Overview of Wireless Networking

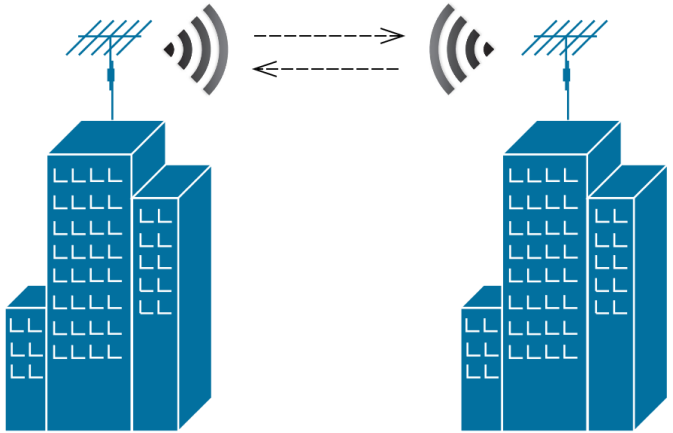
Overview of Wireless Networking

- **IEEE 802.11**: Standard for Wireless Networking
  - Been updated over the last 20 years with numerous improved 802.11 standards:
    - 802.11a
    - 802.11b
    - 802.11g
    - 802.11n
    - 802.11ac
- Wireless LANs (WLANs) use radio frequencies (RFs) that are radiated into the air from an antenna that creates radio waves.
- Can extend the connection of a wired network, used to connect entire local area networks or connect different networks together.

Depicting Wireless Networks

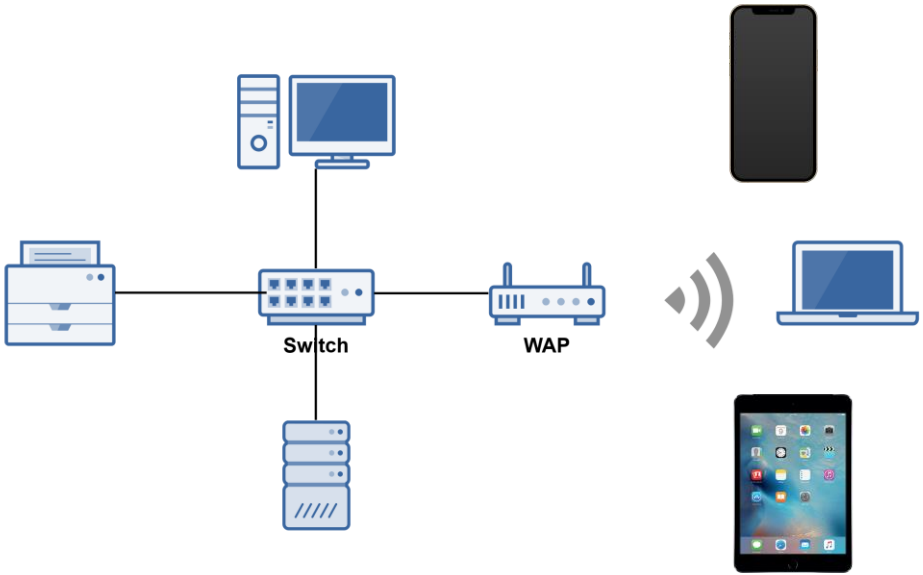
Traditional WLAN

Point-to-Point (P2P) Wireless



Wireless Access Point (WAP)

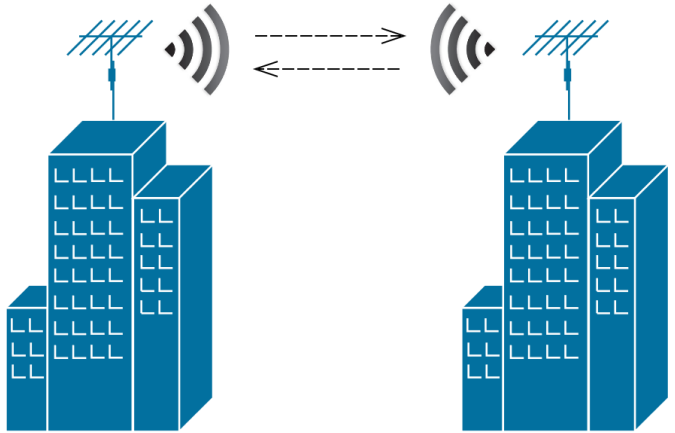
- A wireless access point (WAP) is a bridge that extends the wired network to the wireless network.
- Just like a switch and a wired bridge, it's a Data Link Layer 2 device.
- **Note**: A WAP is not a router.



