Part III:

Network Design

Network Design

Designing a good network requires a good amount of interrelated knowledge.

Network Design

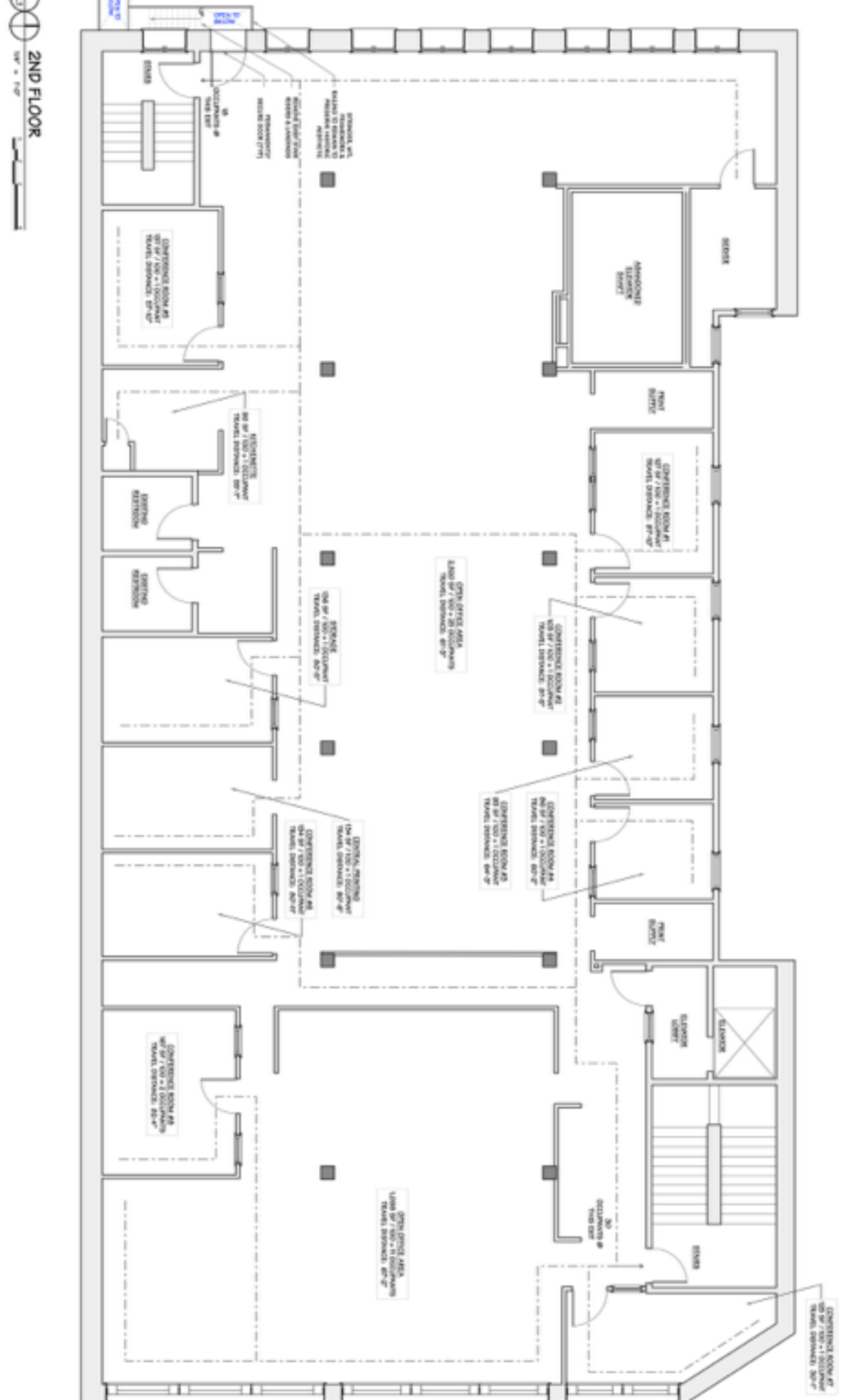
- Site Survey
- Equipment
- RF and Channel Planning
- Capacity Planning

Site Survey

- Knowing the facility that you're designing for is critical

Site Survey

- Facility Size
- Construction and Obstacles
- Usage and Key Spaces
- Neighboring Networks
- Network Infrastructure



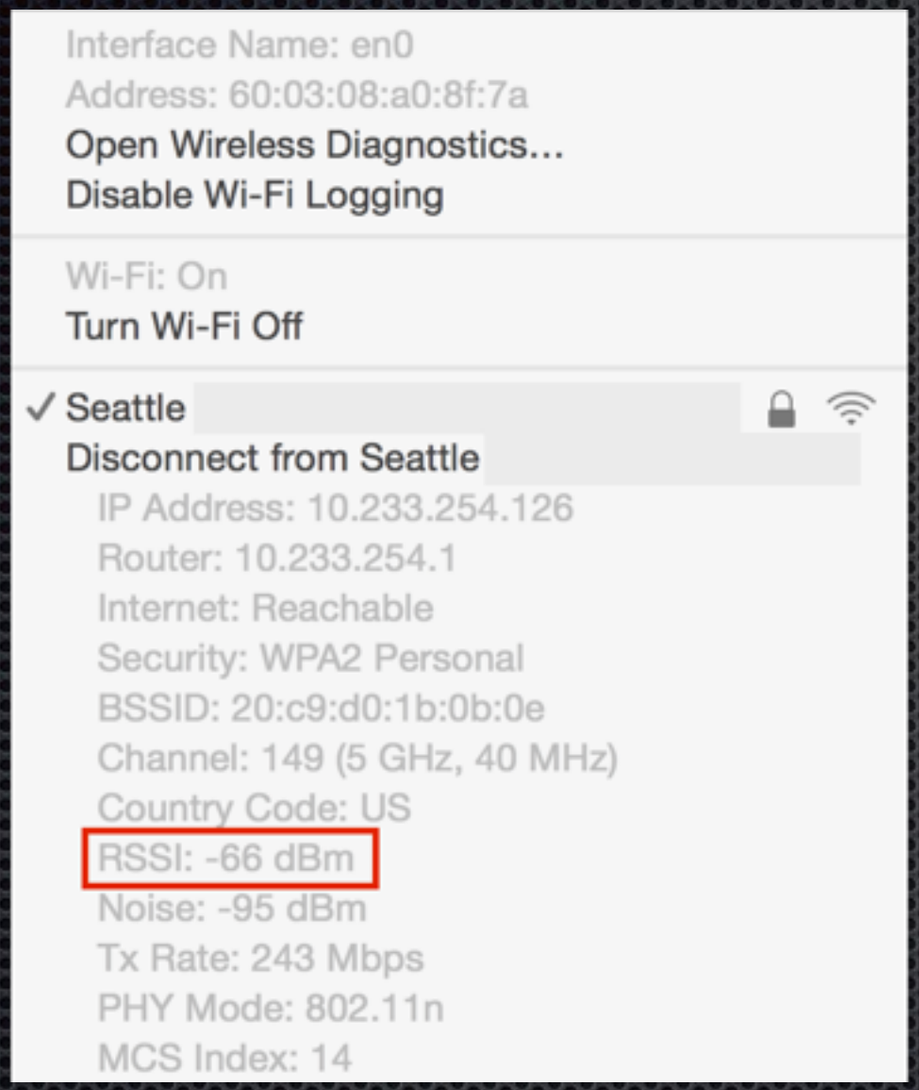
Site Survey
Size

- General size can give you some idea of the amount of equipment required for basic coverage
- Ceiling heights affect coverage and signal intensity
- Multiple floor facilities require special care

