ICT SKILLING FOR SCHOOLS

Wireless Networks

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Outline

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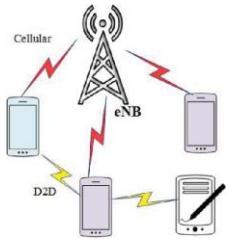
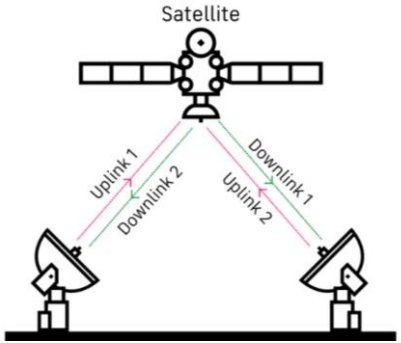
Summary

- Introduction to Wireless Communication
- Overview of Wireless LAN
- Deployment of Wireless LAN
- Troubleshooting
- Practical Session

Introduction - Wireless Communication

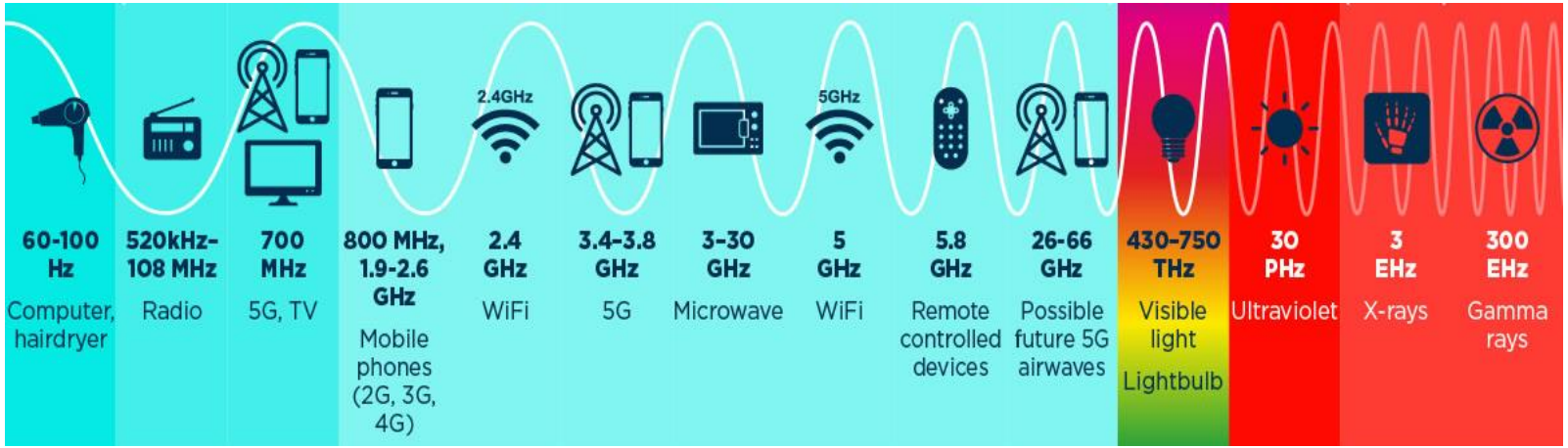
- A form of communication that uses electromagnetic waves to convey data.
- The convenience of wireless communication has spurred its rapid development
- Important wireless data communication technologies today:
  - Mobile communication e.g., 4G+, 5G, 6G
  - Wireless LAN e.g., Wi-Fi 6, 6E, 7
  - Satellite communication e.g., Starlink, OneWeb





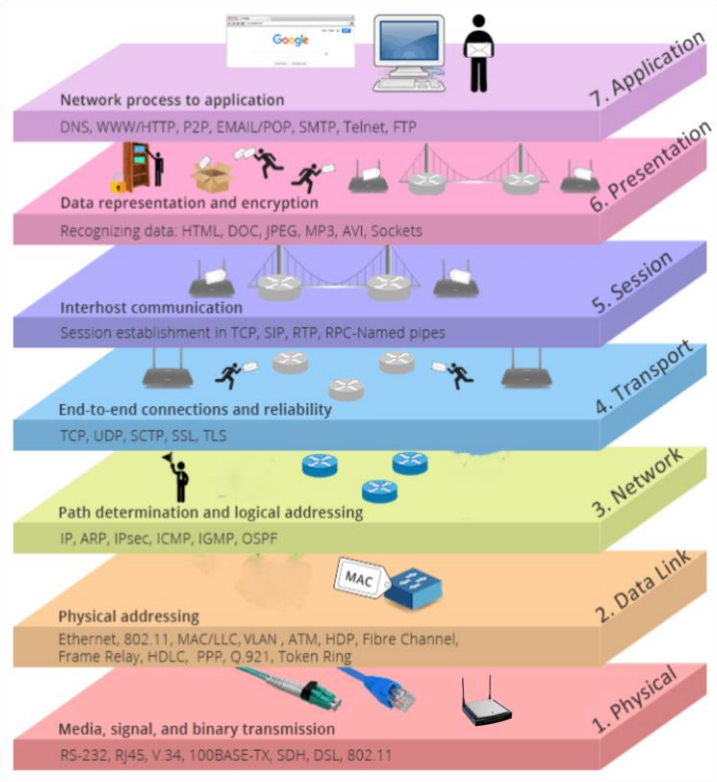
Wireless Communication Spectrum

- All wireless communication technologies share the same physical medium
- Each wireless technology is allocated a range of frequencies for its operation
- Frequency band allocations are managed by the **ITU - Radiocommunication Sector**



Wireless Networks

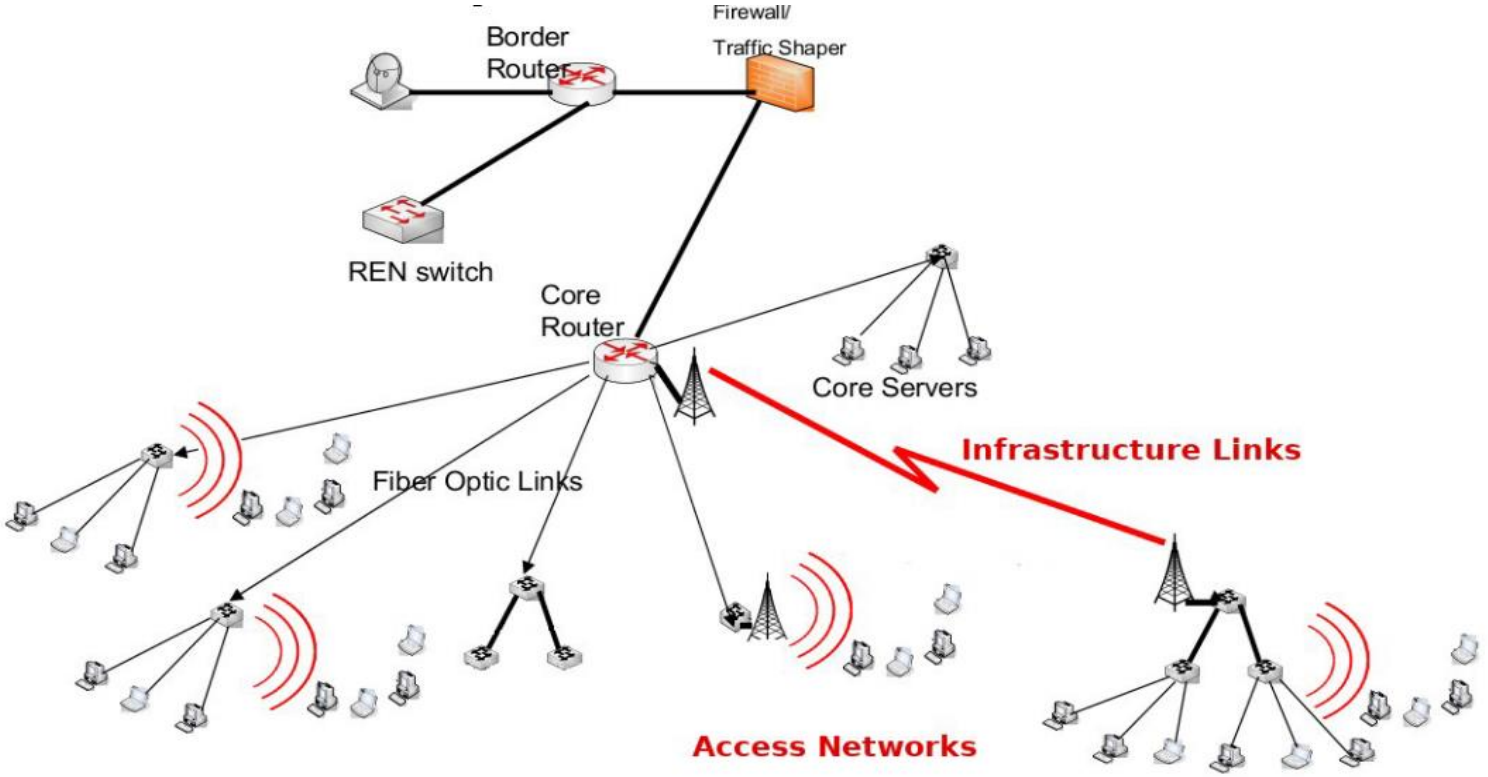
- A wireless network is a type of computer network that uses wireless data connections for connecting network nodes.
- Wireless communication works at the physical layer in a layered computer network architecture.



