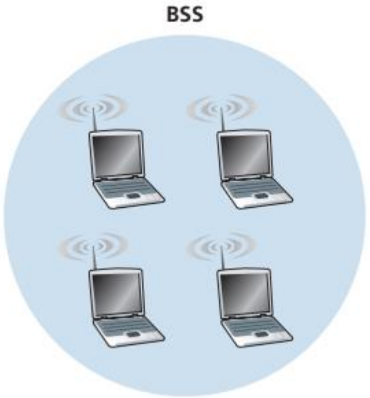
Wireless & Mobile Computing

First Semester 3rd Class

Lecture Six

2025/2024

Wi-Fi: 802.11 Wireless LANs



- Wireless LANs that deploy APs are often referred to as infrastructure wireless LANs, with the “infrastructure” being the APs along with the wired Ethernet infrastructure that interconnects the APs and a router.
- Figure shows that IEEE 802.11 stations can also group themselves together to form an ad hoc network—a network with no central control and with no connections to the “outside world.”
- An ad hoc network might be formed when people with laptops get together (e.g., in a conference room, a train, or a car) and want to exchange data in the absence of a centralized AP.

Wi-Fi: 802.11 Wireless LANs

- Each wireless station needs to associate with an AP before it can send or receive network-layer data.

- When a network administrator installs an access point (AP), they assign a Service Set Identifier (SSID), which is essentially the network name that identifies a specific wireless local area network (WLAN).
- The SSID is usually a one- or two-word label, but it can be up to 32 characters long, allowing it to include descriptive names that can help users easily identify and connect to the correct network.

Wi-Fi: 802.11 Wireless LANs

- **Unique Identifier**:
- Each SSID is unique to the AP or network it represents, allowing multiple networks in an area (like a building or a campus) to coexist without confusion.
- **Broadcasting**:
- By default, many APs broadcast the SSID, allowing users to see and select the network from their Wi-Fi settings.
- However, the administrator can disable SSID broadcasting for additional security, though users will need to enter the network name manually.

Wi-Fi: 802.11 Wireless LANs

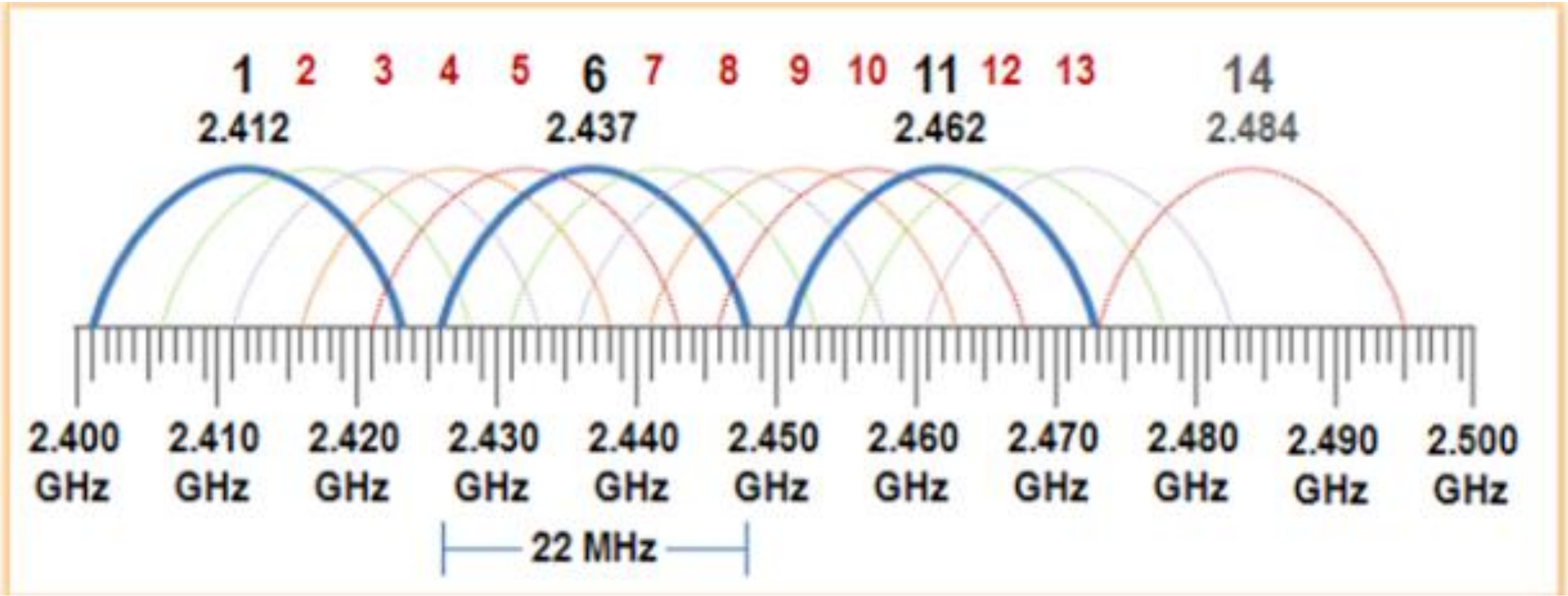
- The administrator must also assign a channel number to the AP.
- To understand channel numbers, recall that 802.11 operates in the frequency range of 2.4 GHz to <u>2.4835</u> GHz.