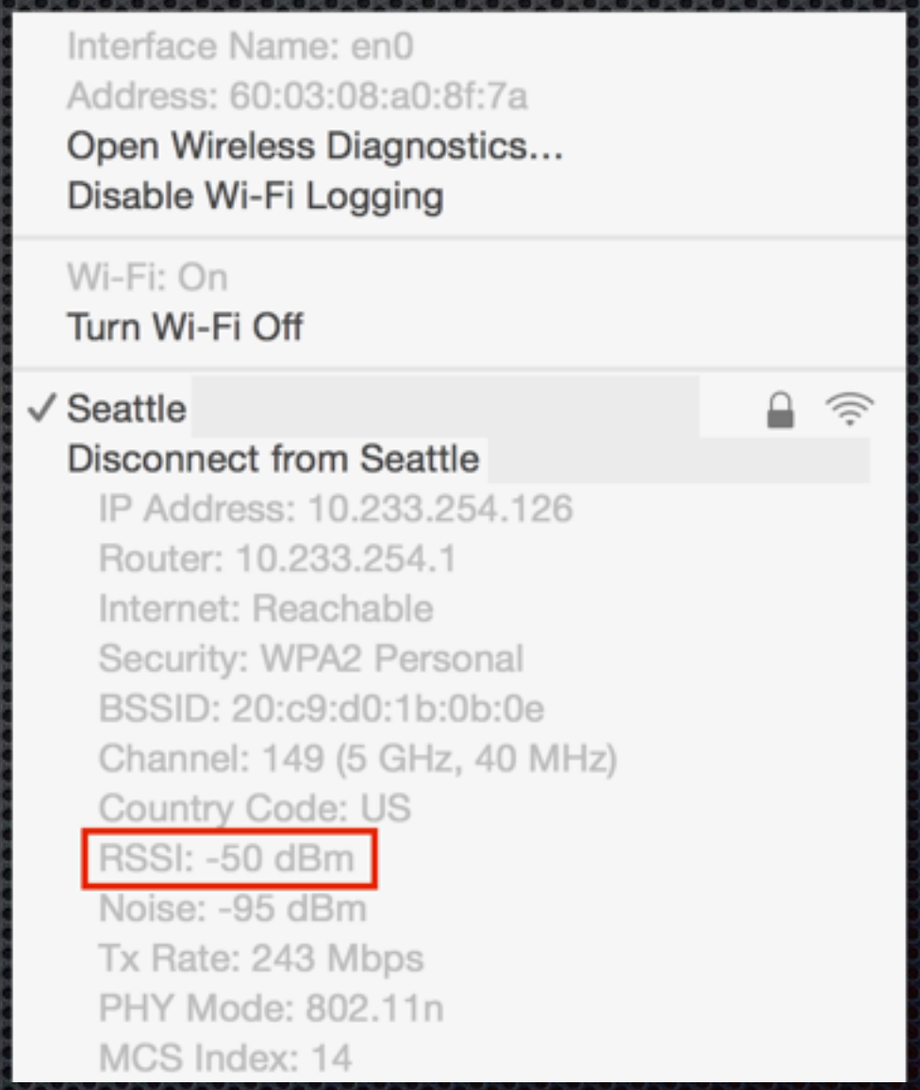
Site Survey
Construction and Obstacles

- Pay attention to facility construction
- Look for concrete, rebar, and elevator shaft; also, lathe and plaster with gypsum lathe
- Look for heavy or metal furniture

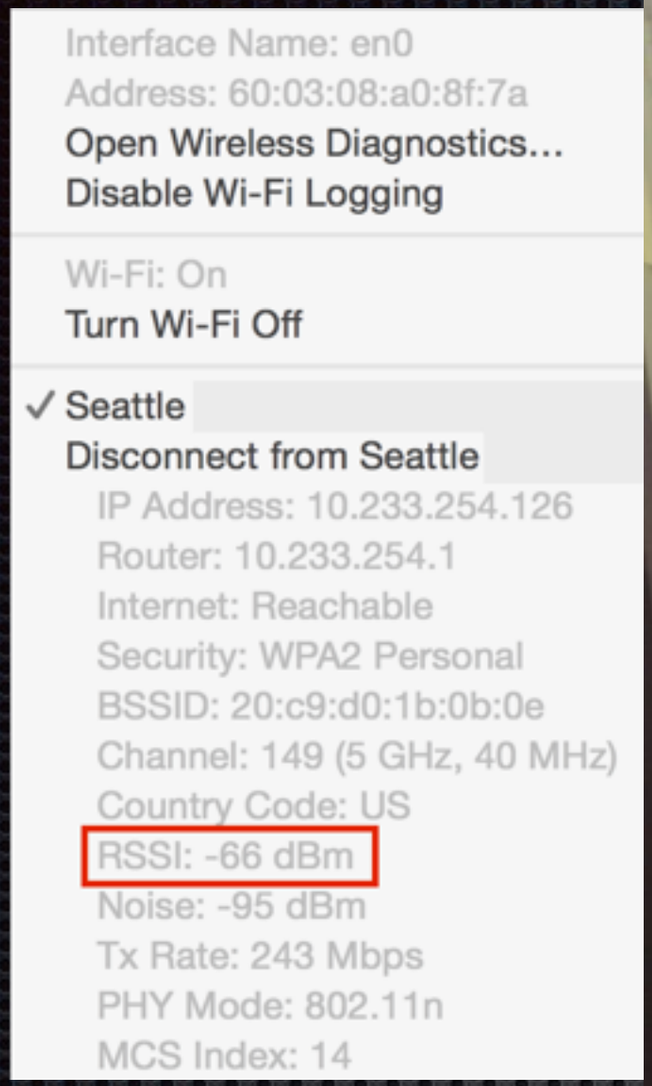
Site Survey
Construction and Obstacles

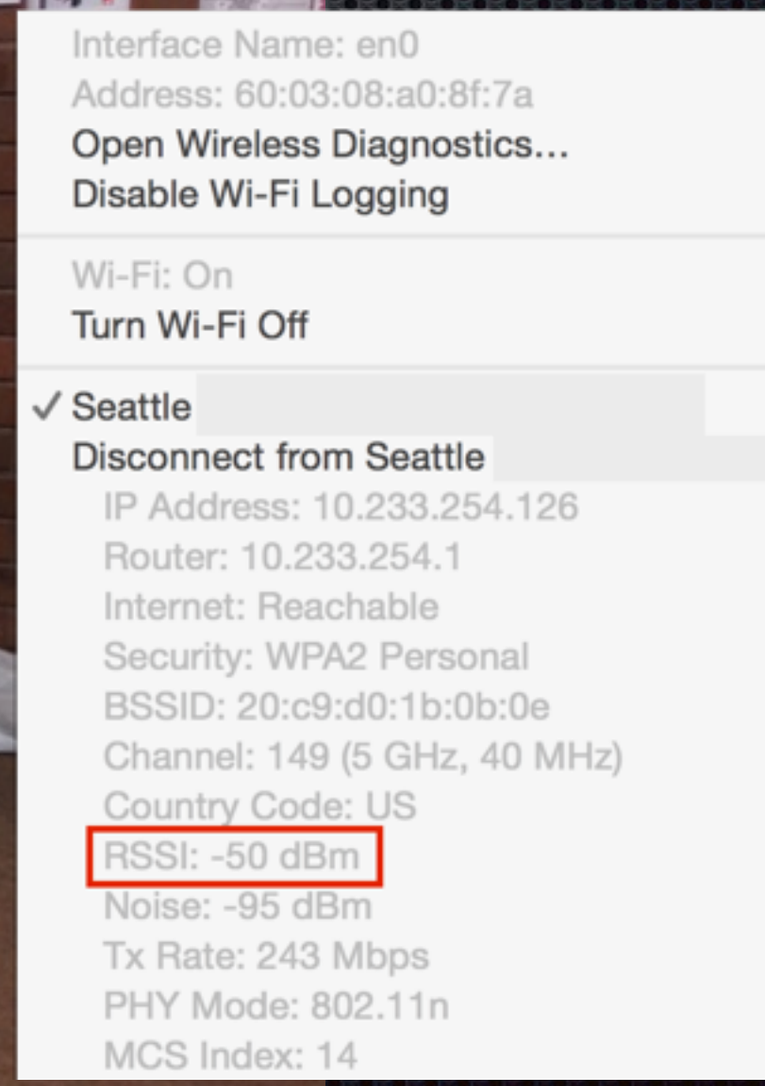


Conference Room
30’ from AP



Workroom
15’ from AP


Interface Name: en0
Address: 60:03:08:a0:8f:7a
Open Wireless Diagnostics…
Disable Wi-Fi Logging
Wi-Fi: On
Turn Wi-Fi Off
✓ Seattle
Disconnect from Seattle
IP Address: 10.233.254.126
Router: 10.233.254.1
Internet: Reachable
Security: WPA2 Personal
BSSID: 20:c9:d0:1b:0b:0e
Channel: 149 (5 GHz, 40 MHz)
Country Code: US
RSSI: -66 dBm
Noise: -95 dBm
Tx Rate: 243 Mbps
PHY Mode: 802.11n
MCS Index: 14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BSSID: 20:c9:d0:1b:0b:0e
Channel: 149 (5 GHz, 40 MHz)
Country Code: US
RSSI: -50 dBm
Noise: -95 dBm
Tx Rate: 243 Mbps
PHY Mode: 802.11n
MCS Index: 14