Wireless Networks - Applications

- Infrastructure links
  - ISP last mile links - Deliver connectivity the school premises
  - LAN extensions (PTP or PTMP links)
- Access network for users and smart gadgets
  - The most popular use of and most needed use of wireless networks
  - Improved mobility
  - Relatively easy to scale

Wireless Networks - Applications



Wireless Networks Terminologies

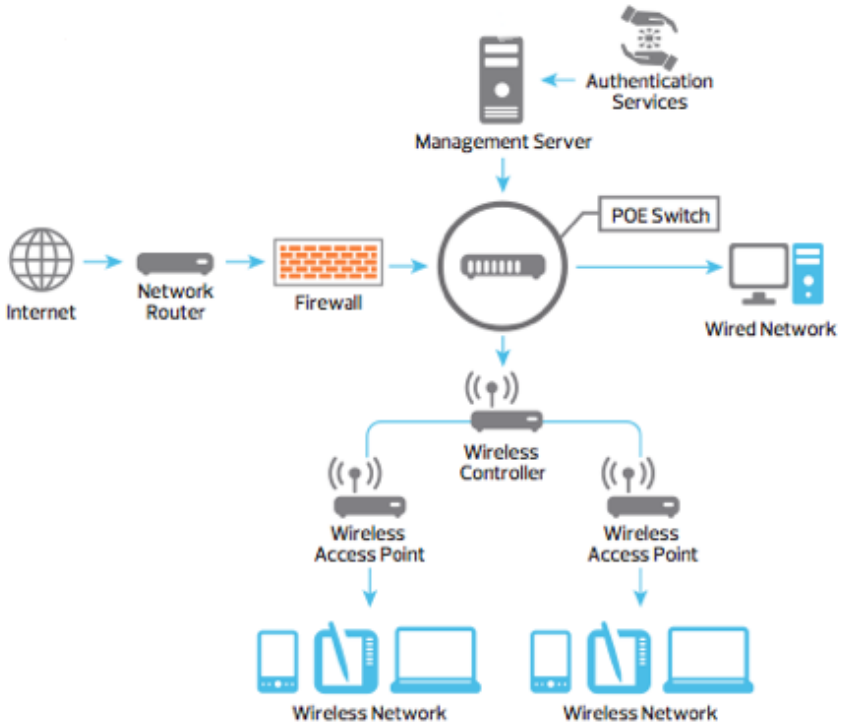
- **AP** (Access Point) – A wireless device that allows wireless-capable devices to connect to a wired network.
- **Wireless Clients –** Devices, like laptops, smartphones, that connect to a wireless network
- **SSID** (Service Set Identifier) - The "Network Name" Often human readable.
- **dBm** (decibel milliwatt) – A unit of measuring the signal strength/power.
- **RSSI** (Received Signal Strength Indicator) - A measure of the amount of power received by a radio unit. The RSSI is indicated by a negative dBm value
- **SNR** (Signal to Noise Ratio) – A measure of how clean the received signal is

Wireless Networks Terminologies

- **Frequency Bands–** Specific frequency range on the electromagnetic spectrum assigned a specific application
- **Channel Bandwidth** – Frequency range occupied by a particular channel
- **Interference –** Disruption of wireless signals caused by overlapping frequencies
- **Line of Sight** (LOS) – A direct straight path between radios antennas

Key Components of a Wireless Network

- Access Point (AP)
- Wireless Controller
- Wireless Clients
- Antenna
- Authentication server



Access Points

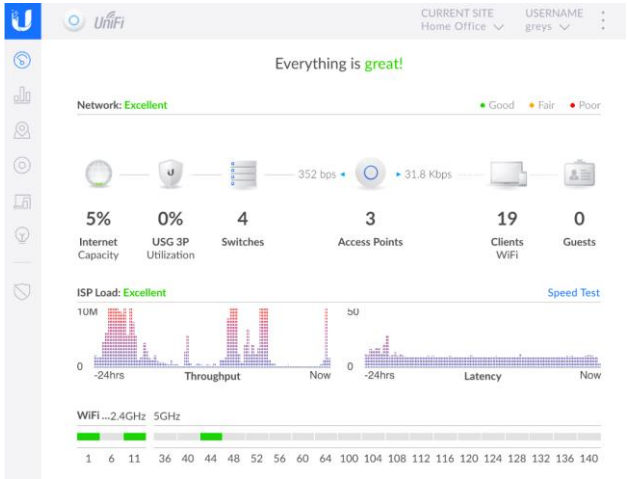
Outdoor APs

Indoor APs

Point to Point Radios

Wireless Controllers

- Vendor specific
- They can be;
  - **Software-based** (Installed on a physical or Virtual Machine)
  - **Hardware-based**



What is Wi-Fi?

- Wi-Fi is a trademark for an alliance
  - Not strictly a **technical term**
  - The alliance tests and certifies products for compliance
- Wi-Fi is used to refer to **802.11** family of wireless standards

What are the Wi-Fi Standards?

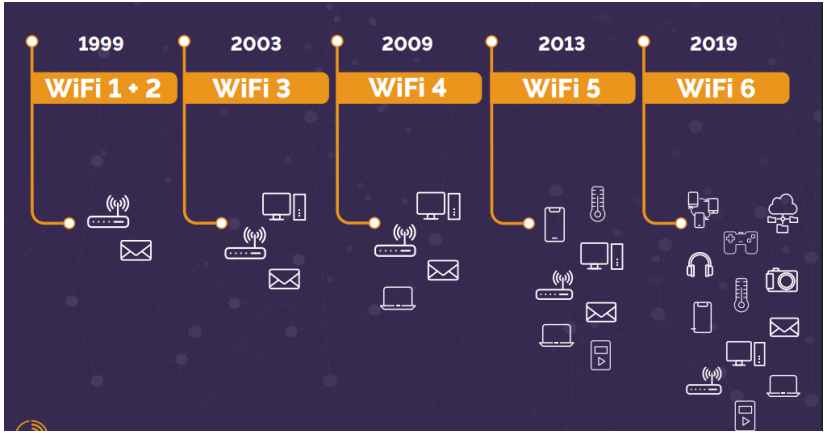
Why do we need standards for Wi-Fi?