- In the 2.4 GHz frequency band used by 802.11 Wi-Fi,
- there are 11 channels available in most countries within an 85 MHz range (2.400 to 2.4*<u>85</u>* GHz).
- These channels are each 22 MHz wide and are partially overlapping.

Wi-Fi: 802.11 Wireless LANs

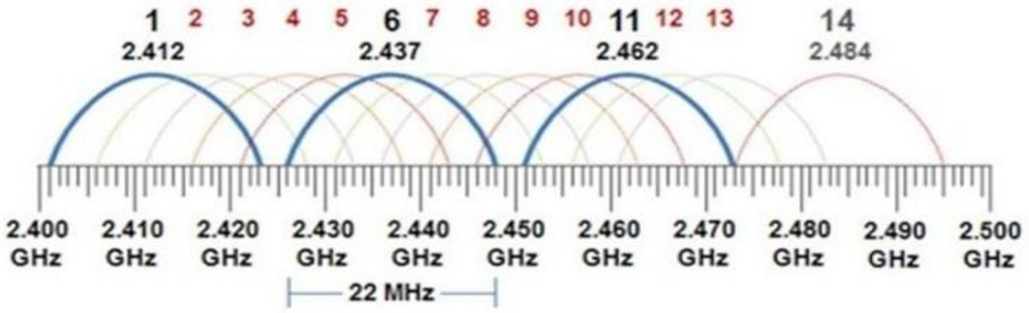
- **Non-Overlapping Channels in the 2.4 GHz Band:**
- In practice, only channels 1, 6, and 11 are considered non-overlapping in most regions. Here's why:
- Channel 1 occupies frequencies from 2.401 to 2.423 GHz.
- Channel 6 occupies frequencies from 2.426 to 2.448 GHz.
- Channel 11 occupies frequencies from 2.451 to 2.473 GHz.
- With a four-channel separation, these channels do not overlap, and using them helps reduce interference, especially in environments where multiple Wi-Fi networks or access points are in proximity.

Wi-Fi: 802.11 Wireless LANs

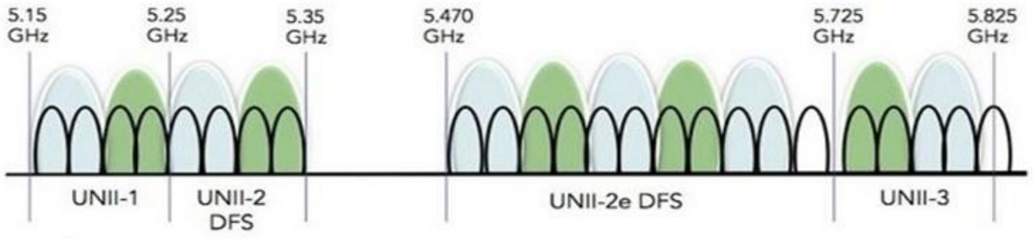


Wi-Fi: 802.11 Wireless LANs

2.4 GHz Bands



5 GHz Bands



Wi-Fi: 802.11 Wireless LANs

- **Partially overlapping channels:**
- Refer to channels that share portions of the same frequency range.
- This overlap can cause signal interference between devices operating on nearby channels, which can degrade network performance, particularly in the 2.4 GHz band used by the 802.11b/g/n standards.
- **How Partial Overlap Happens:**
- For channels to be non-overlapping, they must be separated by at least four channels.
- This separation ensures that the channels do not interfere with each other, as overlapping channels can lead to signal interference and reduced network performance.