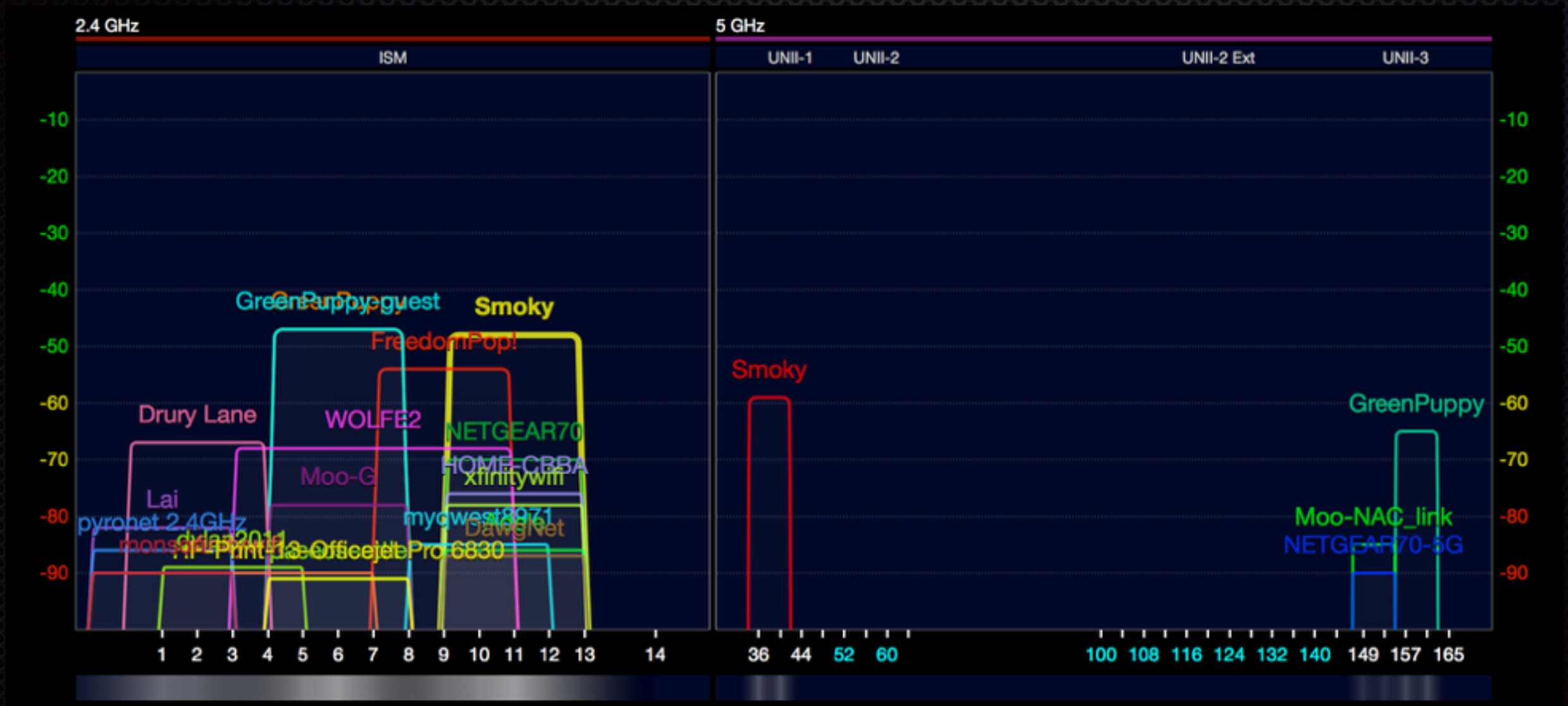
Site Survey
Usage and Key Spaces

Knowing the use of the space is another key to a good network design.

- Administrative office may have only minimal use
- Conference room may have intermittent heavy use
- Classrooms may have consistent heavy use
- A 600-seat lecture hall *will* be a nightmare and is crucial to identify

Site Survey

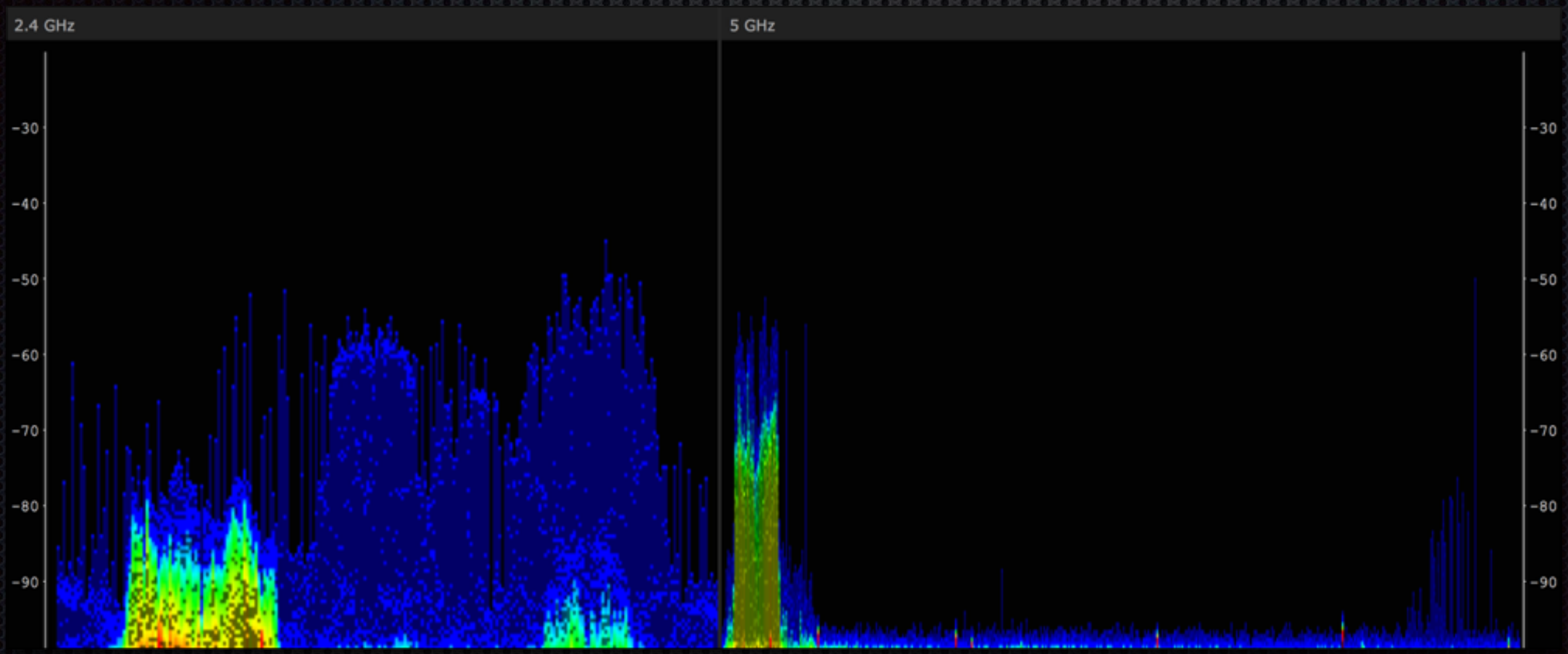
Neighboring Networks and Interference



It is crucial to know what is going on around you in order to plan.