Wi-Fi Standards

- Rules and protocols that govern how wireless devices communicate
- Developed by IEEE's LAN/MAN Standards Committee (LMSC) – **IEEE 802**
- Ensure compatibility and performance between wireless devices from various vendors

Wi-Fi Standards - Evolution

- Wi-Fi standards have evolved to increase;
  - Bandwidth and throughput
  - Overall network performance



Wi-Fi Standards – Evolution Cont'd

Standard	New Name	Year	Data rate [Mbps]	Frequency [GHz]	System Spectral Efficiency [bps/Hz]	Channel Access
802.11b	(Wi-Fi 1 unofficial)	1999/2012	11	2.4	0.2	DSSS
802.11a	(Wi-Fi 3 unofficial)	2003	54	5	0.9	OFDM
802.11g	(Wi-Fi 2 unofficial)	1999/2012	54	2.4	0.9	DSSS, OFDM
802.11n	**Wi-Fi 4**	2009	150/300/600	2.4 / 5	5	DSSS, OFDM, MIMO
802.11ac	**Wi-Fi 5**	2013	1300	5	14.4	OFDM, Mu-MIMO
802.11ax	**Wi-Fi 6**	2021	9600 (?)	2.4 / 5	20	OFDM, Mu-MIMO
802.11ax w 6 Ghz	**Wi-Fi 6E**	2021	9600 (?)	2.4 / 5 / 6	20	OFDM, Mu-MIMO

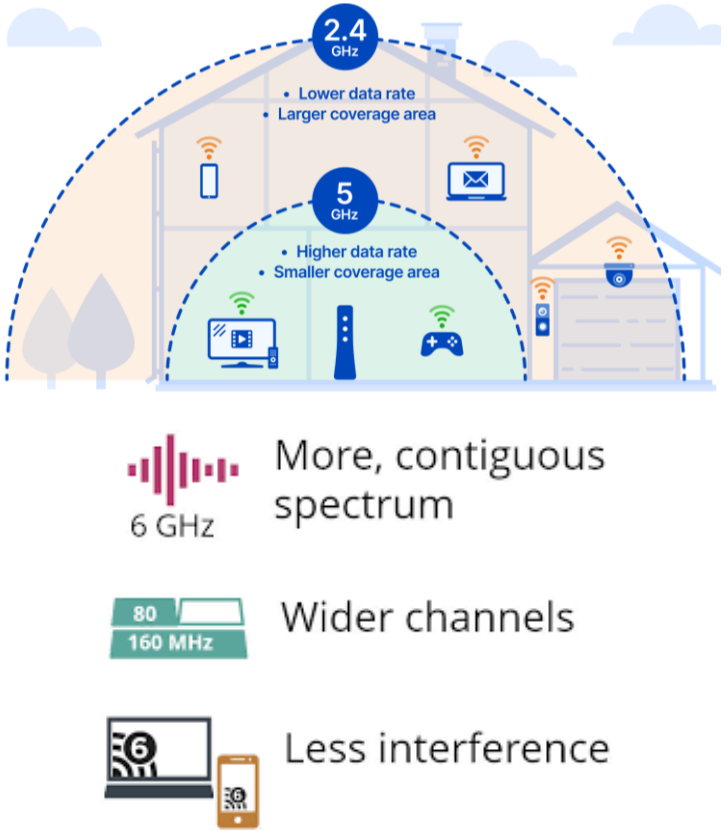
Emerging Wi-Fi Standards

- **Wi-Fi 7 – 802.11be**
  - Maximum Speed – up to **46 Gbps**
  - Channel Bandwidth – up to **360MHz**

Standard	Data rate [Mbps]	Frequency	Channel Access
802.11ad	>6000	60 GHz	Milimetre waves Very short range
802.11af	10-100	2.4	TV White Spaces Non Line of Sight

Frequency Bands

- Frequencies in wireless networks determine;
  - **Coverage and Range**
    - Lower frequencies have a better range and can easily penetrate compared to higher frequencies
  - **Bandwidth**
    - Higher frequencies offer more bandwidth compared to lower frequencies



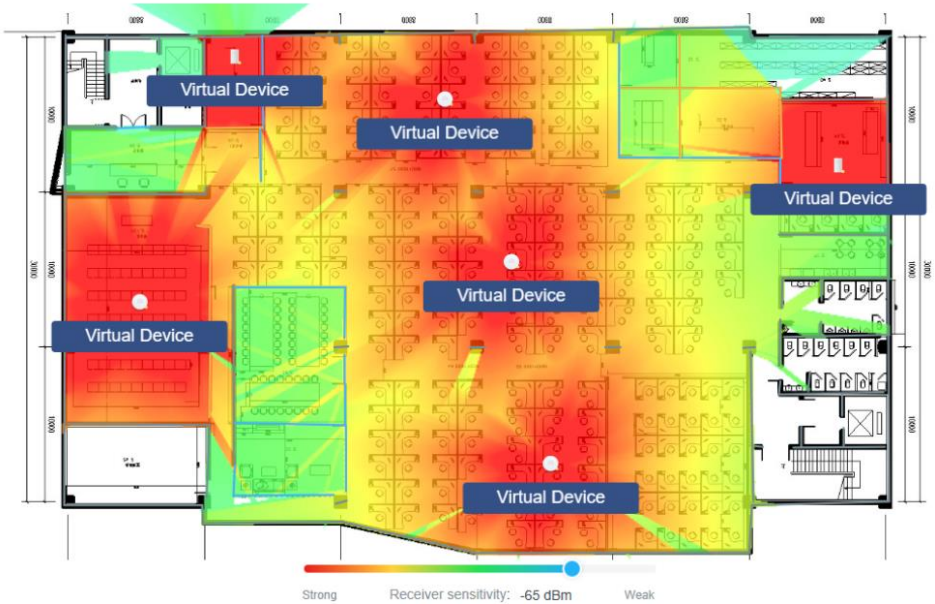
Wireless LAN Deployment

Wireless Network Planning

- **Planning is required;** needed to solve new problems wireless brings
  - Site Survey is mandatory
  - Frequency monitoring & management
  - Reach & Power planning: Link budgets, Antennas
  - SSID planning: Names matter!
  - Rogue activity monitoring and management
  - Plan Subnet Sizes
    - Tradeoff between roaming ease & network scalability

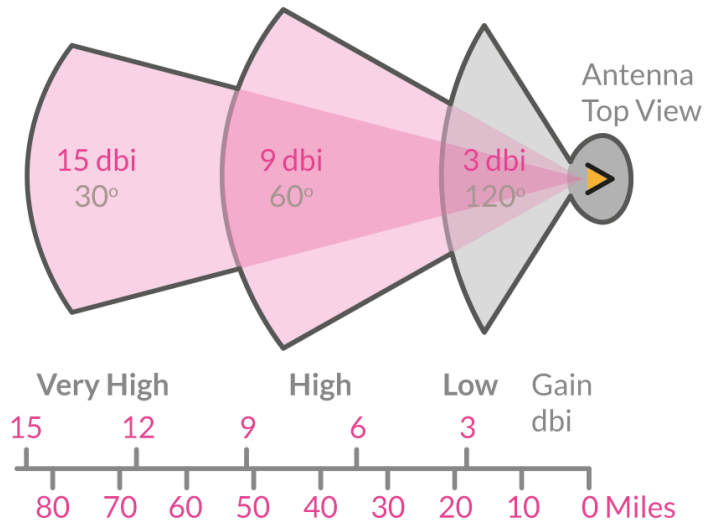
Wireless Network Planning - Tools

- Vendors offer free proprietary design platforms to aid your WLAN planning
  - Unifi Design Center
  - TP-Link Omada Heat Map
  - Cambium Wi-Fi Designer
  - Netspot
    - Limited feature access
    - Multivendor support