Antennas

Omnidirectional

Unidirectional



- Antenna strength is measured in dBi. The higher the dBi, the further distance the signal will travel.

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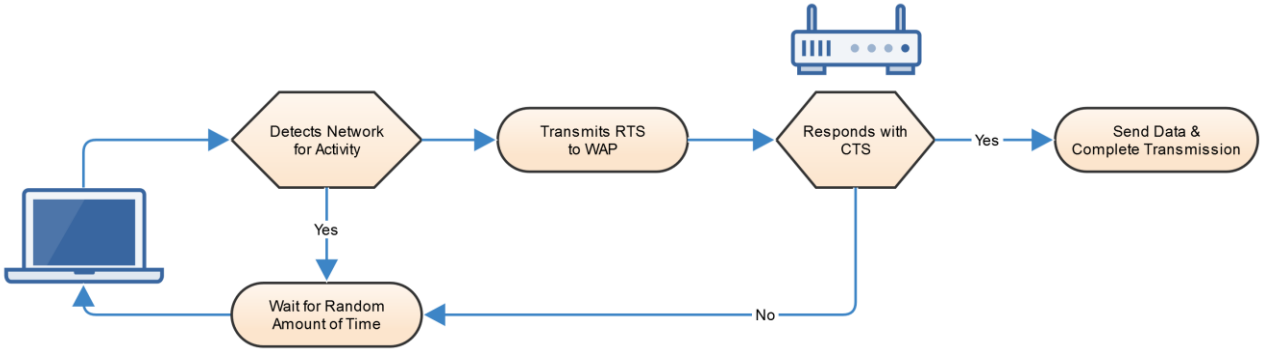
Service Set Identifier (SSID)

- All wireless networks have a service set identifier (SSID) in infrastructure mode.
- The SSID is the wireless network's name.
- Wireless access points broadcast a wireless network's SSID, so it is viewable by devices with a wireless network adapter.
- For network security reasons, SSID broadcasting can be disabled.

CSMA/CA

- **CSMA/CA**: Carrier Sense Multiple Access with Collision Avoidance
- While wired Ethernet networks use CSMA/CD, wireless Ethernet networks use CSMA/CA.
- With wireless networks, it's more difficult to detect collisions, so CSMA/CA tries to avoid them with RTS and CTS:
  - Request to Send (RTS)
  - Clear to Send (CTS)



Understanding Service Set Types

Service Set Types

- There are three service set types:
  - Independent Basic Service Set (IBSS)
  - Basic Service Set (BSS)
  - Extended Service Set (ESS)

Ad hoc Mode

Independent Basic Service Set (IBSS)

- Peer-to-peer (P2P) wireless network where no wireless access point (WAP) infrastructure exits.
- The devices communicate directly with one another.
- Personal area networks (PANs) are a common example of Ad hoc wireless networks.

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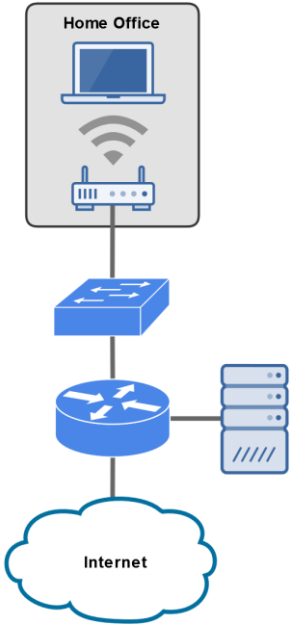
Infrastructure Mode

