Realities of 802.11ac Speeds in the Enterprise

Richard (Rick) T. Steiner

RCDD, NTS, CWNE(#234), CCNA, CCNA-Wireless, ACMP, ACDX (#128)

Airopath, Inc. – Seattle, WA


IT'S WIRELESS. HOW HARD COULD IT BE TO NOT INSTALL WIRES?
4-24-10 ©2010 Scott Adams, Inc./Dist. by UFS, Inc.

The Claims

- Deliver increased scale and coverage
- Offers a significant boost in performance
- Offers up to 7Gbps of throughput
- Can handle up to XXXX users per radio
- MU-MIMO can talk to multiple clients simultaneously
- To deploy you need multigigabit links to the Access Points

What We are Covering

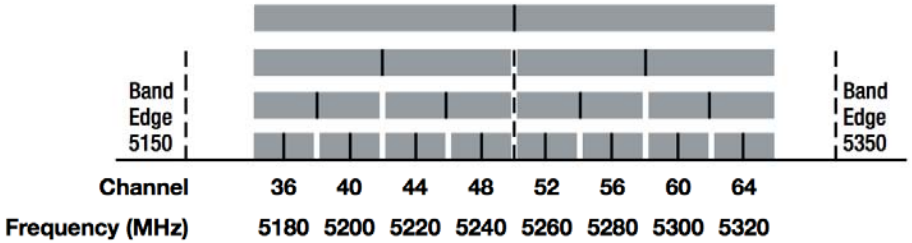
- Definitions and Inner Workings
- Key Factors that affect performance
- The Real Deal
- Refuting or Validation of the Claims

Wireless Basics

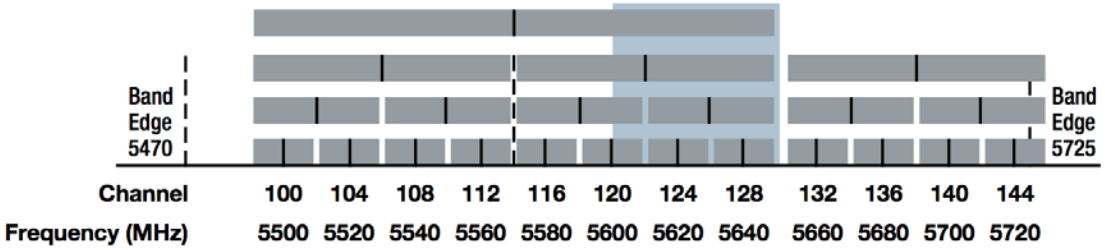
- Half Duplex
  - Only one device can speak
  - Cannot TX and RX at the same time
  - Time slicing
  - CSMA/CA
- Environment is key
  - Attenuation
  - Interference
  - Other factors

Channels defined for 5 GHz bands (U.S. regulations), showing 20, 40, 80 and 160 MHz channels

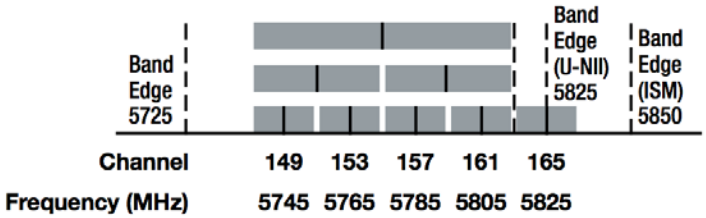
(channel ~~14~~ 144 is now allowed in the U.S. for one additional 20 MHz, one 40 MHz and one 80 MHz channel)



US U-NII 1 and U-NII 2 bands
U-NII 1: 5150-5250 MHz (indoors only)
U-NII 2: 5250-5350 MHz
8x 20 MHz channels
4x 40 MHz channels
2x 80 MHz channels
1x 160 MHz channel
U-NII II requires DFS
(& TPC if over 500 mW/27 dBm EIRP)



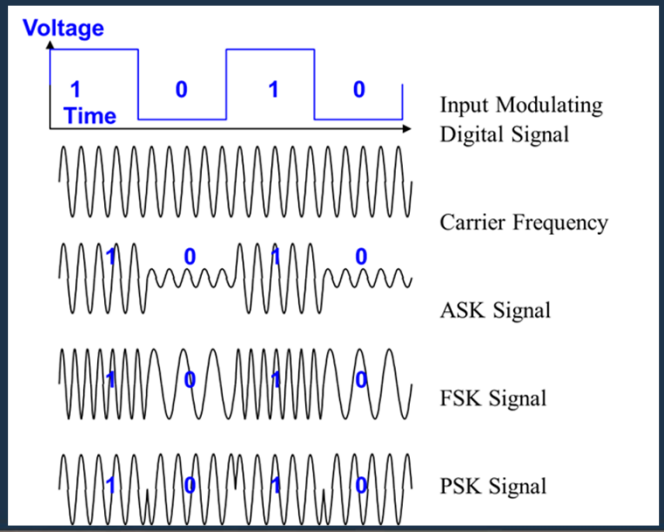
US intermediate band (U-NII 2 extended)
5450-5725 MHz
12x 20 MHz channels
6x 40 MHz channels
3x 80 MHz channels
1x 160 MHz channel
- Requires DFS (& TPC if over 500 mW/27 dBm EIRP)
- 5600-5650 MHz is used by weather radars and is temporarily not available in the U.S.