Site Survey

Neighboring Networks and Interference



Knowledge of the environment includes more than just Wi-Fi signals.

Site Survey
Infrastructure

- How difficult is cabling the facility going to be?
- Does cabling exist already?
- Do you have someone to handle cabling?
- (And what about power?)

Site Survey
Techniques

How are you going to use a site survey to develop a plan?

- “AP on a stick” survey
- Predictive modeling software

Site Survey
Predictive Modeling

Uses specialized software to estimate coverage using known information about equipment and admin-added information about the facility.

- Ekahau Site Survey
- Tamograph
- Bring money

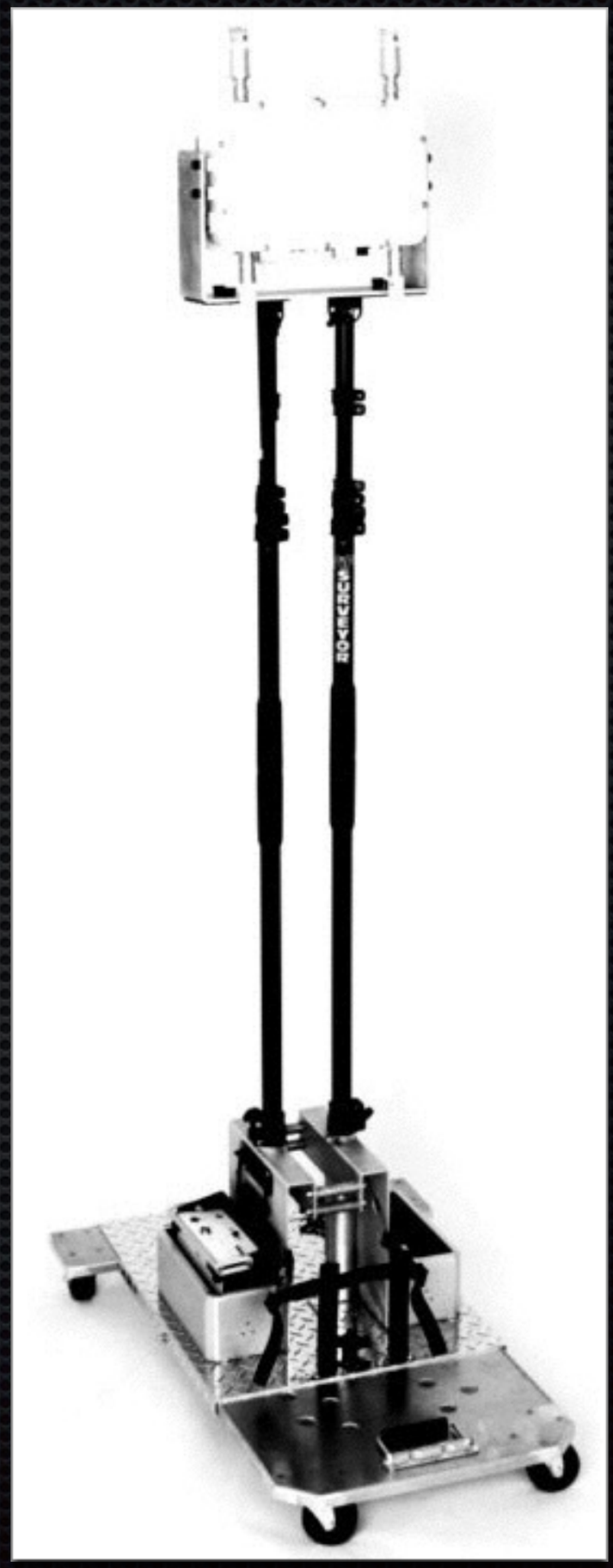
Site Survey
Predictive Modeling

- Speeds up the planning and design process
- Liable to built-in assumptions, e.g. how much attenuation a particular type of wall imposes

Site Survey
AP on a Stick

Actually deploy equipment in the facility and test

- Tests actual equipment in actual facility
- Slow and intrusive



Site Survey

So What Do Professionals Actually Do?

A combination of survey types seems to be the answer

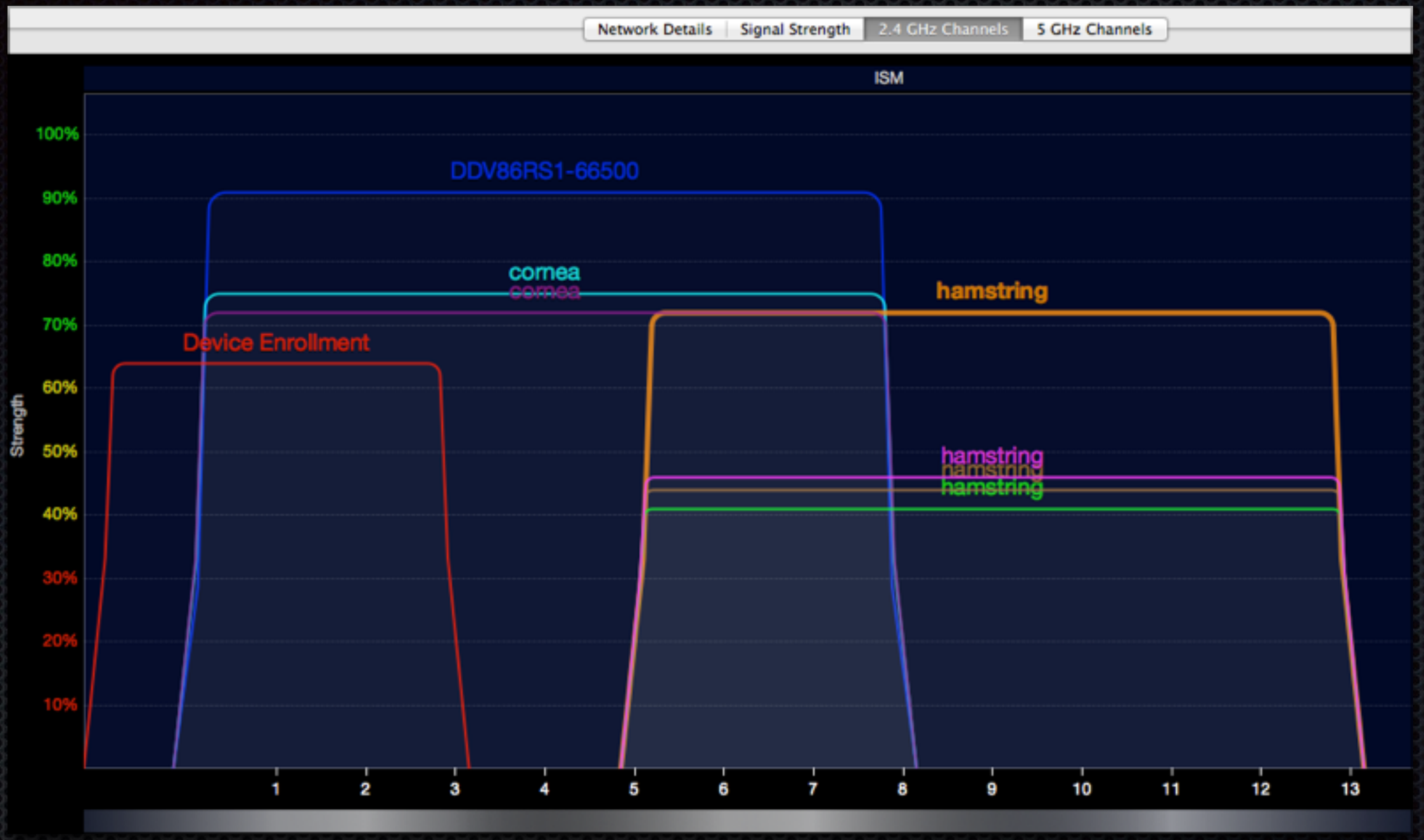
1. Visit site to gather facility information and perform attenuation and interference testing
2. Run a predictive survey using a planning tool
3. Validate the predictive survey onsite using AP on a stick, and adjust as necessary.