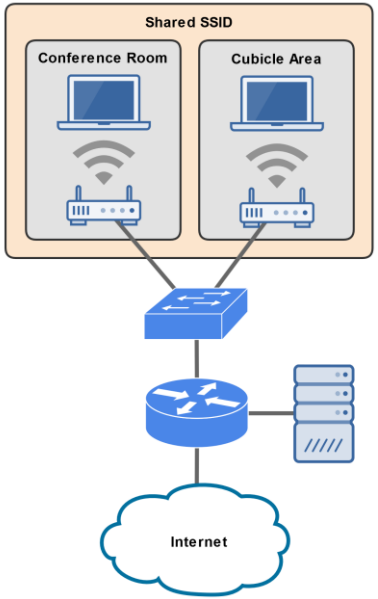
Basic Service Set (BSS)

- Single Wireless Access Point (WAP)
- Most common configuration



Extended Service Set (ESS)

- Multiple WAPs, utilizing the same SSID
- Allows wireless users to seamlessly “roam” from one WAP to another.



Wireless Frequencies and Channels

Understanding Wireless Frequencies

- Wireless signals occupy a spectrum of frequencies:
  - Signals that vibrate slowly have a low frequency.
  - Signals that vibrate quickly have a high frequency.
- For example:
  - **AM Radio**: 10MHz
  - **FM Radio**: 100MHz
  - **Microwave Oven**: 2.4GHz
  - **Cordless Phone**: 2.4GHz
- 802.11 Wireless operates at either 2.4GHz or 5GHz

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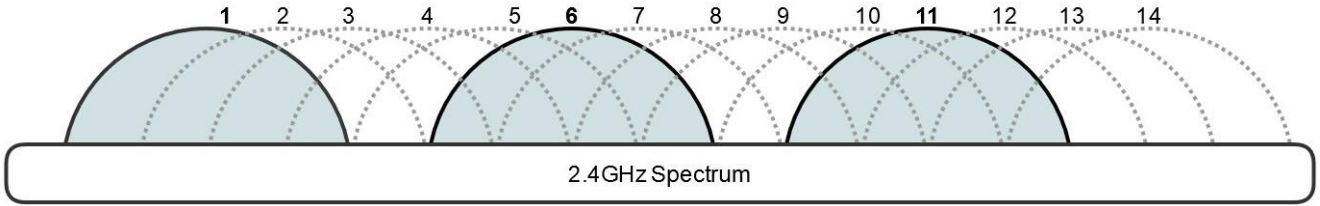
Understanding Wireless Channels

- 802.11 Wi-Fi communication also operates on a channel, which is a portion of the 2.4GHz or 5GHz spectrum.
- **2.4GHz Band**
  - Composed of 14 overlapping 20MHz channels. Due to licensing laws:
    - Only channels 1 through 11 available in the United States.
    - Most other countries allow channels 12 and 13.
    - Channel 14 is only available in Japan.
  - It's recommended to use channels 1, 6 or 11 because they do not overlap.
    - There are just 3 non-overlapping channels.



Understanding Wireless Channels

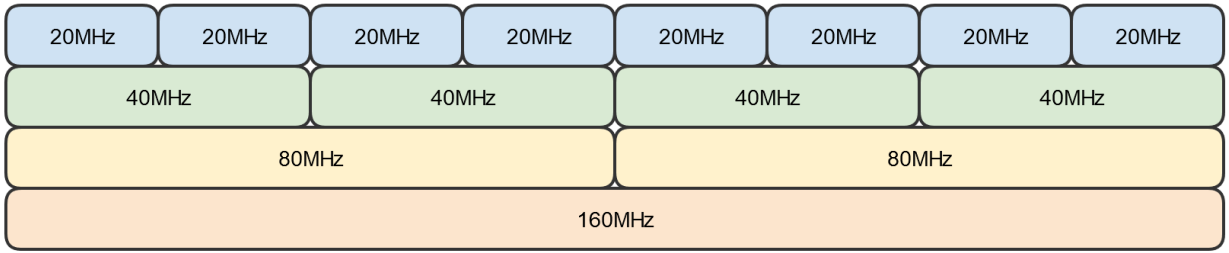
- **5GHz Band**
  - 5GHz offers significantly more channels than 2.4GHz.
  - There are roughly 40 different non-overlapping 20MHz channels.
  - Different countries have widely different rules for which channels can be used.
    - 24 non-overlapping channels available in North America.
  - 802.11 features 5GHz auto-channel switching.

