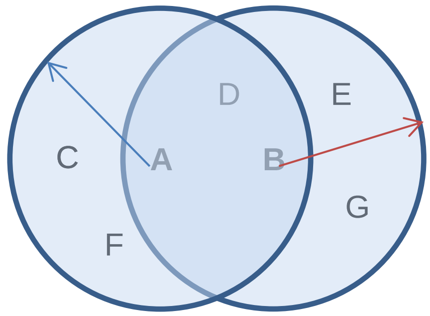
1. The following figure shows the physical distribution of several wireless stations.



a) If A initiates a transfer to B, what stations can cause the problem of "hidden station"?

Solution: E and G

b) The RTS / CTS protocol solves this problem. Explain how the protocol operate, specifically indicating which stations receive the RTS and which the CTS frames.

Solution:

The RTS/CTS protocol requires that before every data transmission the sender station sends a Request to Send (RTS) frame containing the length of the transmission, receiver station responds with a Clear to Send (CTS) frame and then the sender is allowed to send data.

Other stations which receive a RTS or CTS frame keep quiet until scheduled transmission is over.

D, B, C and F receive RTS frame

A, G, and E receive CTS frame

2. Briefly describe the four components of an 802.11 wireless network: the Distribution system, the Access Points, the Wireless Medium, and the Stations.

Solution:

- The *Distribution System* is responsible for communication between access points; it enables users to move from one access point to another. It is made up of one or more access points.
- An *Access Point* is connected to the distribution system, and acts as a bridge between the wired and wireless networks. It is a device that accepts and broadcasts messages from its NICs.
- The *Wireless Medium* for 802.11 networks is the air by use of radio frequencies. The communication can pass through walls and floors, which can be considered part of the medium.
- A *Station* is each computer on an 802.11 wireless network; it consists of the computer and the NIC.

3. What types of topologies can be used in an 802.11 wireless network?

Solution:

- There are two basic types of network topologies used by the 802.11 networks: 1) Independent networks, and 2) Infrastructure networks.
- *Independent networks* (also known as ad-hoc networks) can be formed without using access points; each station can connect directly to other stations in the network.
- *Infrastructure networks* can be structured with an access point that acts much like the hub of Ethernet networks; the access point serves as a centralized control unit to the network. This allows the stations to communicate with other stations that may be out of their range, which is an advantage over an independent network

4. What are the network services that are required in 802.11 wireless networks?

Solution:

- The 802.11 networks provide a total of nine network services to deal with its added complexity.

- The *Distribution* service is used by the access point to deliver messages it receives to the message's destination; all messages must travel through this service.
- The *Integration* service is provided by the distribution service; it is used to connect the access point to the wired Ethernet network.
- The *Association* service is a key feature of 802.11 networks, which is used to allow stations to connect to the network. In an infrastructure network, before a station can be connected to the network it must first associate itself with an access point.
- The *Reassociation* service allows stations the flexibility to evaluate which access point can provide the best connection; the station may reassociate itself with that access point.
- The *Disassociation* service allows stations to move from one access point to another.
- The Authentication service prevents unauthorized use of the network; all stations connecting to the network must be authenticated.
- The *Deauthentication* service terminates an authenticated relationship between a station and the network created by the authentication service.
- The *Privacy* service of wireless networks is the Wired Equivalency Privacy (WEP); it prevents unauthorized use of the network.
- The *MSDU Delivery* service is responsible for getting the data to the actual end point.

5. Assume all nodes are using 802.11 MAC. The radio range is fixed. Also the radio range is slightly longer than the inter-node distance i.e., each node can reach only its left and right neighbors. Assume currently node A is sending a data packet (as opposed to an ACK, an RTS, or a CTS) to node B. Node C wants to send a packet to node D.

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A-->B   C   D
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a) Assume node C (and only C) ignores the 802.11 MAC and sends the packet, would C's packet arrive safely at D? Would A's packet arrive safely at B? Explain.

Solution:

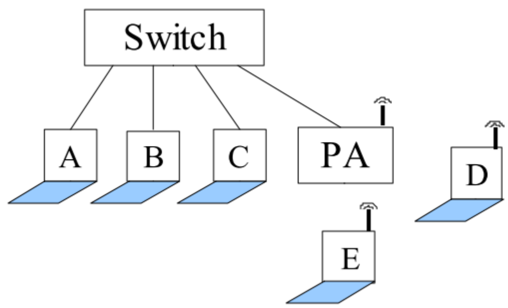
C's packet will arrive safely at D, while A's packet is unlikely to arrive safely at B.

b) Assume the same situation as above. If all nodes are using the 802.11 MAC, then C will wait until the end of A's transmission plus DIFS. When C uses 802.11, how does it know exactly when A's transmission end?