Wi-Fi: 802.11 Wireless LANs

- A **Wi-Fi jungle** describes an environment crowded with multiple Wi-Fi networks and devices all competing for the same radio frequency spectrum, which is often found in **apartment complexes**, **offices**, **public venues**, and **urban areas**.
- **A Wi-Fi jungle** is any physical location where a wireless station receives a sufficiently strong signal from two or more APs.
- In many cafés City, a wireless station can pick up a signal from numerous nearby APs.
- One of the APs might be managed by the café, while the other APs might be in home near the café.
- Each of these APs would likely be located in a different IP subnet and would have been independently assigned a channel.

Wi-Fi: 802.11 Wireless LANs

- Now suppose you enter such a Wi-Fi jungle with your smartphone, tablet, or laptop, seeking wireless Internet access.
- Suppose there are five APs in the Wi-Fi jungle.
- To gain Internet access, your wireless device needs to join exactly one of the subnets and hence needs to associate with exactly one of the APs.
- Associating means the wireless device creates a virtual wire between itself and the AP.
- Specifically, only the associated AP will send data frames (that is, frames containing data, such as a datagram) to your wireless device, and your wireless device will send data frames into the Internet only through the associated AP.

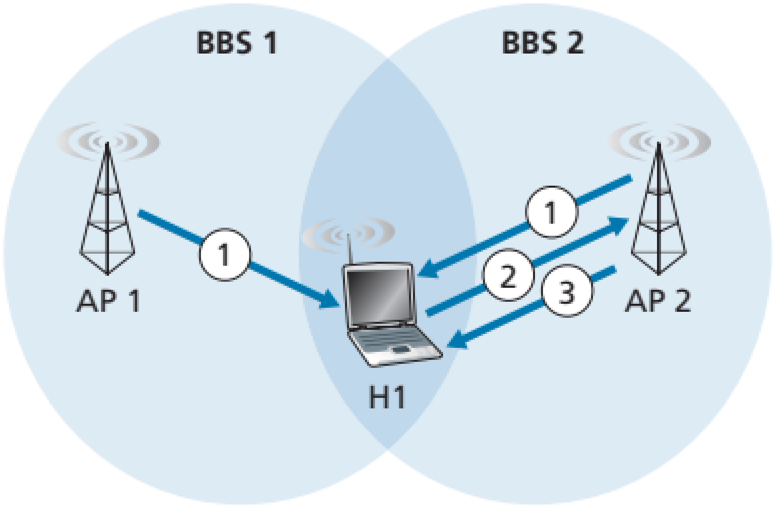
Wi-Fi: 802.11 Wireless LANs

- **How does your wireless device associate with a particular AP?**
- **How does your wireless device know which APs, if any, are out there in the jungle?**
- The 802.11 standard does not specify an algorithm for selecting which of the available APs to associate with;
- that algorithm is left up to the designers of the 802.11firmware and software in your wireless device.
- Typically, the device chooses the AP whose beacon frame is received with the highest signal strength.
- It's possible that the selected AP may have a strong signal, but may be overloaded with other affiliated devices.