Understanding Channel Bandwidth

- The width of a channel is a channel's bandwidth
- Expressed in MHz but equates to how many bits can be transmitted per second.
- The larger the channel bandwidth, the faster the data throughput.
- In 802.11, channel bandwidth varies from 20MHz up to 160MHz

Understanding Channel Bonding

- 802.11 provides a channel bonding feature:
  - When two adjacent channels are combined (bonded together) to increase bandwidth.
  - When channels are bonded together, their bandwidths doubles.
  - 20MHz channels can be bonded to 40MHz, 80MHz, or 160MHz Channels



2.4GHz versus 5GHz

2.4GHz Frequency Band

- Longer Frequency Waves
  - Prorogates through solid surfaces well
  - Good solution for long-distances
  - Slower data rates
- Lower data rates over longer distances
- Fewer Channels
  - 3 non-overlapping channels
- Suffers from frequency congestion & interference
  - Microwaves, cordless phones, and Bluetooth operate at 2.4GHz

5GHz Frequency Band

- Shorter Frequency Waves
  - Less effective penetrating solid surfaces
  - Not as effective over long-distances
  - Faster data rates
- Higher data rates over shorter distances
- More Channels
  - 24 non-overlapping channels
  - Channel bonding available
- Less congested than 2.4GHz frequency
  - Frequency congestion and interference isn't a big issue

802.11 Standards and MIMO

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802.11 Standards

	802.11	802.11a	802.11b	802.11g	802.11n	802.11ac	802.11ax
Date	1997	1999	1999	2003	2009	2014	2019
Frequency Band	2.4GHz	5GHz	2.4GHz	2.4GHz	2.4GHz & 5GHz	5GHz	2.4GHz & 5GHz
Channel Bandwidth	20MHz	20MHz	20MHz	20MHz	20/40MHz	20/40/80/160MHz	20/40/80/160MHz
Max Theoretical Rate	2Mbps	54Mbps	11Mbps	54Mbps	150Mbps	866Mbps	600Mbps
MIMO & Channel Bonding Throughput	N/A	N/A	N/A	N/A	600Mbps	6.9Gbps	9.6Gpbs
Backwards Compatibility	N/A	N/A	802.11	802.11b	802.11a/b/g	802.11a/n	802.11a/b/g/n/ac

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Understanding MIMO

- MIMO (Multiple Input, Multiple Output)
  - Wireless technology that uses multiple antennas to increase data transfer speeds.
  - Requires multiple antennas on the WAP and wireless NIC.
  - Wireless devices can make multiple simultaneous connections to a Wi-Fi router utilizing several antennas.
- While speeds increase, only one person can transmit data at a time
  - Commonly Called Single-User MIMO (SU-MIMO)
  - 802.11n utilizes SU-MIMO
  - With up to four antennas, 802.11n can increase its single-channel speeds from 150Mbps to 600Mbps.

Multiple User MIMO (MU-MIMO)

- 802.11ac introduces the use of Multiple User MIMO (MU-MIMO)
- MU-MIMO allows multiple users to communicate with a WAP at the same time.
  - Huge technological advancement for wireless networking.
- Drastically improves network speeds and greatly reduces network latency.
  - It's as if each device has its own WAP.
  - 802.11ac and 802.11ax support MU-MIMO connections.