Channel/RF Planning

We want to ensure that our clients receive adequate radio signal and suffer the least possible contention and interference.

Channel/RF Planning

- The most solved of WiFi planning problems
- Frequencies and channel widths are well documented.



Channel/RF Planning

Still easy enough to get wrong; there's three major things wrong here. Actually four, but we'll get to that.

Channel/RF Planning

- Channel selection
- Channel width
- DFS (again)

Channel Selection

In designing a channel plan, pick channels to minimize co-channel interference and avoid adjacent channel interference.

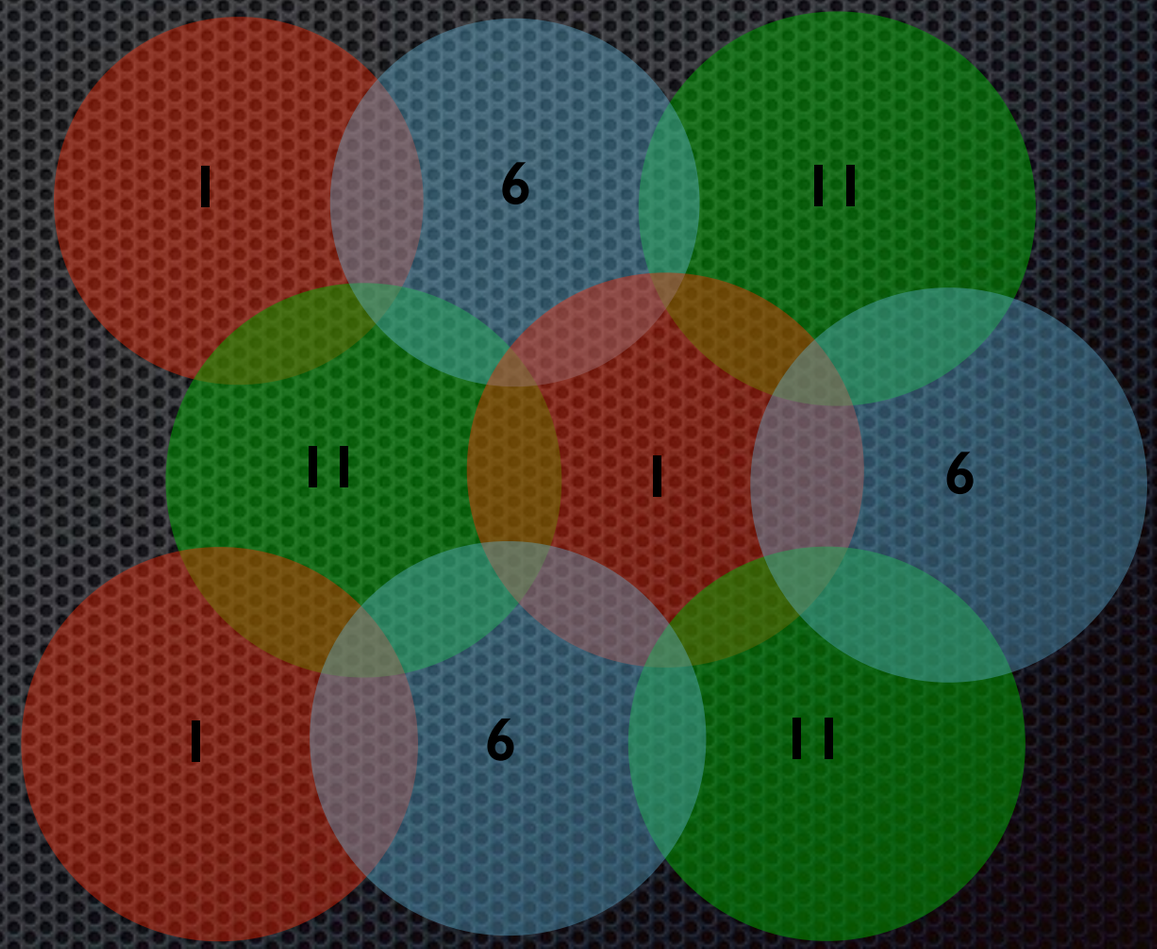
Channel Selection (2.4 GHz)

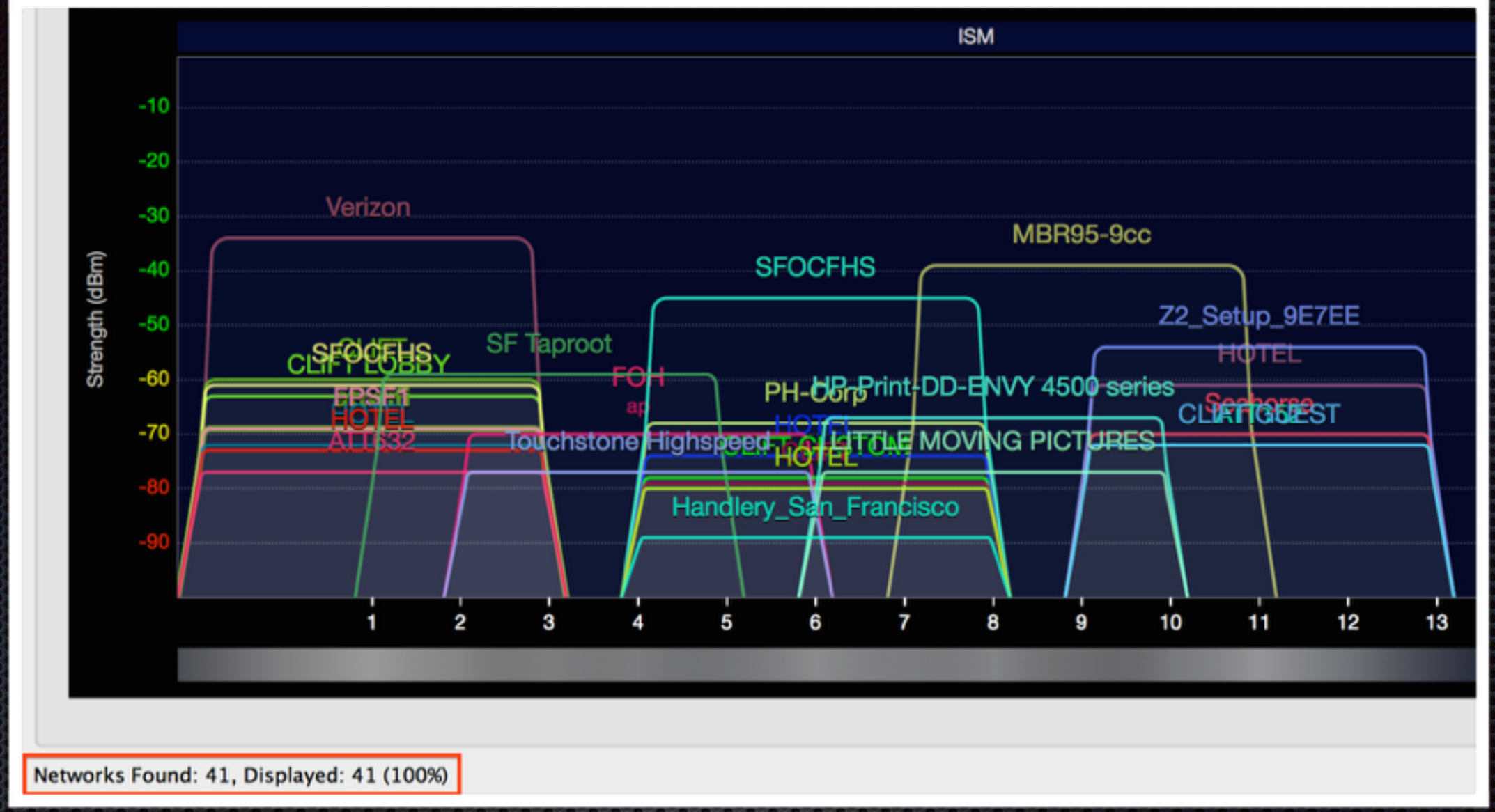
- 3 non-overlapping 20 MHz channels in North America:

1, 6, 11

Channel Selection (2.4 GHz)

- It's exceedingly difficult to create a channel plan that does not include overlap.
- Successful design for client density is nearly impossible using only 2.4 GHz channels.