Wi-Fi: 802.11 Wireless LANs

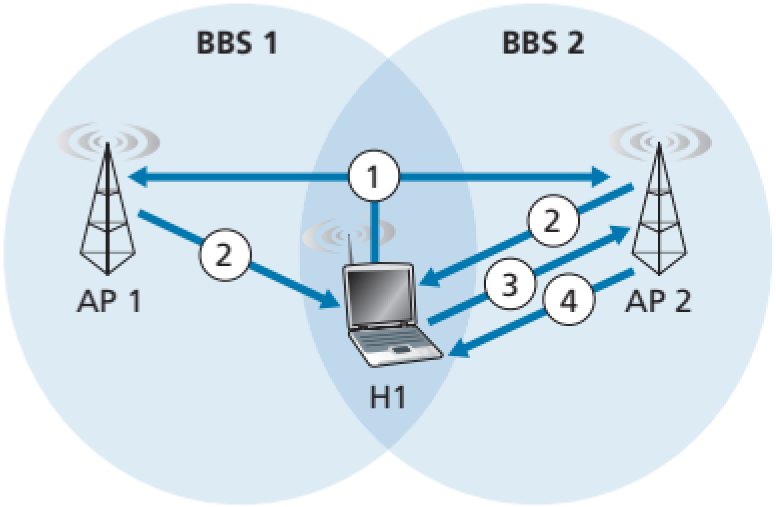
- The process of scanning channels and listening for beacon frames is known as passive scanning.
- A wireless device can also perform active scanning, by broadcasting a probe frame that will be received by all APs within the wireless device’s range, as shown in Figure.
- APs respond to the probe request frame with a probe response frame.
- The wireless device can then choose the AP with which to associate from among the responding APs.

Wi-Fi: 802.11 Wireless LANs



a. Passive scanning

1. Beacon frames sent from APs
2. Association Request frame sent: H1 to selected AP
3. Association Response frame sent: Selected AP to H1



a. Active scanning

1. Probe Request frame broadcast from H1
2. Probes Response frame sent from APs
3. Association Request frame sent: H1 to selected AP
4. Association Response frame sent: Selected AP to H1

Wi-Fi: 802.11 Wireless LANs

- After selecting the AP with which to associate, the wireless device sends an association request frame to the AP, and the AP responds with an association response frame.
- Note that this second request/response handshake is needed with active scanning, since an AP responding to the initial probe request frame doesn’t know which of the (possibly many) responding APs the device will choose to associate with.
- In order to create an association with a particular AP, the wireless device may be required to authenticate itself to the AP. 802.11 wireless LANs provide a number of alternatives for authentication and access.
- One approach, used by many companies, is to permit access to a wireless network based on a device’s MAC address. A second approach, used by many Internet cafés, employs usernames and passwords.

The 802.11 MAC Protocol

- Once a wireless device is associated with an AP, it can start sending and receiving data frames to and from the access point.
- But because multiple wireless devices, or the AP itself may want to transmit data frames at the same time over the same channel,
- a multiple access protocol is needed to coordinate the transmissions.
- The designers of 802.11 chose a random access protocol for 802.11 wireless LANs.
- This random access protocol is referred to as CSMA with collision avoidance, or more succinctly as CSMA/CA.
- As with Ethernet’s CSMA/CD, the “CSMA” in CSMA/CA stands for “carrier sense multiple access,” meaning that each station senses the channel before transmitting, and refrains from transmitting when the channel is sensed busy.

The 802.11 MAC Protocol

- Although both Ethernet and 802.11 use carrier-sensing random access,
- the two MAC protocols have important differences.
- First, instead of using collision detection, 802.11 uses collision-avoidance techniques.
- Second, 802.11 (unlike Ethernet) uses a link-layer acknowledgment/retransmission (ARQ) scheme.
- Ethernet’s collision-detection algorithm, an Ethernet station listens to the channel as it transmits. If, while transmitting, it detects that another station is also transmitting, it aborts its transmission and tries to transmit again after waiting a small, random amount of time.
- Unlike the 802.3 Ethernet protocol, the 802.11 MAC protocol does not implement collision-detection. WHY?

The 802.11 MAC Protocol

- There are two important reasons for this:
- The ability to detect collisions requires the ability to send (the station’s own
- signal) and receive (to determine whether another station is also transmitting) at the same time.
- Because the strength of the received signal is typically very small compared to the strength of the transmitted signal at the 802.11 adapter, it is costly to build hardware that can detect a collision.
- In 802.11 Wi-Fi networks, the received signal strength at the adapter is usually significantly weaker than the strength of the transmitted signal due to signal attenuation over distance, interference, and obstacles in the environment.
- This low signal strength makes it challenging to detect a collision.