Solution:

C knows how long to wait from the NAV vector in the CTS sent by B.

6. The network in the figure below consists of an Ethernet switch that connects computers A, B, C, and the wireless access point PA. At this access point are associated mobile stations D and E.
   The switch knows the complete network configuration. ARP caches of all systems have the necessary information.
   Describe the frame or frames that are generated, in the following cases, until they reach the desired destination (to indicate the physical address of a device, use the name of that device: A, B, Switch, PA, ...):



a) A sends a frame to B

Nº	Tipo trama (Ethernet o 802.11)	Dir. Dest. o Dir. 1	Dir. origen o Dir. 2	Dir. 3
	Ethernet	B	A	----

b) A sends a frame to E

Nº	Tipo trama (Ethernet o 802.11)	Dir. Dest. o Dir. 1	Dir. origen o Dir. 2	Dir. 3
	Ethernet	E	A	---
	802.11	E	PA	A

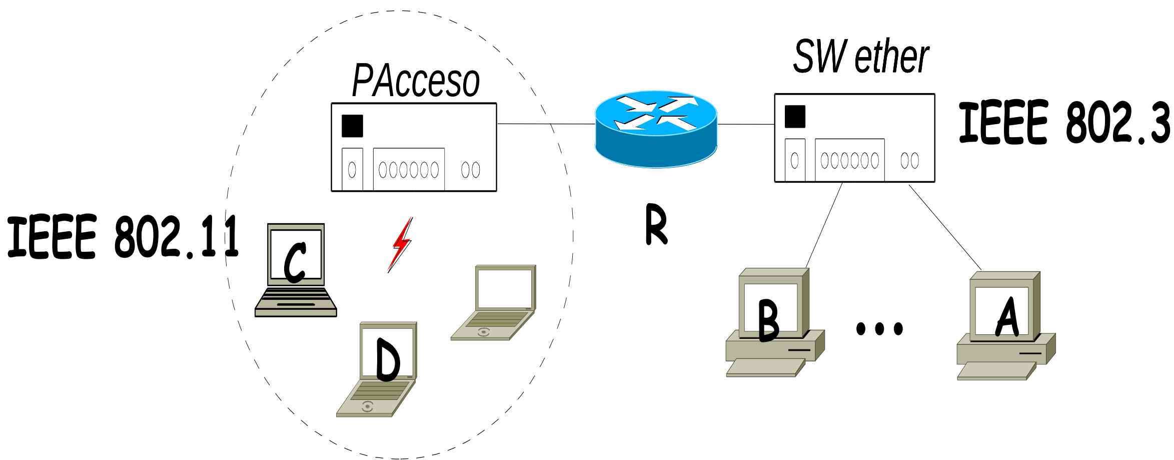
c) D sends a datagram to A

Nº	Tipo trama (Ethernet o 802.11)	Dir. Dest. o Dir. 1	Dir. origen o Dir. 2	Dir. 3
	802.11	PA	D	A
	Ethernet	A	D	---

d) D send a datagram to E

Nº	Tipo trama (Ethernet o 802.11)	Dir. Dest. o Dir. 1	Dir. origen o Dir. 2	Dir. 3
	802.11	PA	D	E
	802.11	E	PA	D

7. Consider the configuration in the following Figure:



a) In the table below, write the header fields of each frame when **A** sends a IP datagram to **D**. Only the ARP cache of **A** has all the necessary information for the transmission. ARP caches of other stations are empty. C and D are associated to the access point. Indicate the frames that arrive to network interface of C.

Frame	***Address 1*** ***(Destination)***	***Address 2*** ***(Sender)***	***Address 3***
1ª	FF: ...:FF (Broadcast)	AP	R_1 , Source
2ª	AP	D	R_1, destination
3ª	D	AP	R_1, Source

b) Function of the frame and type of information in its data field.

Solution:

1st frame: ARP request from R to find the physical address of D, the data field corresponds to the ARP protocol. ARP message contains the IP addresses of R and D, as well as the MAC address of R.

2nd frame: ARP reply from D to R, the data field corresponds to the ARP protocol. ARP message contains the same as frame 1 and also the MAC address of D.

3rd frame: contains the IP datagram sent by A. The type of information in the data field corresponds to the IP protocol.

c) Indicate if the network card (C) processes or discards the frame and the maximum level in the network architecture that analyzes the received information.

Solution:

C will process the 1^{st} frame, because the destination address is the broadcast address. The received information is processed by the ARP protocol.

The frames 2 and 3 are discarded because the destination address does not match with the MAC address of C.