Channel Selection (2.4 GHz)

Starbucks, Geary Street in San Francisco

Channel Selection (5 GHz)

- Many more channel options
- Many more caveats

Channel Selection (5 GHz)

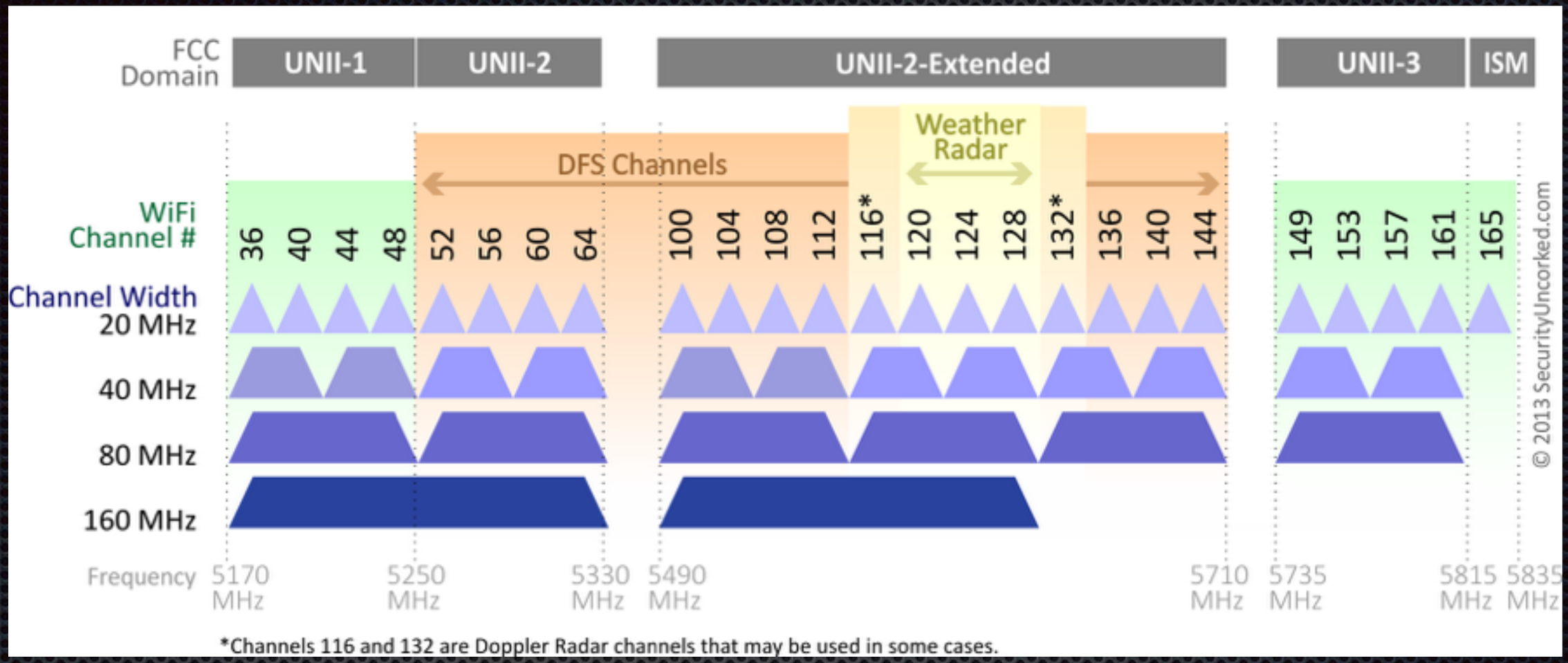
- 9 x 20 MHz channels + 15 x 20 MHz DFS channels
- Options for wider channels (40 MHz and 80 MHz), which can provide higher performance*
- Wider channels reduce the number of channels available

*Assuming your clients can take advantage of that higher performance.

Channel Selection (5 GHz)

Keep in mind that 5 GHz signals attenuate more quickly than 2.4 GHz signals.

Courtesy NASA/JPL/CalTech



Channel Selection (5 GHz)

Note how as channels get wider, the number available falls. Pay particular attention to the 160 MHz channels.

5 GHz and DFS

Wait, there’s a wrinkle

Channel Selection

5 GHz and DFS

15 of the 24 available 20 MHz channels in the 5 Ghz band share frequencies with the Terminal Doppler Weather Radar (TDWR) used at major airports to improve takeoff and landing safety by detecting wind shear associated with thunderstorms.

Channel Selection

5 GHz and DFS

Wi-Fi access points using these channels are required implement Dynamic Frequency Selection, meaning that they must dynamically switch channels if they detect radar.