CSMA/CA

- WLANs are half-duplex, shared media configurations.
- Half-duplex means that only one client can transmit or receive at any given moment.
- Shared media means that wireless clients can all transmit and receive on the same radio channel.
- This creates a problem because a wireless client cannot hear while it is sending, which makes it impossible to detect a collision.
- To resolve this problem, WLANs use *carrier sense multiple access with collision avoidance (CSMA/CA)* as the method to determine how and when to send data on the network.
- A wireless client does the following:

1. Listens to the channel to see if it is idle, which means that it senses no other traffic is currently on the channel. The channel is also called the carrier.

2. Sends a ready to send (RTS) message to the AP to request dedicated access to the network.

CSMA/CA

3. Receives a clear to send (CTS) message from the AP granting access to send.
4. If the wireless client does not receive a CTS message, it waits a random amount of time before restarting the process.
5. After it receives the CTS, it transmits the data.
6. All transmissions are acknowledged. If a wireless client does not receive an acknowledgment, it assumes a collision occurred and restarts the process.

Wireless Client and AP Association

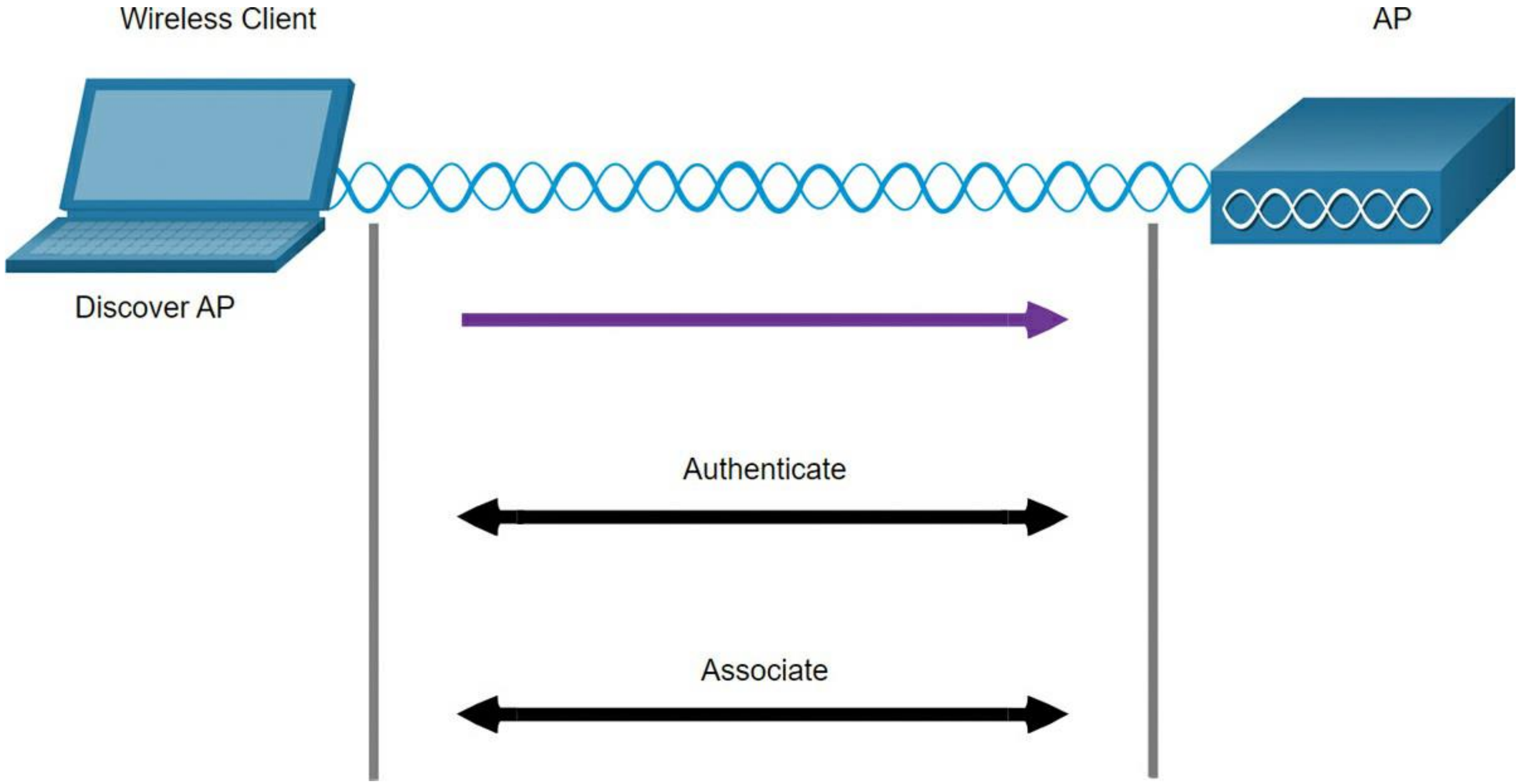
For wireless devices to communicate over a network, they must first associate with an AP or wireless router.