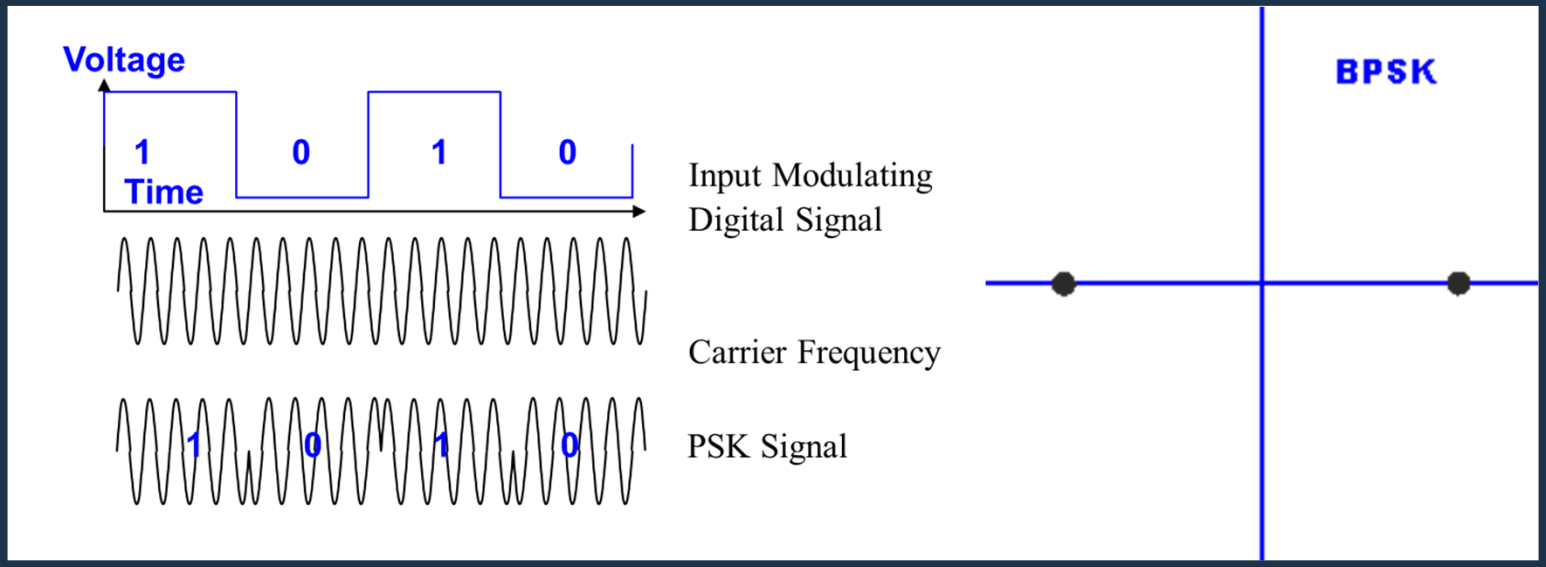
US U-NII 3/ISM band
5725-5825 MHz
5x 20 MHz channels
2x 40 MHz channels
1x 80 MHz channel
- Slightly different rules apply for channel 165 in ISM spectrum