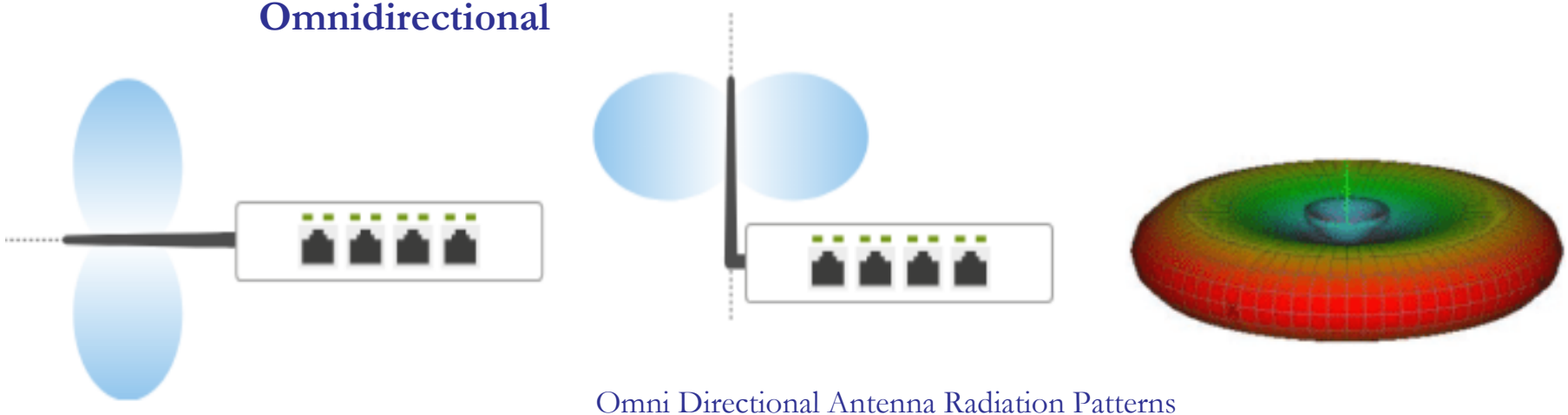
Choosing a wireless Access Point

- Cloud Management
  - Unifi, TP-Link Omada, D-Link, Cambium, et
- Wi-Fi Technology
  - MIMO, MESH, PoE, Beam forming
- Antenna Gain
  - The higher the better for long range coverage
- Antenna Type
  - Directional Vs Omni directional antennas
- Speed
- Number of simultaneous connections supported



Wireless AP Placement

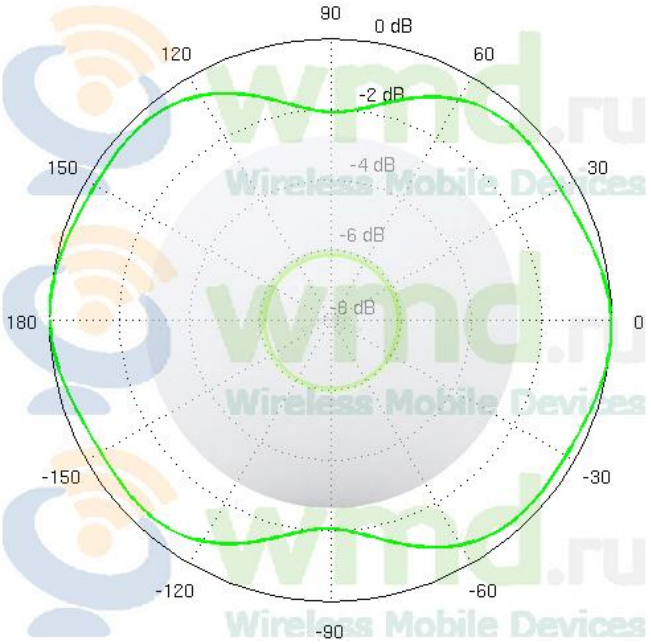
- Access point mounting and location are critical for effective Wi-Fi coverage
- Based on the antenna radiation pattern – **Directional Vs Omnidirectional**

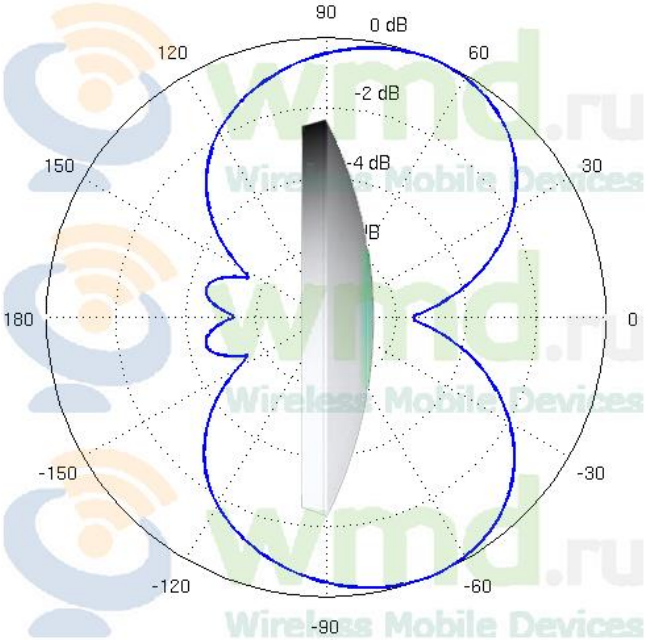


Omni Directional Antenna Radiation Patterns

Wireless AP Placement – Cont'd

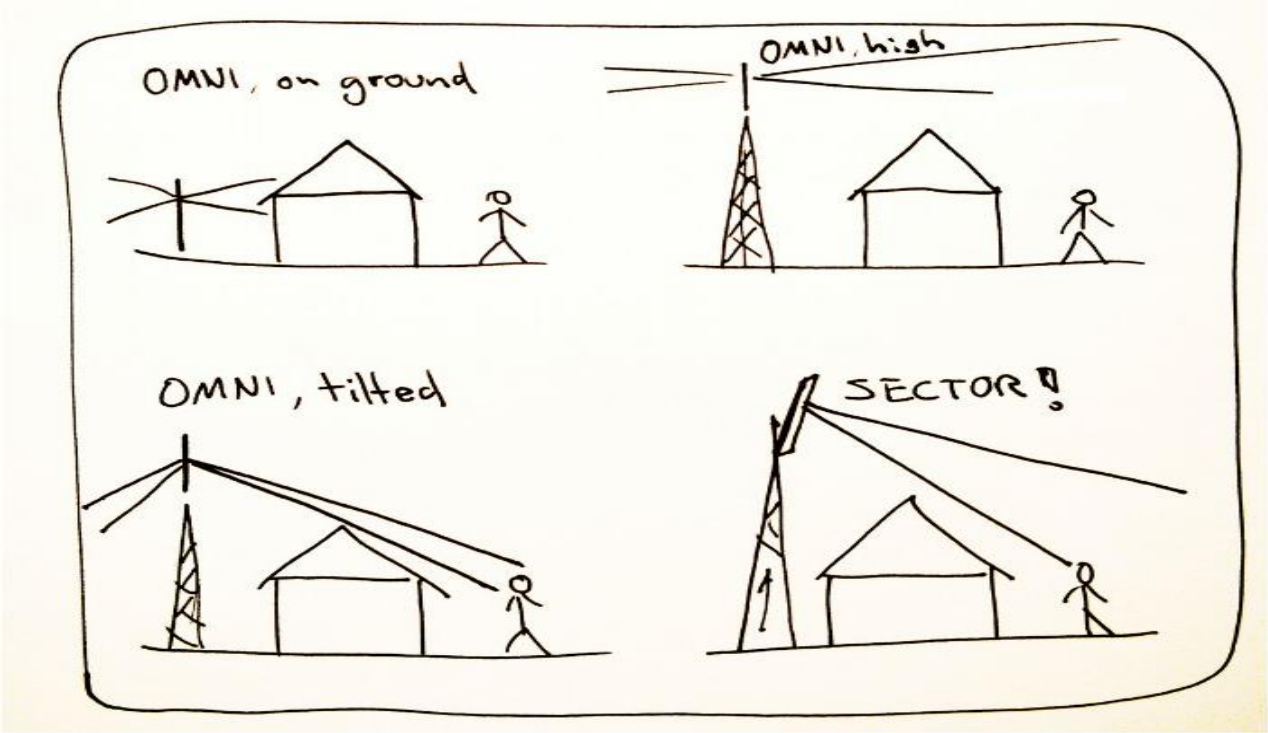
- **Directional Antenna:** AP radiates power in a particular direction





