message is sent, it will be received correctly by those within the transmission radius of the sender.

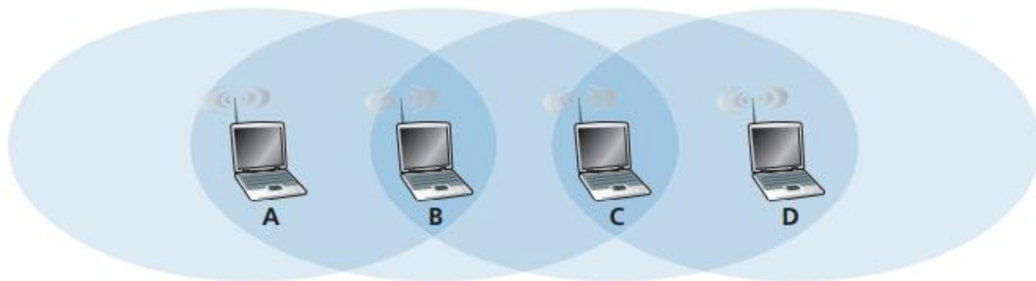

Figure 7.31 ♦ Scenario for problem P8

a. Suppose now that an omniscient controller (i.e., a controller that knows the state of every node in the network) can command each node to do whatever it (the omniscient controller) wishes, that is, to send a message, to receive a message, or to remain silent. Given this omniscient controller, what is the maximum rate at which a data message can be transferred from C to A, given that there are no other messages between any other source/destination pairs?

b. Suppose now that A sends messages to B, and D sends messages to C. What is the combined maximum rate at which data messages can flow from A to B and from D to C?

c. Suppose now that A sends messages to B, and C sends messages to D. What is the combined maximum rate at which data messages can flow from A to B and from C to D?

d. Suppose now that the wireless links are replaced by wired links. Repeat questions (a) through (c) again in this wired scenario.

e. Now suppose we are again in the wireless scenario, and that for every data message sent from source to destination, the destination will send an ACK message back to the source (e.g., as in TCP). Also suppose that each ACK message takes up one slot. Repeat questions (a)–(c) above for this scenario.

a) 1 message/ 2 slots

b) 2 messages/slot

c) 1 message/slot

d) i) 1 message/slot
   ii) 2 messages/slot
   iii) 2 messages/slot

e) i) 1 message/4 slots
   ii) slot 1: Message A to B, message D to C
       slot 2: Ack B to A
       slot 3: Ack C to D
       = 2 messages/ 3 slots
   iii) slot 1: Message C to D
       slot 2: Message D to C, message A to B
       slot 3: Ack B to A
       Repeat slot 1 to slot 3

P10. Consider the following idealized LTE scenario. The downstream channel (see Figure 7.22) 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 utilizes 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 your solution 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.

c. Suppose that the fairness criterion is that any node can receive at most twice as much data as any other node during the sub-frame. What is the average transmission rate by the base station (to all nodes) during the sub frame? Explain how you arrived at your answer.

a) If it simply transmits to node A, it will be 10 Mbps. This solution isn't fair because only A gets served. The term "fair" refers to each of the four nodes receiving an equal number of slots.

b) 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.

data transmitted to A in 1 slot = 10t Mbits

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

$n2 = 2*n1$

$n3 = 4*n1$

$n4 = 10*n1$

$n1+ n2+ n3+ n4 = N$

$n1+ 2\ n1 + 4\ n1 + 10\ n1 = N$

$n1 = N/17$

$n2 = 2N/17$

$n3 = 4N/17$

$n4 = 10N/17$

average transmission rate = $(10t*n1+5t*n2+ 2.5t*n3+t*n4)/tN = 2.35$ Mbps

c) Let node A receives twice as much data as nodes B, C, and D during the sub-frame.

$10tn1 = 2 * 5tn2 = 2 * 2.5tn3 = 2 * tn4$

$n2 = n1$

$n3 = 2n1$

$n4 = 5n1$

$n1 + n2 + n3 + n4 = N$
$n1 + n1 + 2n1 + 5n1 = N$
$n1 = N/9$

average transmission rate = $(10t*n1+5t*n2+ 2.5t*n3+t*n4)/tN$ = 2.78 Mbps

P11. In Section 7.5, one proposed solution that allowed 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.
a) No. It's possible that not all routers will be able to route the datagram right away. This is due to the fact that the Distance Vector method (along with inter-AS routing protocols like BGP) is decentralized and takes time to complete. As a result, some routers may be unable to route datagrams destined for the mobile node while the algorithm is still running as a result of ads from the new foreign network.
b) Yes. This can happen if one of the nodes has recently left one foreign network and joined another. In this case, the routing entries from the previous foreign network may not have been completely removed when the new network's entries were propagated.
c) The number of hops between the router and the edge router of the foreign network for the node determines how long it takes a router to discover a path to the mobile node.

P13. Consider a mobile device that powers on and attaches to an LTE visited network A, and assume that indirect routing to the mobile device from its home network H is being used. Subsequently, while roaming, the device moves out of range of visited network A and moves into range of an LTE visited network B. You will design a handover process from a base station BS.A in visited network A to a base station BS.B in visited network B. Sketch the series of steps that would need to be taken, taking care to identify the network elements involved (and the networks to which they belong), to accomplish this handover. Assume that following handover, the tunnel from the home network to the visited network will terminate in visiting network B.
P14. Consider again the scenario in Problem P13. But now assume that the tunnel from home network H to visited network A will continue to be used. That is, visited network A will serve as an anchor point following handover. (Aside: this is actually the process used for routing circuit-

switched voice calls to a roaming mobile phone in 2G GSM networks.) In this case, additional tunnel(s) will need to be built to reach the mobile device in its resident visited network B. Once again, sketch the series of steps that would need to be taken, taking care to identify the network elements involved (and the networks to which they belong), to accomplish this handover.
What are one advantage and one disadvantage of this approach over the approach taken in your solution to Problem P13?