An important part of the 802.11 process is discovering a WLAN and subsequently connecting to it.

Wireless devices complete the three stage process.

Wireless Client and AP Association

1. Discover a wireless AP.
2. Authenticate with AP.
3. Associate with AP.



Wireless Client and AP Association

- To have a successful association, a wireless client and an AP must agree on specific parameters.
- Parameters must then be configured on the AP and subsequently on the client to enable the negotiation of a successful association.
- **SSID**
- The SSID name appears in the list of available wireless networks on a client.
- In larger organizations that use multiple VLANs to segment traffic, each SSID is mapped to one VLAN.
- Depending on the network configuration, several APs on a network can share a common SSID.
- **Password**
- This is required from the wireless client to authenticate to the AP.

Wireless Client and AP Association

- **Network mode**
- This refers to the 802.11a/b/g/n/ac/ad WLAN standards.
- APs and wireless routers can operate in a Mixed mode, meaning that they can at same time support clients connecting via multiple standards.
- **Security mode**
- This refers to the security parameter settings, such as Wired Equivalent Privacy (WEP), Wi-Fi Protected Access (WPA), WPA2, or WPA3. Always enable the highest security level supported.
- **Channel settings**
- This refers to the frequency bands used to transmit wireless data.
- Wireless routers and APs can scan the radio frequency channels and automatically select an appropriate channel setting.
- The channel can also be set manually if there is interference with another AP or wireless device.

Passive and Active Discover Mode

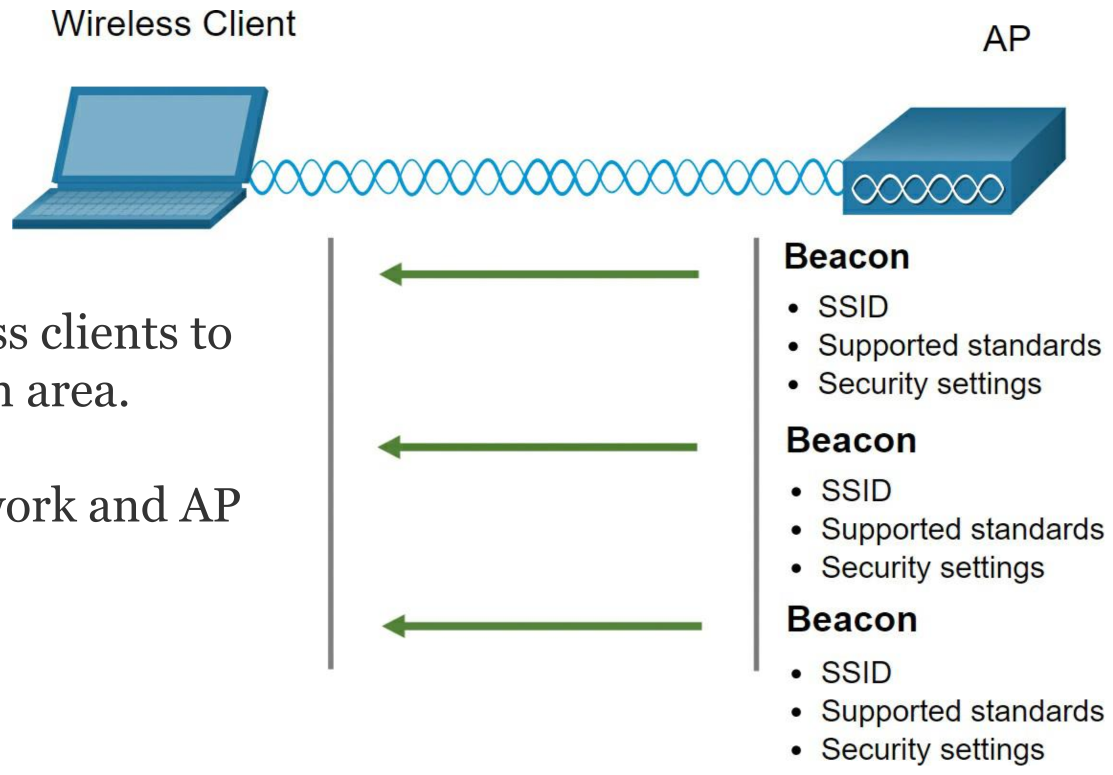
- Wireless devices must discover and connect to an AP or wireless router.
- Wireless clients connect to the AP using a scanning (probing) process.
- This process can be passive or active.