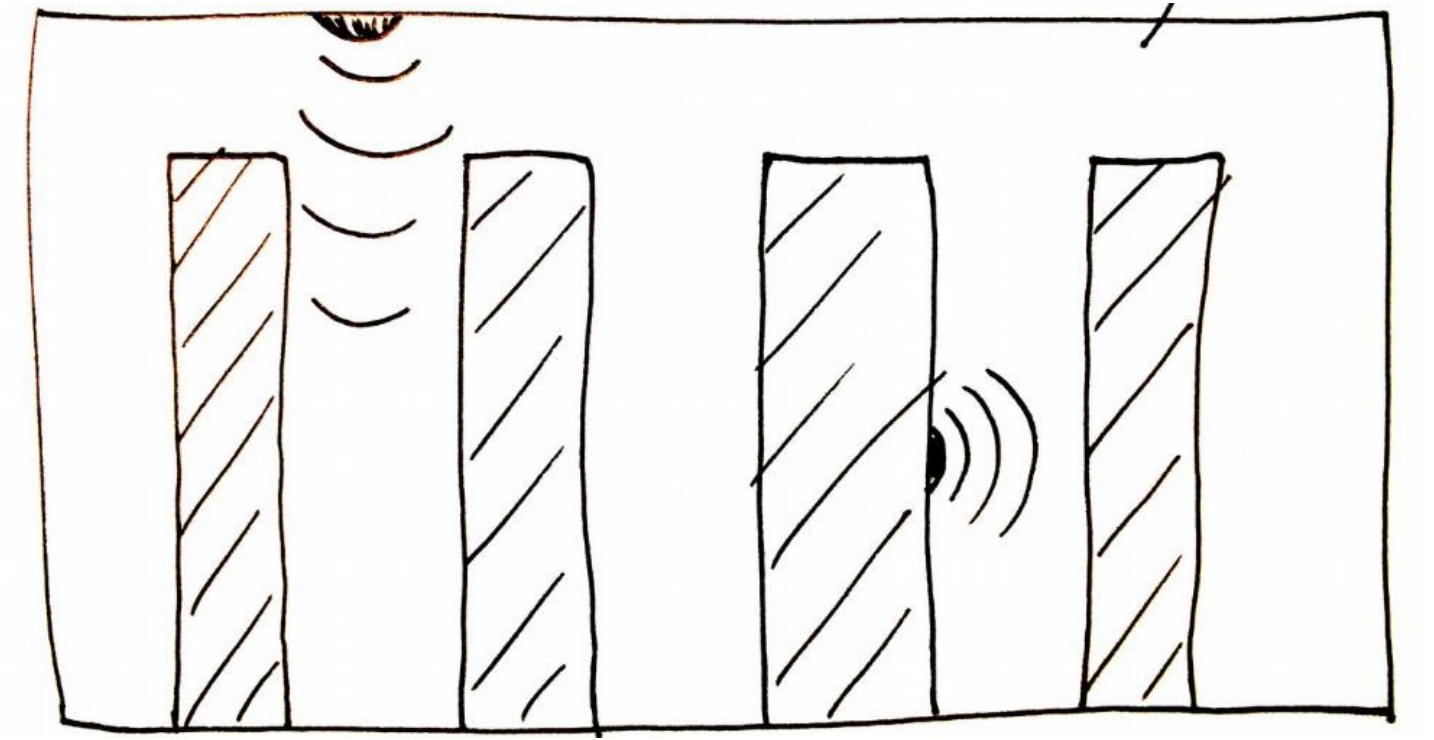
Wireless AP Placement – Cont'd

- Omnidirectional Vs Directional/Sector antennas



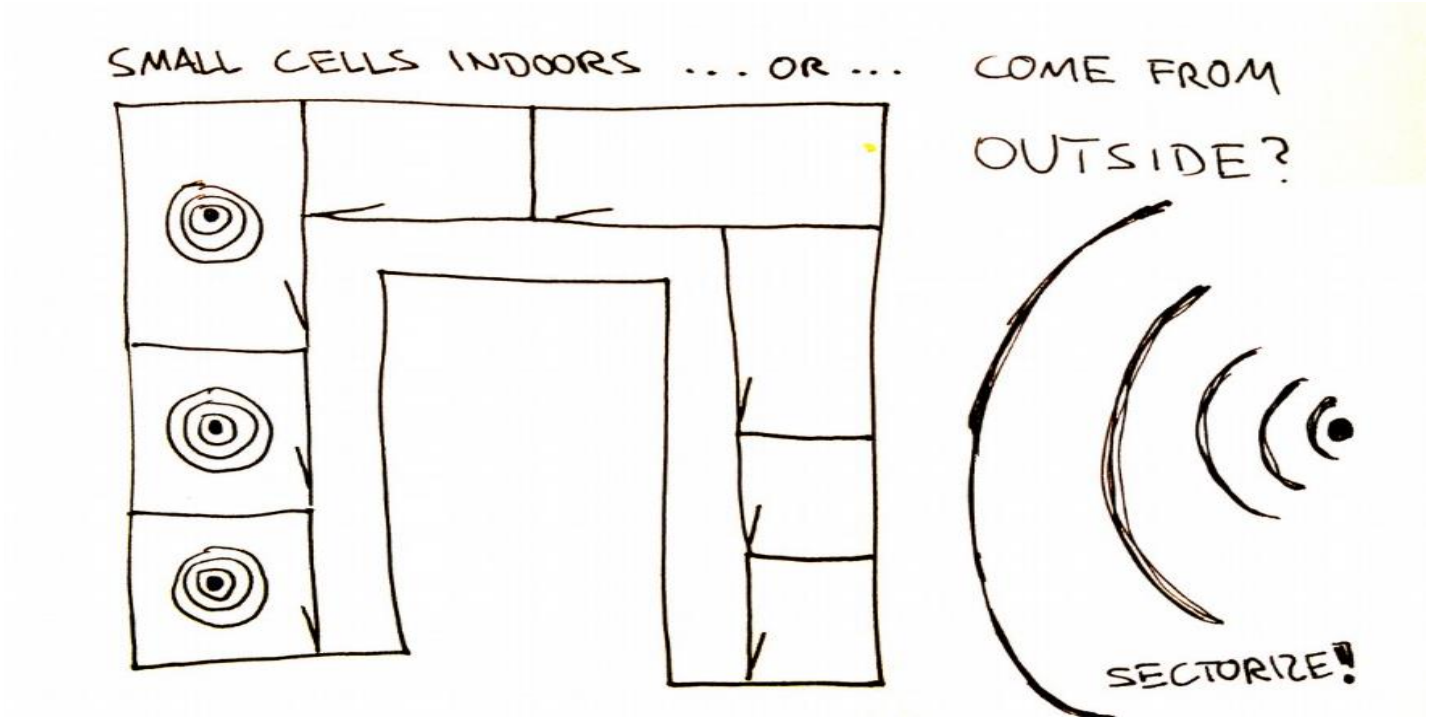
Wireless AP Placement – Cont'd

- Ceiling Mounted Vs Wall mounted AP Coverage



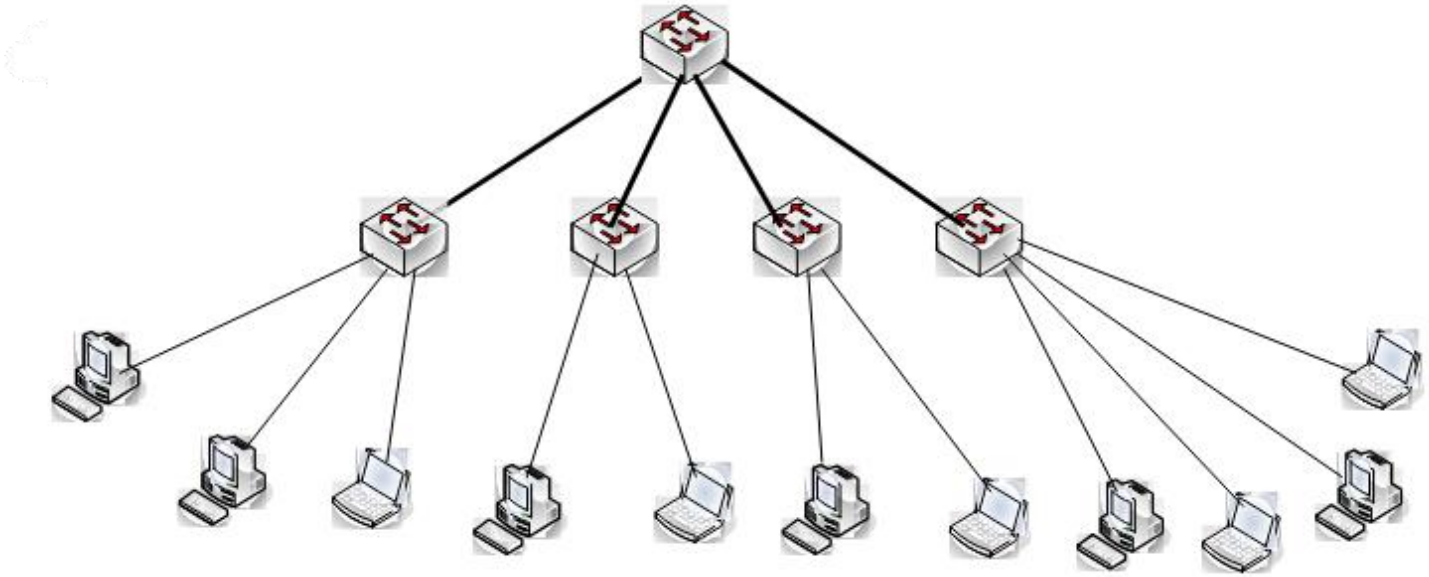
Wireless AP Placement – Cont'd

- Small Cells Coverage



Wireless Network Topologies

- Build stars / trees
- NOT daisy chains!
- Meshing can be used as failover

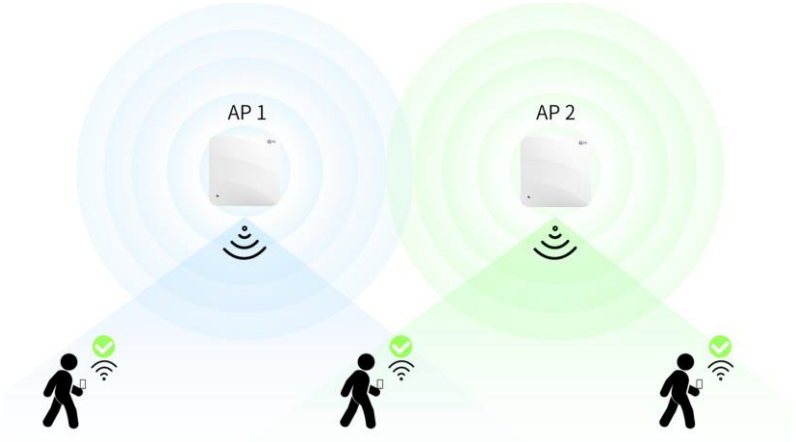


Roaming

- What happens when wireless clients move:
  - From one AP to another, in the same building?
  - From one building to another?
  - To a different part of campus, or a remote campus
- Is it important to stay on the network, without interruption (for example, to have a video call?
- Is it acceptable to log on again when entering a new network zone?

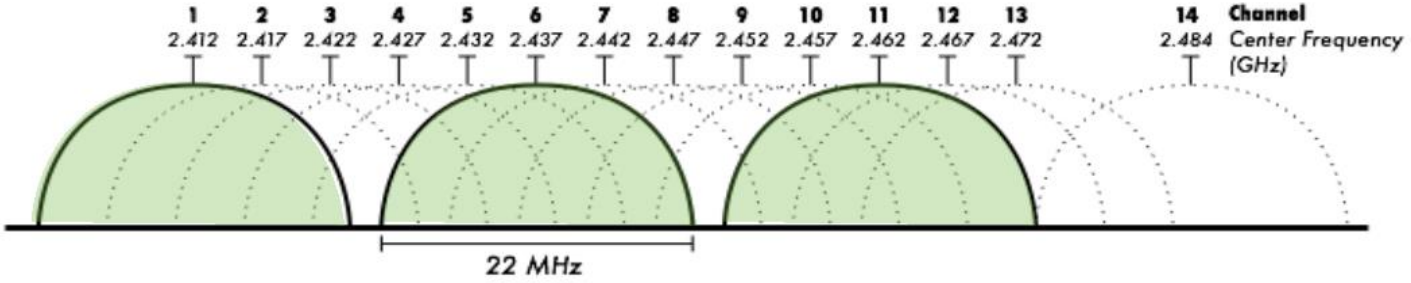
Wireless Roaming

- Ability of a wireless device to seamlessly switch between different APs within the same network.
- Avoids Interruption
- Avoids re-authentication



