# Fundamentals of Wi-Fi

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# Wi-Fi Networks Are An Argument with Physics

# Today's Agenda

- A Brief History of 802.11 (90 minutes)
  - Coffee!
- Terminology and Jargon (75 minutes)
  - Lunch!
- Building Good Networks (90 minutes)
  - Snacks!
- Troubleshooting (75 minutes)

# A (Not So) Brief History of 802.11

- The Birth of Wi-Fi
- Standards We Care About (802.11a/b/g/n/ac)
- The 2.4 and 5Ghz spectra
- The Physical Constraints of Wi-Fi

# Terminology & Jargon

- Basic Radio Frequency (RF) Stuff
- Interference
- Attenuation
- AirTime
- Signal
- Noise
- MCS
- Other

# Building Good Networks

- Physical Materials
- Models for Planning
- Authentication and Connectivity Control
- Wireless Bridging

# Troubleshooting

- Is it the Spectra?
- Is it the Radio?
- Is it the Device?
- Is it the Network?
- Is it Something Else?

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# Wi-Fi Is Everywhere

# How Did We Get Here?

# In the beginning was 802.11

# Why 2.4GHz?

IGN

Because of the Science Oven.

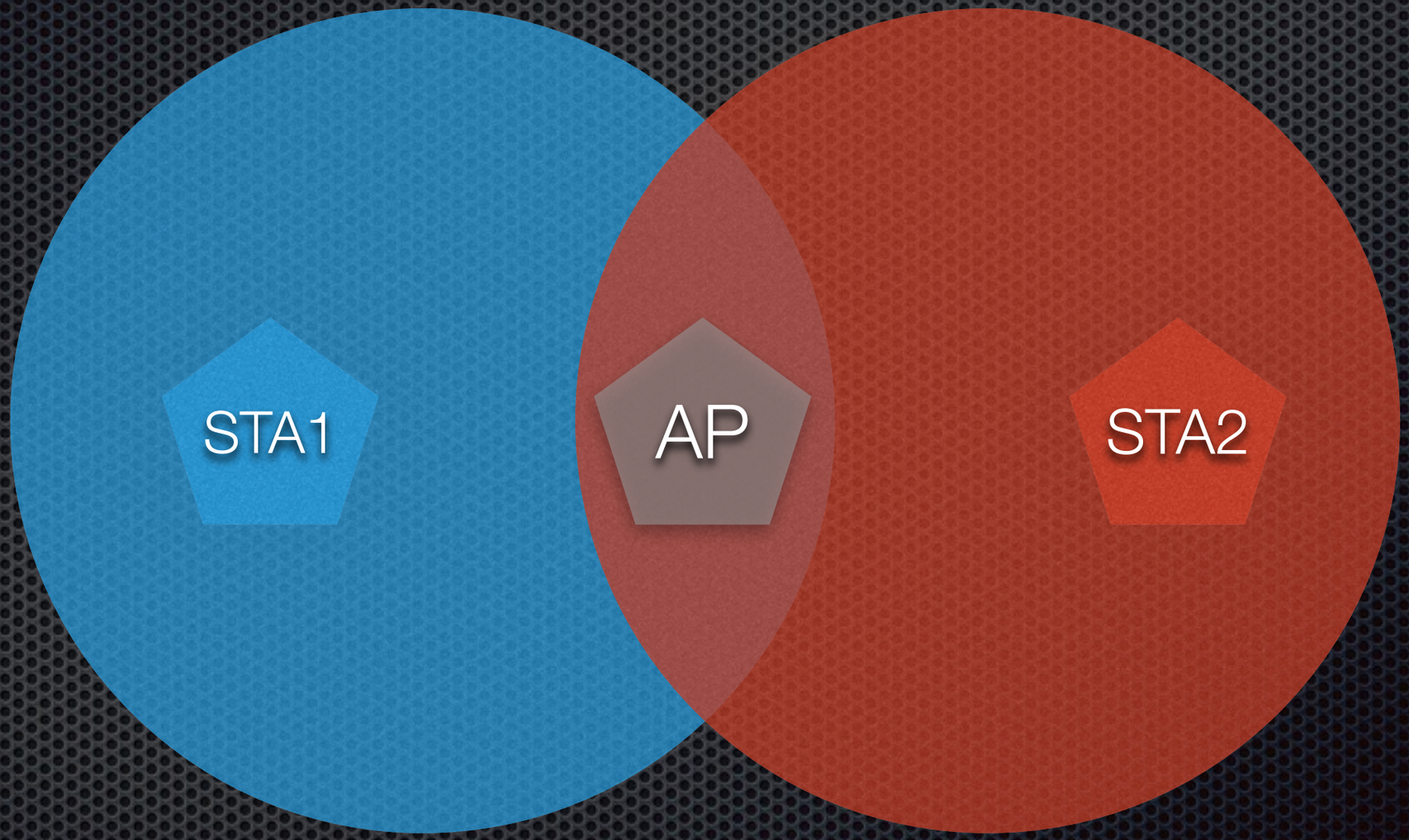
# The Ground Rules of Wi-Fi

# Physical Layer

- Each radio is like one big hub - that requires Collision control.
- There is no Collision Detection in Wi-Fi
- There is only Collision Avoidance
- All your comms are Half Duplex

# Detection
# vs
# Avoidance

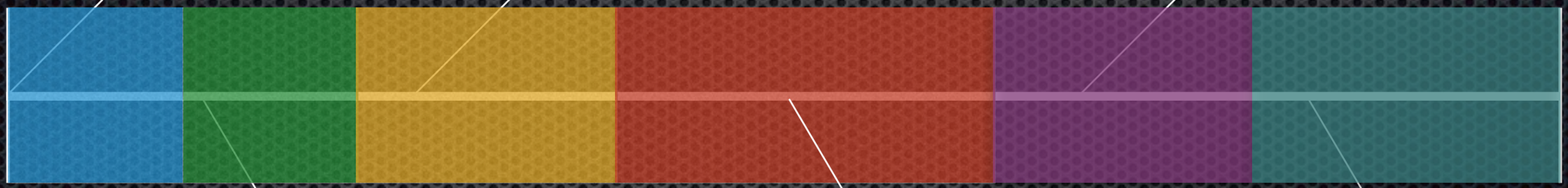
# Why Avoidance?



802.11
(1997)

802.11g
(2003-6)

802.11ac (W1)
(2011-13)



1997

2015

802.11a/b
(1999)

802.11n
(2006-11)

802.11ac (W2)
(2013-15)

# 802.11 (1997)

- 2.4Ghz
- 2Mbps
- Sets the 20Mhz Channel Width
- Sets original 11 Channels
- Frequency Hopping or DSSS

# 802.11a/b (1999)

- 2.4GHz for b, 5.8 GHz for a
- 11Mbps for b, 54Mbps for a
- WEP Encryption only
  (40-bit, then 128-bit, both insecure)
- Beacon rates can slow the network substantially
- Uses CCK in b, OFDM in a