Deploying Wireless Networks

Deploying Wireless Networks

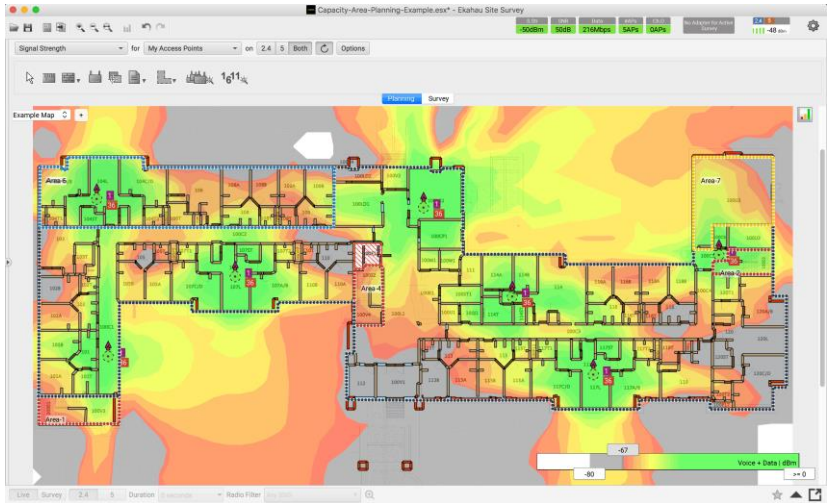
- When planning to deploy a wireless network, there are a variety of factors to consider:
  - Site Surveys
  - Speed and Distance Requirements
  - Signal Degradation & Interference
  - WAP Placement & Channel Selection
  - Antenna Types
  - Network Security Considerations

Site Surveys

- The first thing you should do when deploying a wireless network is perform a site survey.
- A site survey involves:
  - Analyzing the physical site via building blueprints
  - Performing a physical building walk-through inspection
  - Using a wireless survey tool

Wireless Survey Tools

- A wireless survey tool is specialized software that allows you to perform wireless network analysis and optimization.
  - Discover existing wireless networks
  - Temporarily set-up new WAPs
  - Perform network heat maps to optimize:
    - WAP Placement
    - Channel Selection
    - Antenna Selection



Ekahau Survey Example Heat Map

Speed & Distance Requirements

- Understand your speed and distance requirements:
  - What speeds does your WLAN need to support?
  - How many concurrent users?
  - 802.11 backward compatibility requirements?
- Signal degradation and interference factors should also be considered.

	802.11n	802.11ac	802.11ax
MIMO & Channel Bonding Throughput	600Mbps	6.9Gbps	9.6Gpbs
Approximate Indoor Range	70m (230ft)	35m (115ft)	30m (98ft)

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Signal Degradation & Interference

- When installing a wireless network, signal degradation and interference are two very important issues to consider.
- Advertised distances are rarely real-world distances.
- The weaker the signal, the less reliable the network connection will be and the lower the effective data rate.
- Some Key Factors that affect signal strength:
  - Distance, Walls, Trees & Other Barriers
  - WAP Channel Interference
  - 2.4GHz Interference Sources:
    - Bluetooth Devices
    - Cordless Phones
    - Microwaves



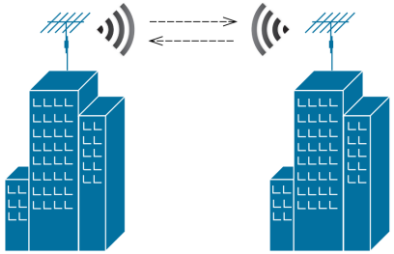


Revisiting Antenna Types

Omnidirectional

- Signal radiates equally in all directions.
- Commonly ceiling-mounted.

Unidirectional



- Focuses wireless signal in one direction.

- Antenna strength is measured in dBi. The higher the dBi, the further distance the signal will travel.