- **Passive Mode**
- In passive mode, the AP openly advertises its service by periodically sending broadcast beacon frames containing the
- SSID, supported standards, and security settings.

Passive and Active Discover Mode

- The primary purpose of the beacon is to allow wireless clients to learn which networks and APs are available in a given area.

- This allows the wireless clients to choose which network and AP to use.



Beacon

- SSID
- Supported standards
- Security settings

Beacon

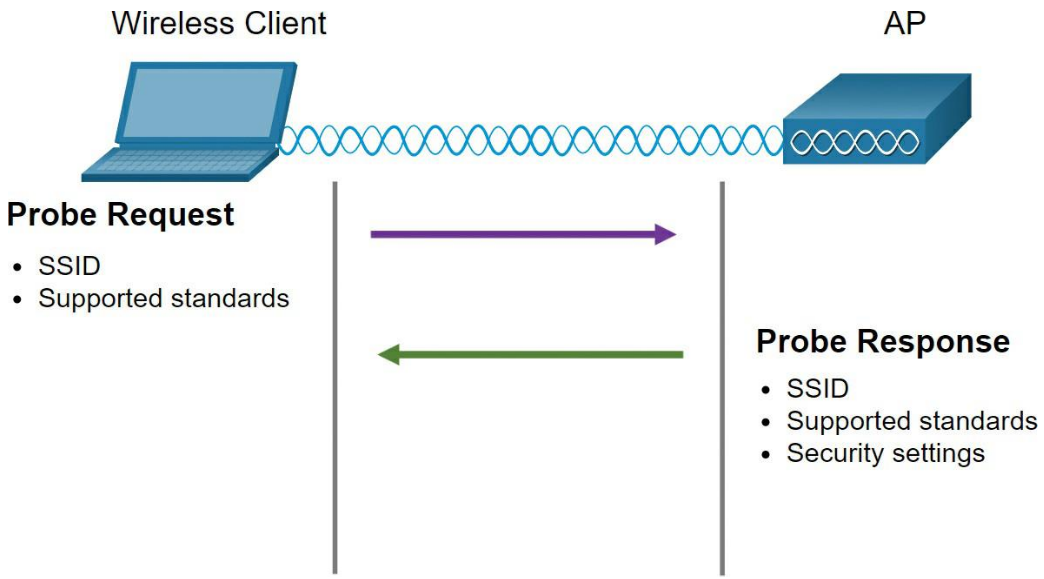
- SSID
- Supported standards
- Security settings

Beacon

- SSID
- Supported standards
- Security settings

Passive and Active Discover Mode

- **Active Mode**
- In active mode, wireless clients must know the name of the SSID.
- The wireless client initiates the process by broadcasting a probe request frame on multiple channels,



Wireless Client

AP

Probe Request

- SSID
- Supported standards

Probe Response

- SSID
- Supported standards
- Security settings

Passive and Active Discover Mode

- The probe request includes the SSID name and standards supported.
- APs configured with the SSID will send a probe response that includes the SSID, supported standards, and security settings.
- Active mode may be required if an AP or wireless router is configured to not broadcast beacon frames.
- A wireless client could also send a probe request without a SSID name to discover nearby WLAN networks.
- APs configured to broadcast beacon frames would respond to the wireless client with a probe response and provide the SSID name.
- APs with the broadcast SSID feature disabled do not respond.