# 802.11g (2003-2006)

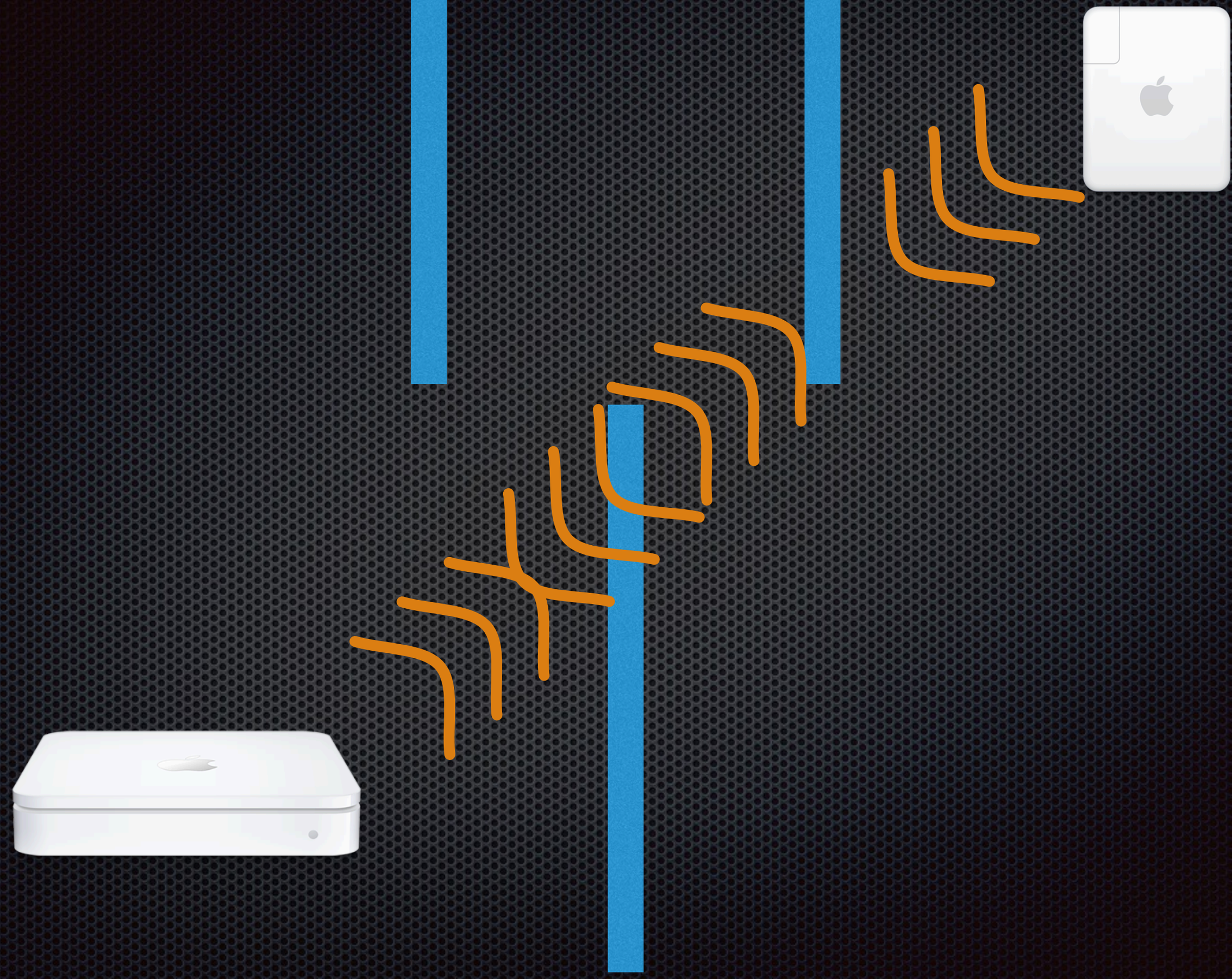
- Adds WPA Encryption (still vulnerable)
- Switch from CCK to OFDM to improve interference handling
- But has to support CCK mode for 802.11b compatibility, which can slow whole networks down
- 54Mbps comes to 2.4GHz

“But Tom, what about Wireless Distribution System?”