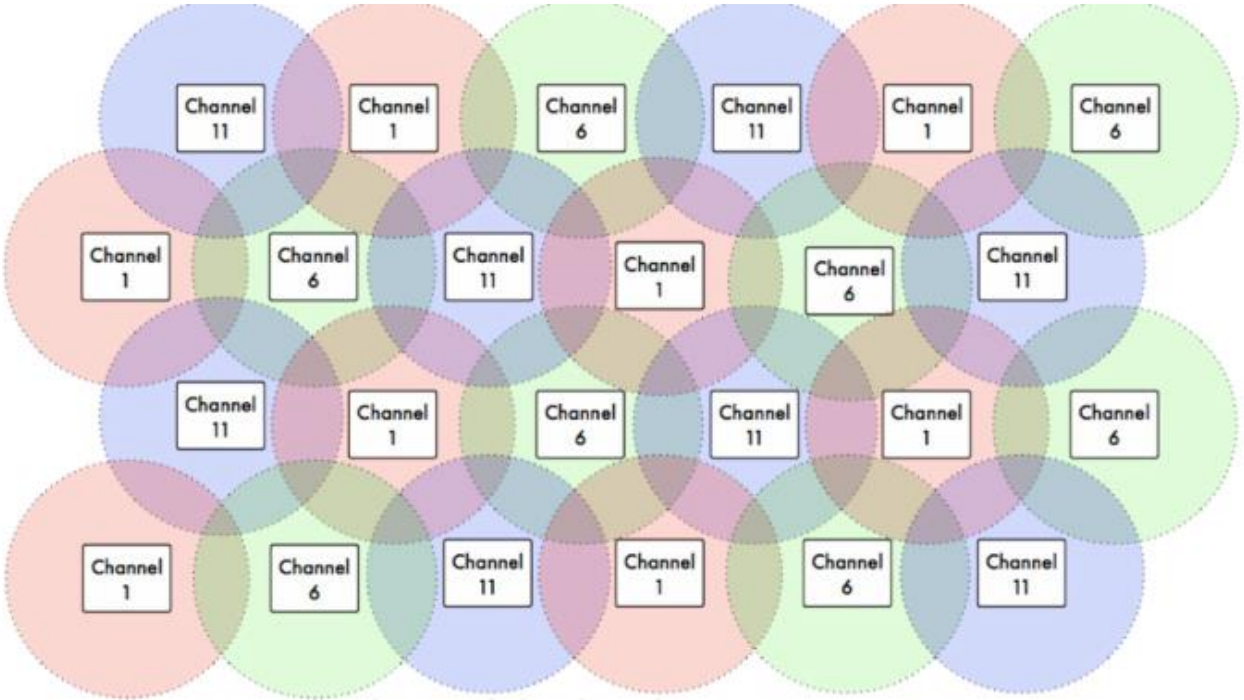
Channel Selection & Optimization

- A physical survey gives insights on the available channels within a specific deployment area.
- **Fixed Vs Dynamic** channel optimization
- 2.4GHz band non overlapping channels 1, 6, 11, 14



Channel Selection & Optimization – Cont'd

- Three channel coverage design



Channel Selection & Optimization – Cont'd

- 5Ghz band has 25 non over lapping channels including DFS channels
  - U-NII-1: 5170-5250 has 4 of 20 MHz each
    - 36 ,40, 44, 48
  - U-NII-2A: 5250-5330 has 4 of 20 MHz each
    - 52, 56, 60, 64 **(DFS)**
  - U-NII-2C: 5490-5730 has 12 of 20 MHz each
    - 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140, 144 **(DFS)**
  - U-NII-3: 5735-5835 has 5 of 20 MHz each
    - 149, 153, 157, 161, 165

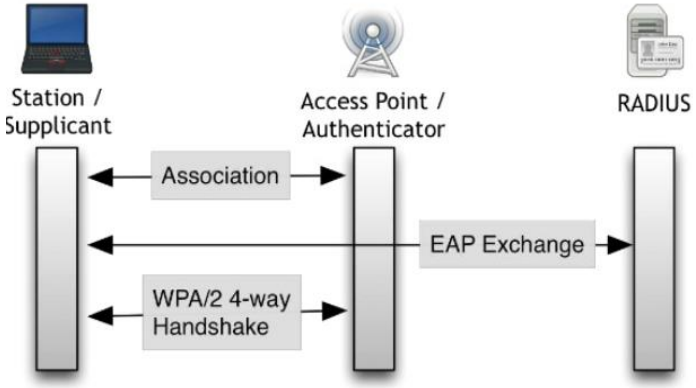
Wireless at Layer 3

- Wi-Fi Routers do many things
  - Routing, NAT, Firewall, DHCP
  - These are Layer 3 functions!
- Keep Layer 3 functions in the wired core
  - You cannot scale a network with Wi-Fi Routers
- An Access Point simply bridges networks
  - This is a layer 2 function: 802.3 <> 802.11
  - Scalable networks use Access Points, not Wi-Fi Routers
  - Configure Wi-Fi Routers in Access Point mode

Wi-Fi Router

Wireless Network Access

- Authentication can be implemented in many ways:
  - MAC Address Restrictions
  - Pre-Shared Key based Authentication
    - WPA-PSK – insecure, not scalable
  - Captive Portal Authentication
    - Better than a pre-shared key, but not the ideal
  - 802.1x/WPA2 Enterprise Authentication = Ideal!
    - Performed on centralized servers



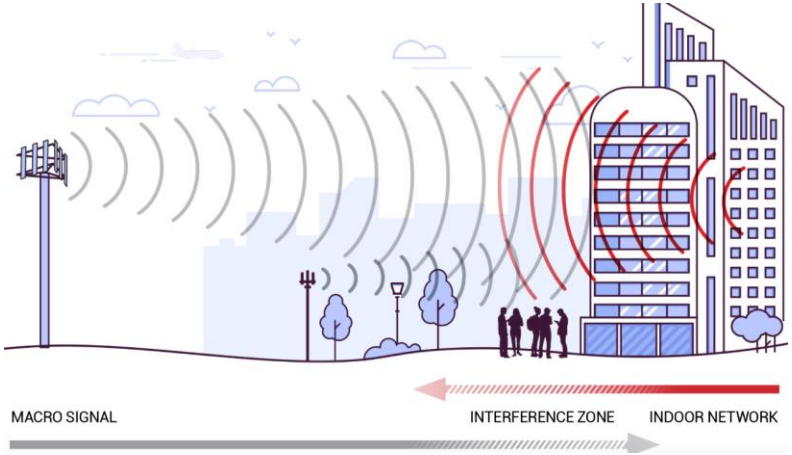
Wireless LAN Troubleshooting

Common Wireless LAN Challenges

- Interference
- Signal coverage and Dead zones
- Channel Utilization
- Device compatibility
- Security Risks

Interference

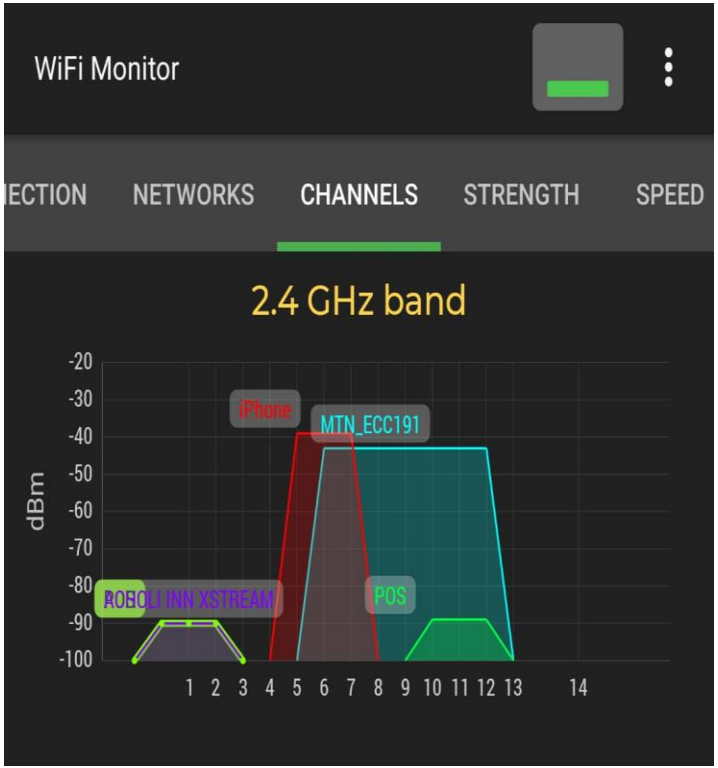
- Disruption or weakening of a wireless signal
- Caused by
  - Nearby Wi-Fi networks in the same channel
  - Non-Wi-Fi devices like microwaves PTP, Microwave ovens, Bluetooth devices, etc



Interference – Causes

What to Look out for?