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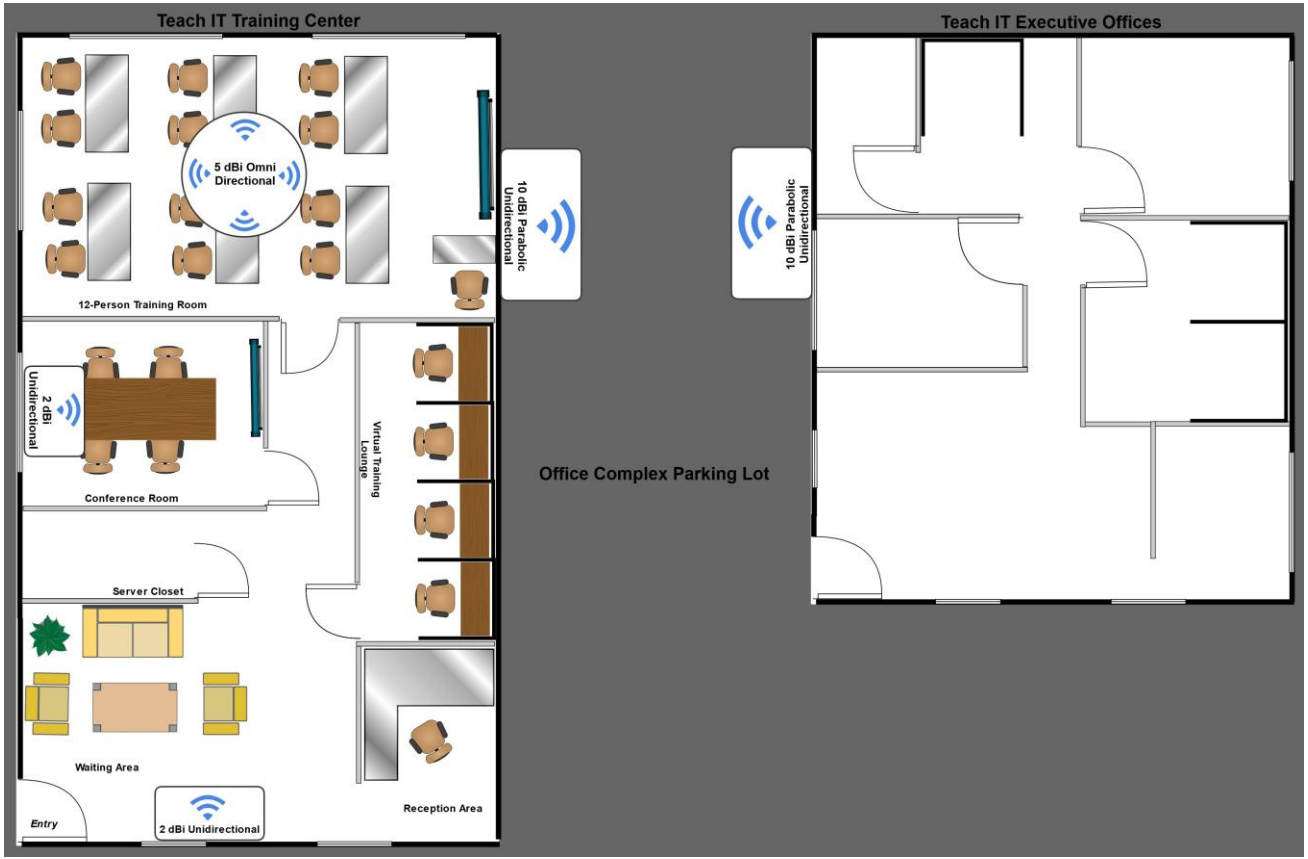
Antenna Selection & Placement



Network Security Considerations

- It’s vitally important to secure your wireless network with proper authentication and encryption measures in place.
- We’ll introduce these concepts in the next lecture.