*- Conference Workshop Attendee, Probably*

# Wireless Distribution System

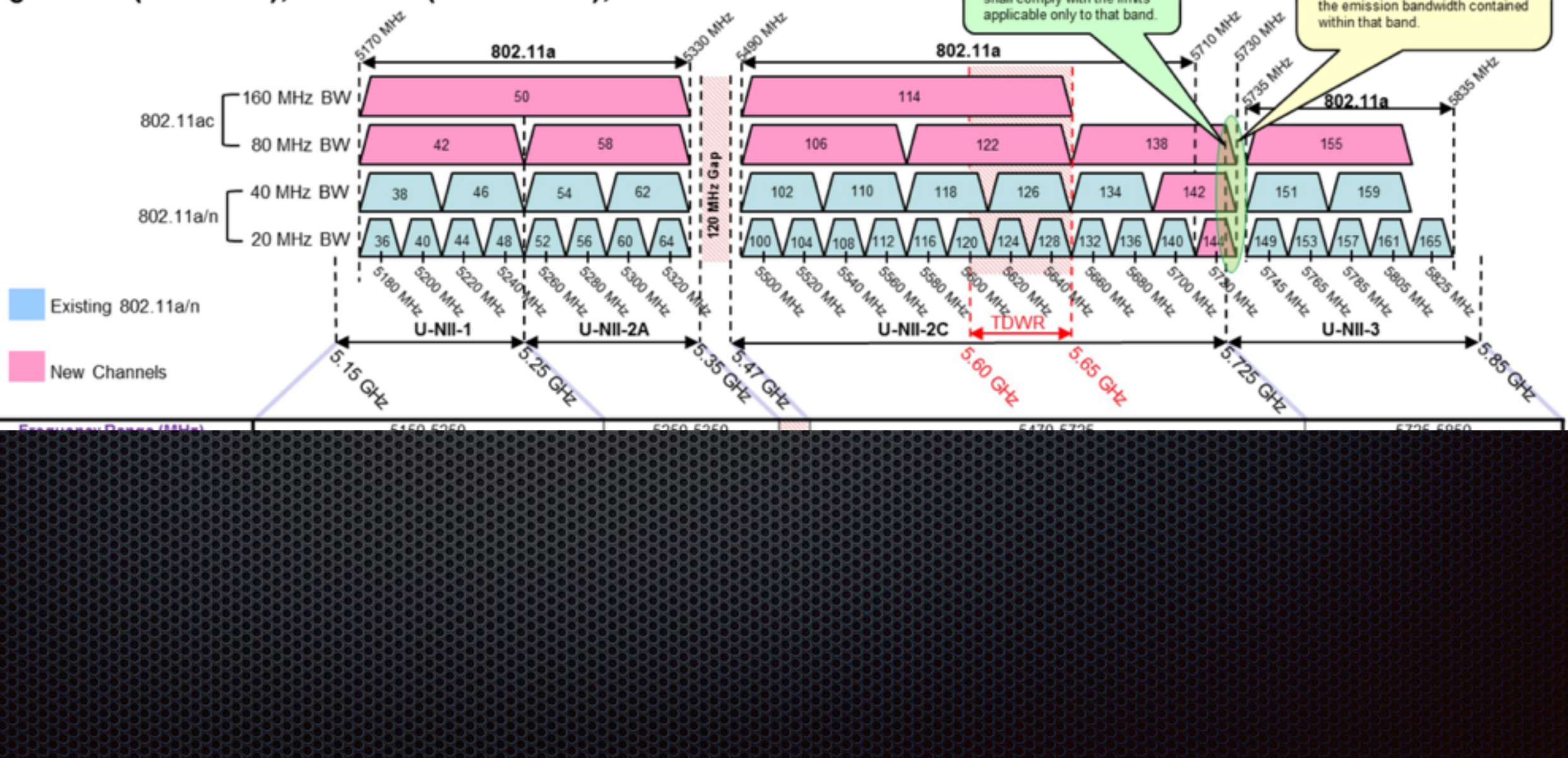
- What happens when you extend wireless *with* wireless?
- Consists of Main Base Station, Relay Base Stations, Remote Base Stations
- Use the same channel, encryption type and key
- Each WDS link halve the bandwidth