UNII-2: 52, 56, 60, and 64

UNII-2 Ext: 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140

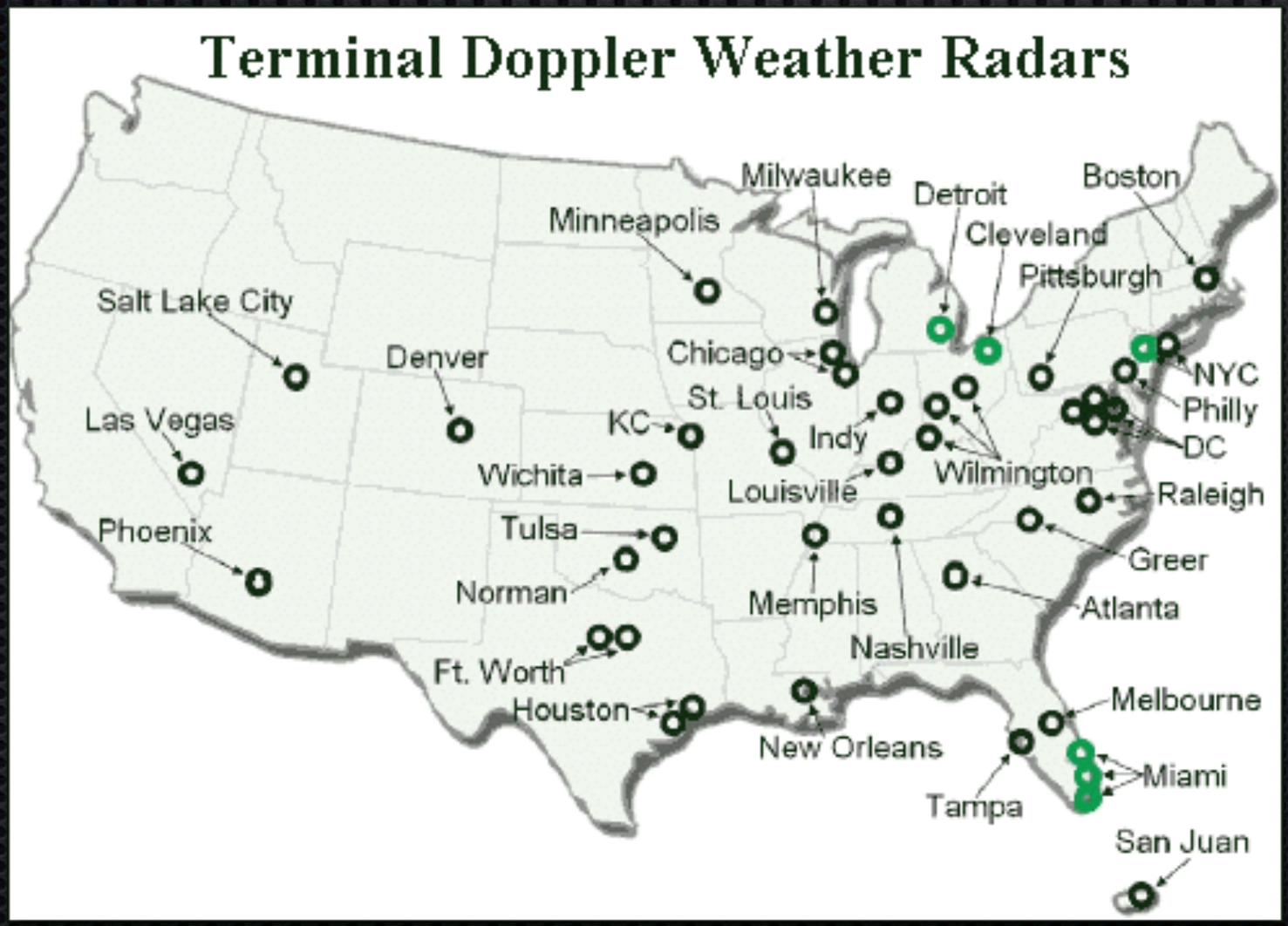
Channel Selection

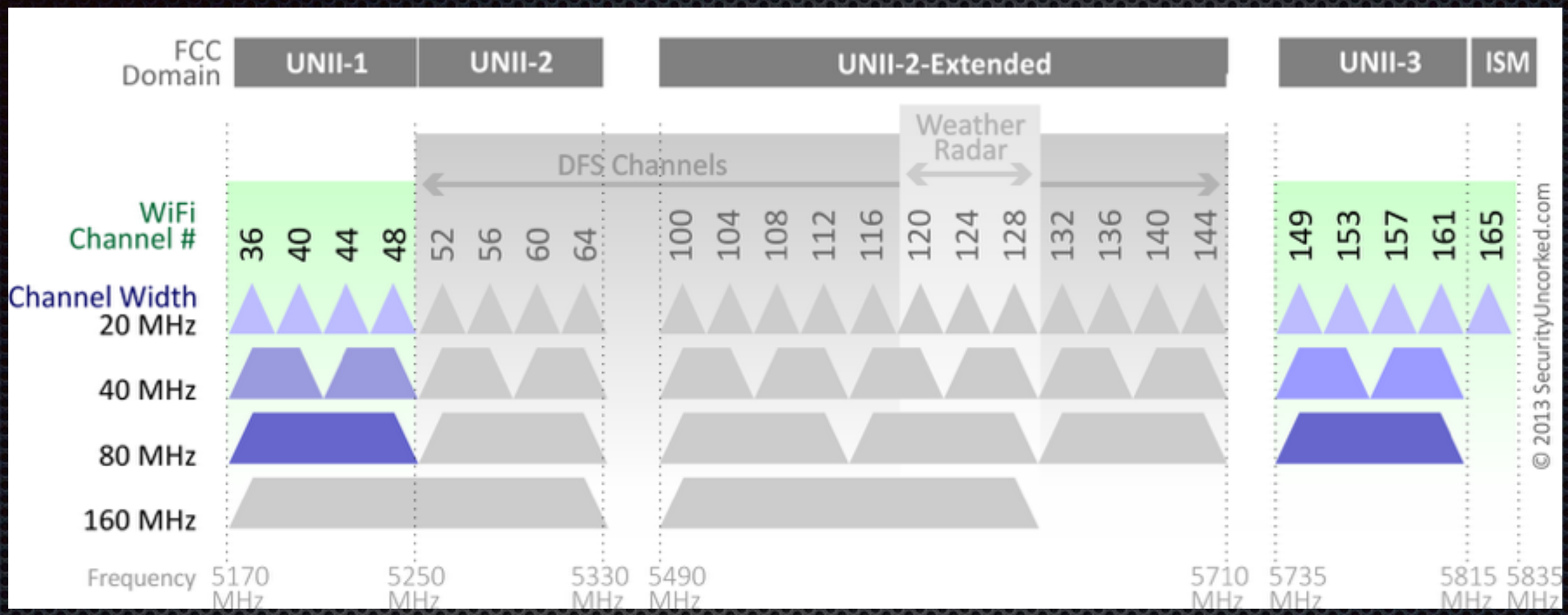
5 GHz and DFS

In addition, FCC regulations disallow DFS channels within 35 km of Terminal Doppler Weather Radar systems.

Channel Selection

5 GHz and DFS





Channel Selection

5 GHz and DFS

Excluding DFS vastly reduces the number of available channels of each width.

Capacity Planning

The Going Gets Weird

Capacity Planning

- Equipment specs and limitations
  - Power
  - Network throughput
  - Installation and mounting
- Density
- Airtime

Capacity Planning

- Generally, discussion of capacity planning moves us away from Wi-Fi standards, and toward reliance on vendor implementations
- Standards simply do not exist here

Equipment Considerations
Vendor Requirements

- Controllers have upper limits to the number of client devices and APs that they can handle
- Controllers are often licensed for a specified # of APs
- There isn’t a quantifiable standard for AP capacity.

Equipment Considerations:
Power

- Enterprise APs have specific power requirements
- PoE switches provide a specified amount of power per-port
- Power specs include a “power budget” for the whole switch

Equipment Considerations
Power

- Two different PoE Standards
  - 802.3af: 15.4W/port, 12.95W guaranteed delivered
  - 802.3at: 30W/port, 25W guaranteed delivered
- 802.11ac requires 802.3at to achieve maximum performance, but many APs will step down wireless output or disable ports to work with 802.3af

Equipment Considerations

Power

- GS-1900-8 PoE switch
  - 8 ports and 802.3at or 802.3af-capable
  - 70W power budget
- Put all those together, and that's
  - 2 x 25W APs
  - 4 x 12.95W APs

Network Throughput

- Remember that wireless APs *can* move more than 100 Mbps
- Check whether your switches can handle speeds required; in many cases you will need gigabit