Wireless Network Vulnerabilities & Security

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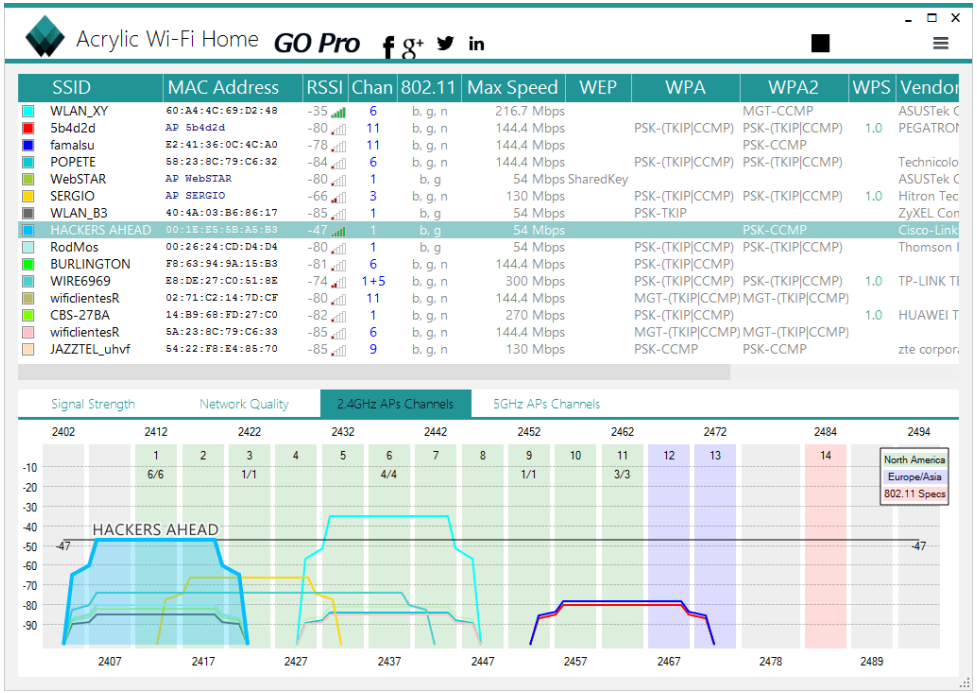
Wireless Networking Security Vulnerabilities

- A significant vulnerability of wireless networks is that they broadcast network traffic over the air.
- Since data freely emanate over the air, anyone can intercept it with a transceiver tuned to the correct frequency.
- Since IEEE standardizes the frequencies, they're easy to learn by hackers.



Securing Wireless Network Essentials

- Decrease its Signal Footprint:
  - Lower its Signal Strength and/or Range.
- Implement a Security Protocol
  - WPA2 or WPA3
  - 802.1x (Centralized Authentication)
  - **DO NOT** use WEP or WPA
- Change the Default Administrator Password
- Implement Authentication
- Disable SSID Broadcasting
- Change the Default SSID
- Enable MAC Filtering
- Update Firmware Regularly

Internet of Things (IoT)

Internet of Things (IoT)

- Internet of Things (IoT) describes embedding computing and networking capabilities into everyday objects.
- There are a variety of IoT technologies:
  - Z-Wave
  - ANT+
  - Bluetooth
  - NFC
  - IR
  - RFID
  - 802.11

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Z-Wave

- Wireless protocol used for home automation.
- Common Z-Wave Smart Devices:
  - Smart Door Locks
  - Smart Light Bulbs
  - Smart Doorbells
  - Smart Garage Door Openers
  - Smart Motion Sensors
  - Smart Thermostats

ANT+

- A wireless protocol designed to monitor sensor data that operates at the 2.4GHz frequency band.
- It's maintained by the ANT+ Alliance, which is owned by Garmin, which is why a majority of ANT+ devices are focused on health and fitness.
- Common ANT+ Devices:
  - Heart Rate Monitor
  - Blood Pressure Monitor
  - Bicycle Computers
  - Bicycle Power Meters
  - Bicycle Tire Pressure Monitor

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Bluetooth

- A very popular wireless communication protocol for personal area networks (PANs).
- Operates at the 2.4GHz frequency band.
- Considered a market leader for short-distance wireless communications.
- Common Bluetooth Devices:
  - Speakers
  - Headsets

Near Field Communication (NFC)

- A wireless communication protocol that enables two devices to transfer information over distances of 4 cm (1.6 inches) or less.
- Most commonly used in “tap to pay” payment systems.

Infrared (IR)

- A wireless communication protocol that has been around for a very long time.
- Uses infrared beams to send data transmissions with a limited range of generally 30 feet or less that requires a direct line of sight.
- Common IR devices:
  - Television Remotes
  - Keyboards
  - Thermometer

Radio-Frequency Identification (RFID)

- Uses electromagnetic fields to automatically identify and track tags attached to objects.
- Commonly used for supply chain and inventory management purposes, as well as door access cards.
- Tags contain electronically-stored information and “proximity readers” are able to read data stored on RFID tags.

802.11

- A majority of this section was dedicated to 802.11.
- Traditional Wi-Fi can also be used for IoT applications.