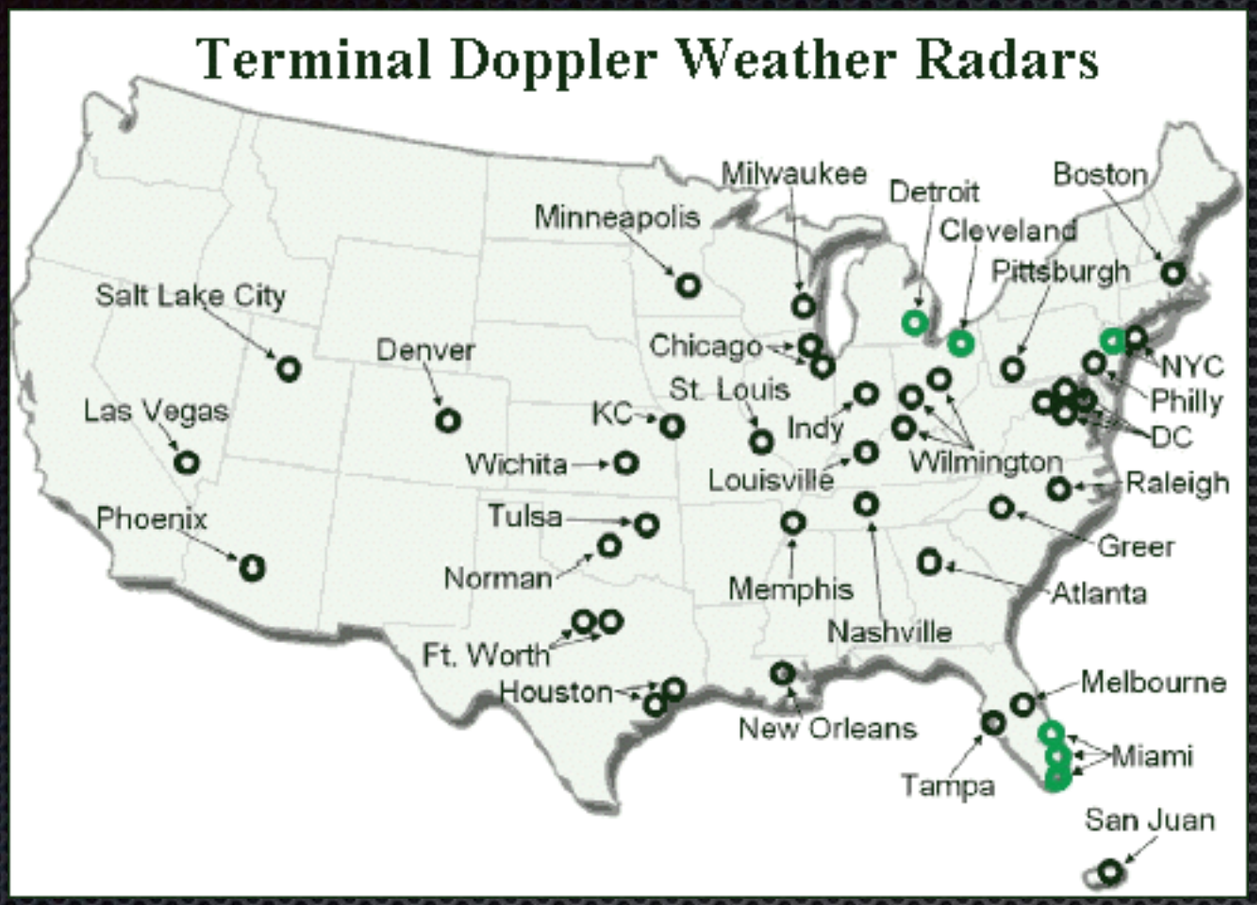
# 802.11n (2006-2011)

- 2.4 or 5GHz
- 20 OR 40 MHz channel widths
- 600Mbps theoretical max
- Hello, MIMO
- WPA2 Introduced, TKIP deprecated, AES introduced