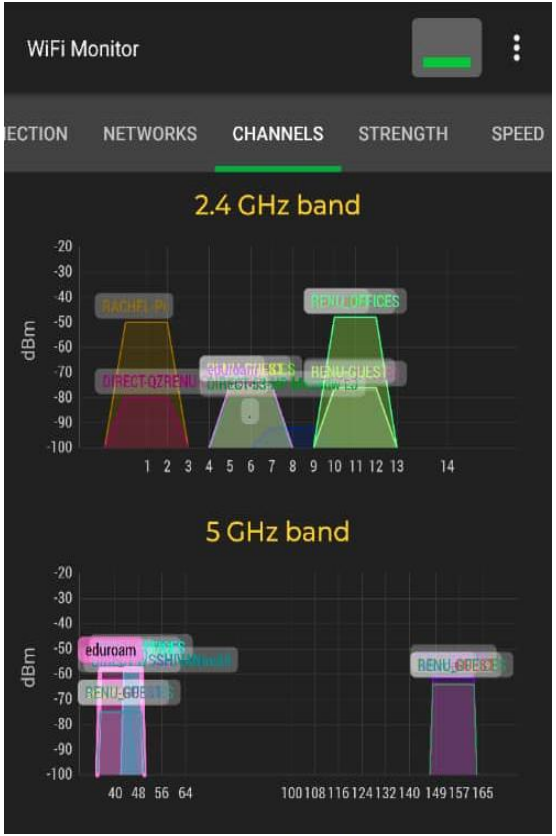
- Overlapping channels
  - Poor channel management with in a wireless network
- Channel Congestion
  - Rogue Aps broadcasting within your network's channels
  - Non-Wi-Fi wireless networks



Interference – Detection & Mitigation

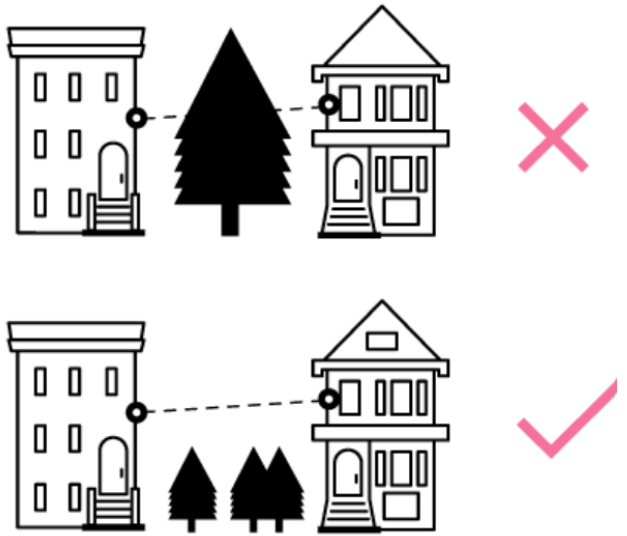
- **Wi-Fi Spectrum Analyzers**
  - Detect surrounding Wi-Fi networks and their Channels
- **Mitigation**
  - Use of non-overlapping channels
  - Avoid channels used by nearby wireless networks

WiFi Monitor WiFiman Wi-Fi Monitor



Line of Sight Obstruction

- Physical obstructions in the path carrier waves between the two wireless devices
- Caused by:
  - Rapid changes in the environment like vegetation growth
  - Sudden misalignment of radios

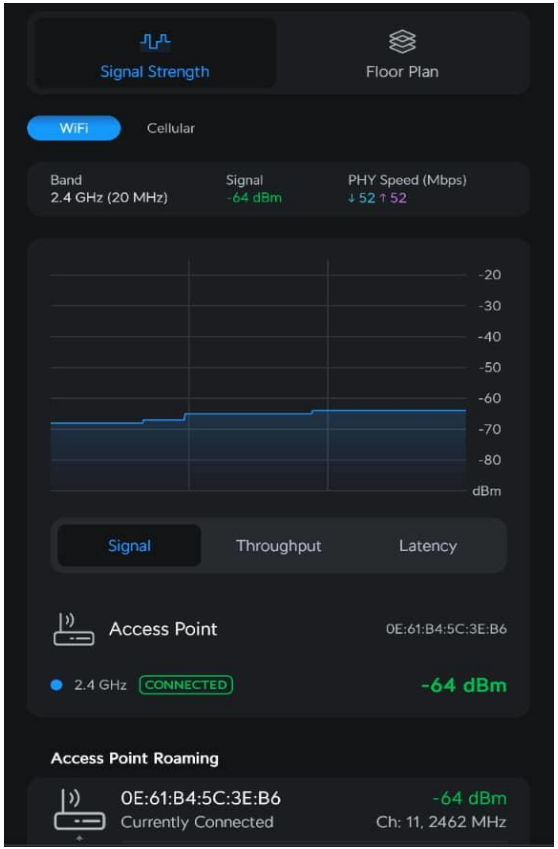


Signal Coverage and Dead Zones

- The extent to which a device can receive and transmit wireless signals
- Places where the signal can't reach
- Dead zones are caused by;
  - Obstacles – Absorb AP power
  - Extensive distance from access points

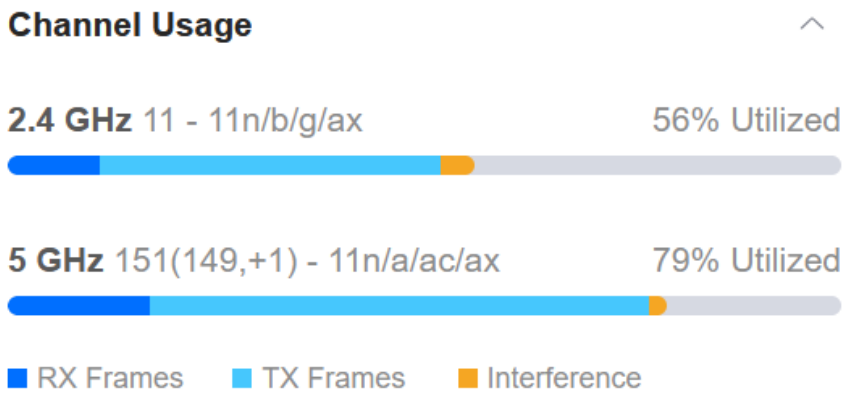
Dead Zones – Detection & Mitigation

- **Wi-Fi Monitoring Tools**
  - Detection and tracking of signal strength
- **Mitigation**
  - Wireless network survey (before and after network setup)
  - Increase Transmit power
  - Add more Aps to boost signal strength
  - Strategic AP placement – Based on user presence



Channel Utilization

- Percentage of time the wireless channel is busy
- High Utilization is caused by;
  - Too many users connected to an Access Point
  - Interference – Co-channel & Adjacent Channel
  - High bandwidth applications like video streaming, online gaming
  - Legacy devices- 802.11b/n/g



Channel Utilization – Cont'd

- Best Practices
  - **Data Traffic** – Utilization should be below 75%
  - **Video Traffic** – Utilization should be below 50%
  - **Voice Traffic** – Utilization should be below 20%
- Reducing Channel Utilization
  - Upgrading to higher performance Aps OR Install sufficient number of APs
  - Disable 2.4GHz radio in high performance environments
  - Disable lower data rates

THE END