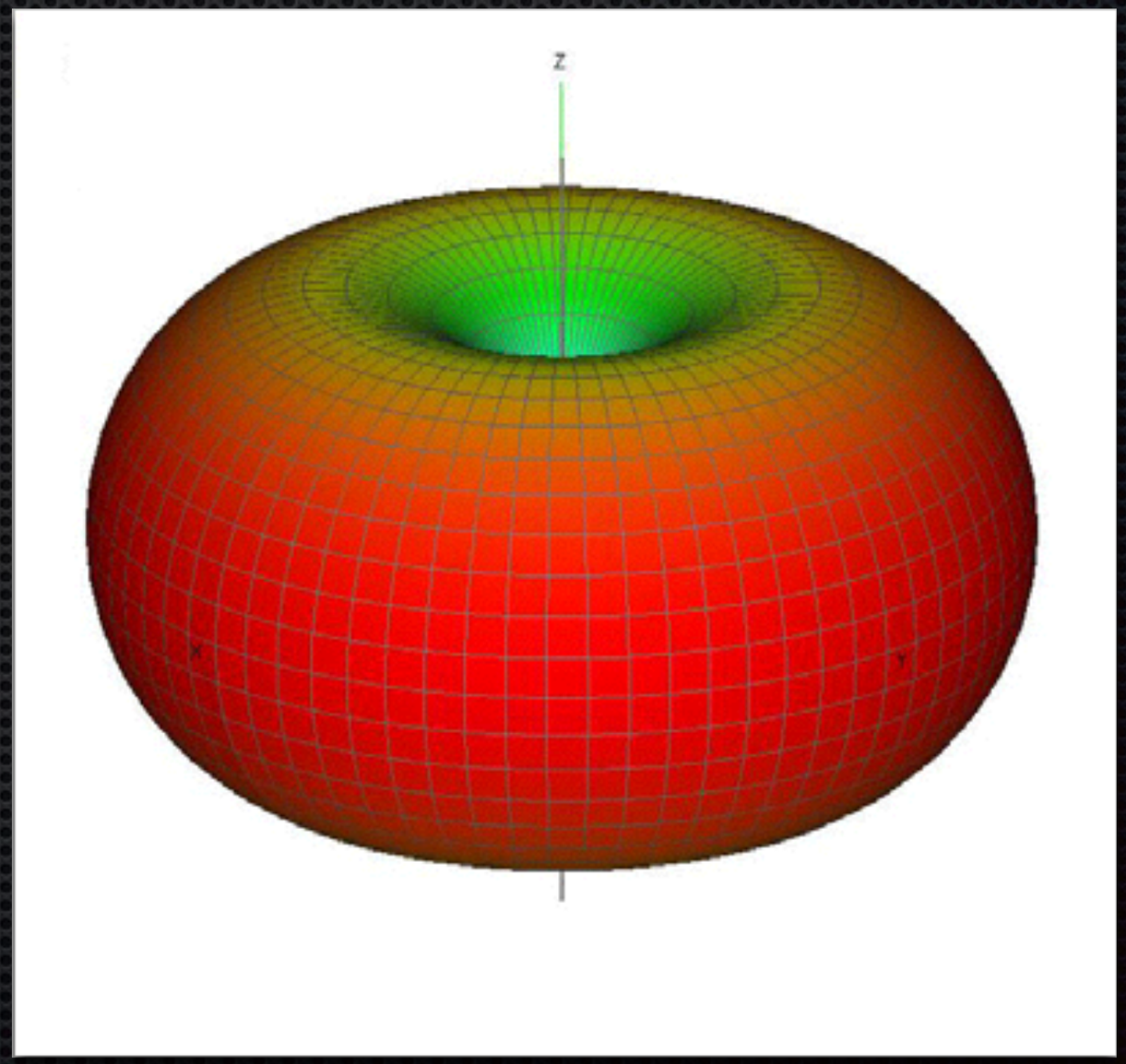
Equipment Considerations

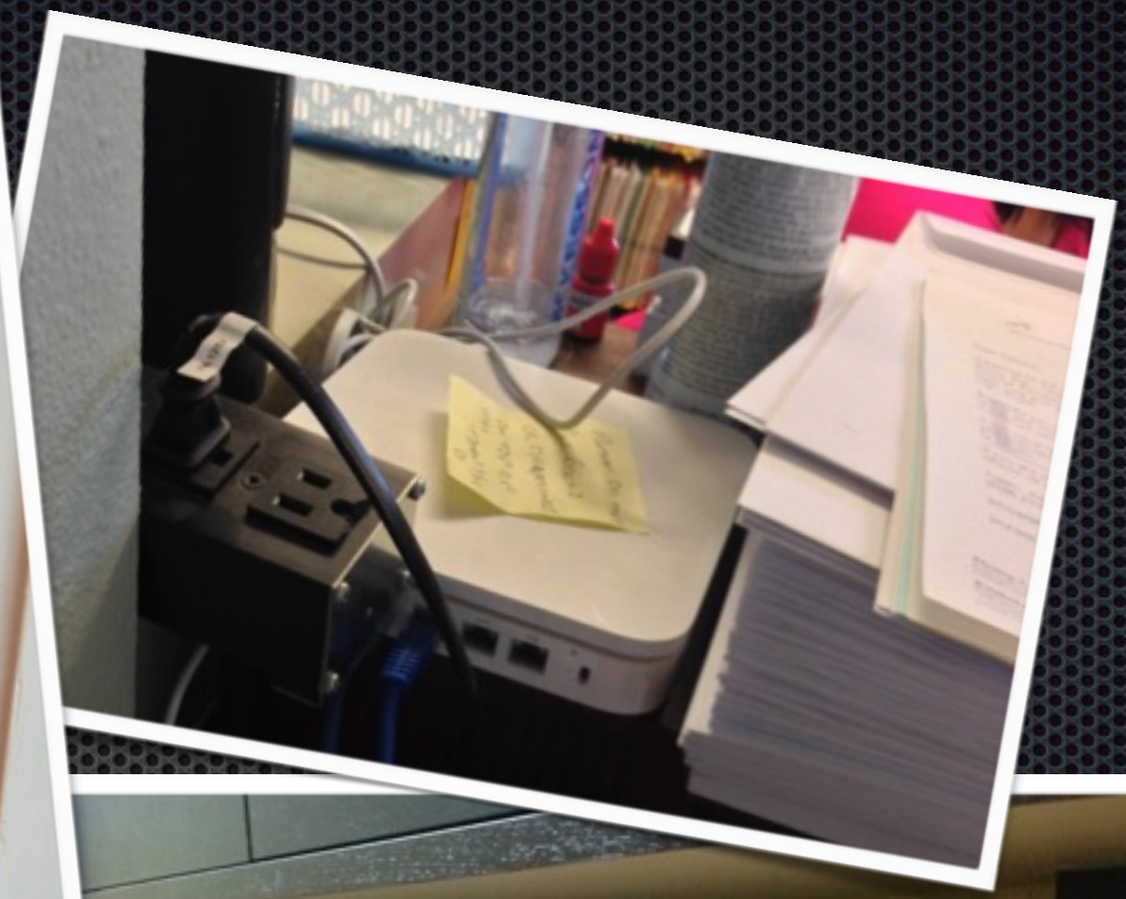
Installation and Mounting

Vendors who pursue enterprise customers typically design equipment to be mounted on walls or ceilings in order to maximize the area of coverage.

Equipment Considerations
Installation and Mounting

- Vendors typically use omnidirectional antennas in APs, which generate a specific radiation pattern.
- In general, vendors design enterprise grade APs for wall or ceiling mounting to provide best coverage





Installation and Mounting

Density

- Critical when you think about certain environments such as lecture halls or classrooms
- Critical when thinking about the use model for Wi-Fi network

Density

- How many devices are you going to have in an area?
- How many devices will your users carry?
- How many devices can you expect APs handle?

Density
Client Count

- Vendors make various claims about clients per-AP
- Many of these claims are “best case”
  - Ruckus says 500 until you ask about encryption, then says 100 per-radio.
  - Aerohive claims 100 per-radio

(Remember that dual-band APs have two radios)

Density

An client association with an AP is *not* the same as a connection to a switch, in which each connection gets a consistent link speed such as 1 Gbps.

Wi-Fi is more complicated.

Density and Airtime

The sharing of the bandwidth in an AP makes things more analogous to use of an Ethernet hub, and we have more thinking to do about performance issues.

Airtime

The Weird Turn Pro

Airtime

Calculated percentage of available time a client device will utilize; determining this requires:

1. Known application bandwidth requirement
2. Known *real* client performance

Airtime: Calculation

$$\frac{Bandwidth\ \ Required}{Real\ \ Throughput} = Airtime\ \ Required$$

Airtime: iPad 2

SD Video = 1 Mbps

65 Mbps max TX = 30 Mbps actual performance

Question: If iPad 2 can only provide 65 Mbps theoretical throughput, how much does a 1300 Mbps-capable AP help network performance?

Airtime: iPad 2

$$\frac{1\ Mbps}{30\ Mbps} = .033\ or\ 3.33\%$$

Airtime: iPad 2

- In theory then, 30 iPad 2 units stream 1 Mbps video would chew up all the available airtime on a single access point.
- Note how this assumes *no* performance loss from interference, attenuation, or other sources.

Airtime: Another Wrinkle

- iPad Mini 3 will work on 20 MHz and 40 MHz channels

40 MHz = 300 Mbps TX = ~135 Mbps real

20 MHz = 144 Mbps TX = ~65 Mbps real

Airtime

Mix device capabilities, and things get *complicated.*