# OPERATION IN U-NII BANDS – 802.11 CHANNEL PLAN
# §15.407 (Part 15E), 1st R&O (FCC 06-96), effective 6/2/2014

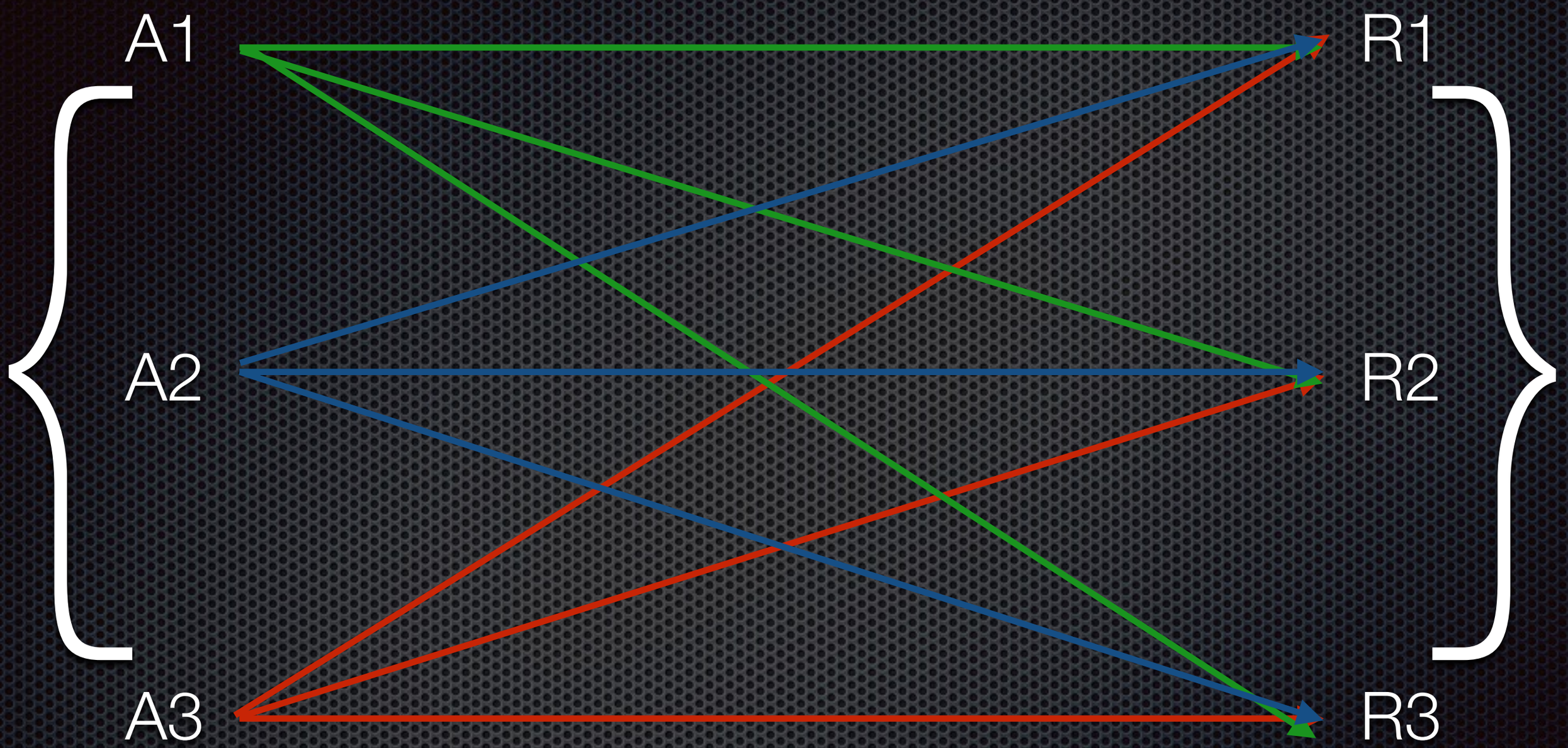


# What's DFS?



# Dynamic Frequency Selection

# What’s MIMO?




Multiple In, Multiple Out

# What's T × R : S?

# 802.11ac Wave 1 (2013)

- 5GHz only
- 80 or 160 MHz channel widths
- 1.2Gbps Theoretical Max
- Can use up to 8 streams
- Can use 256 QAM

# 802.11ac Wave 2 (2014)

- 5GHz only
- 80, or 160 MHz channel widths
- 6.9Gbps Theoretical Max
- That means you need 10GbE to your AP!
- MU-MIMO!