MODULATION

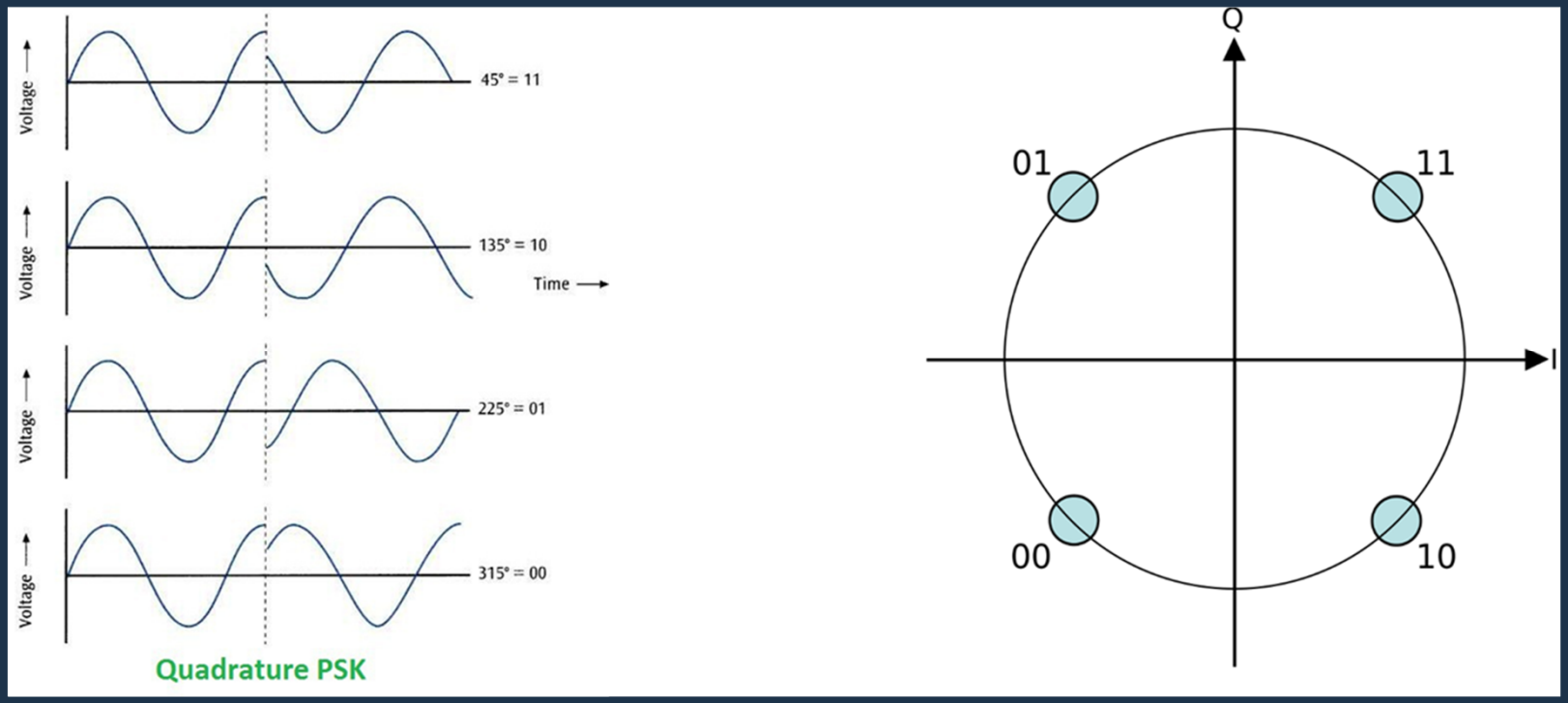
- Modulation
  - Method of modify the carrier signal to represent 1's and 0's - Symbols
  - Amplitude, Phase, and Frequency or a combination (Ex. QAM)



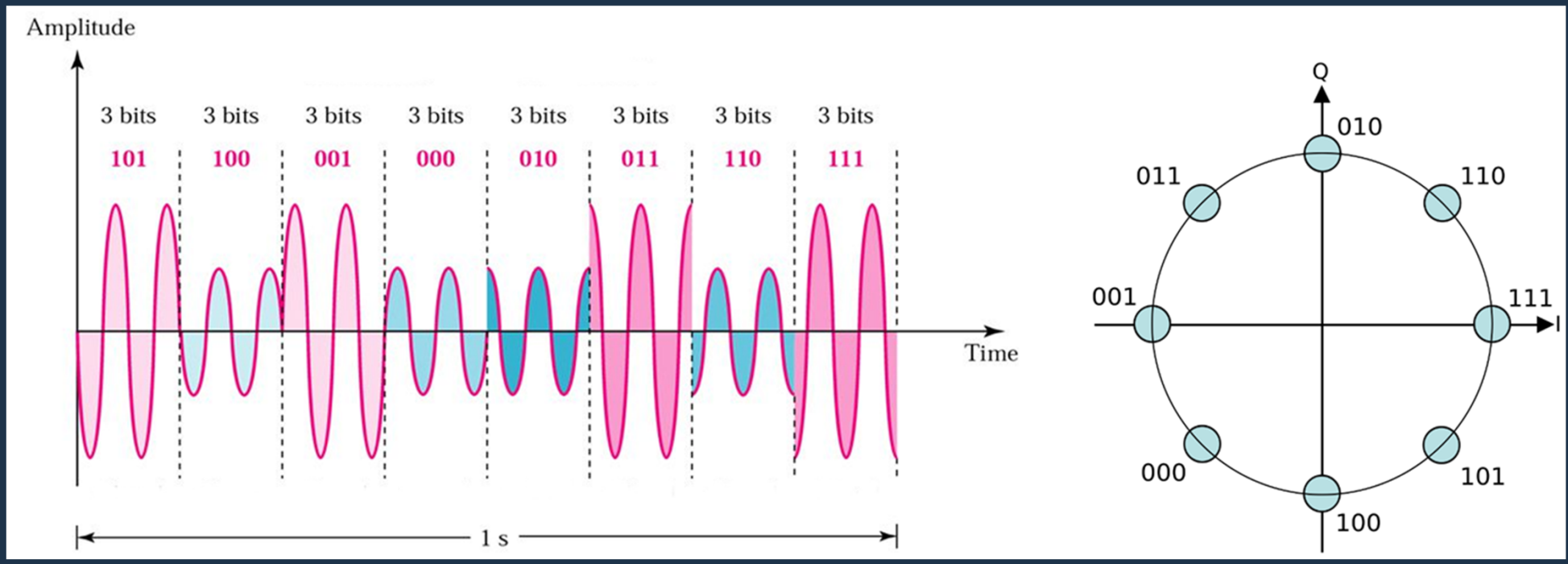
MODULATION CONTINUED



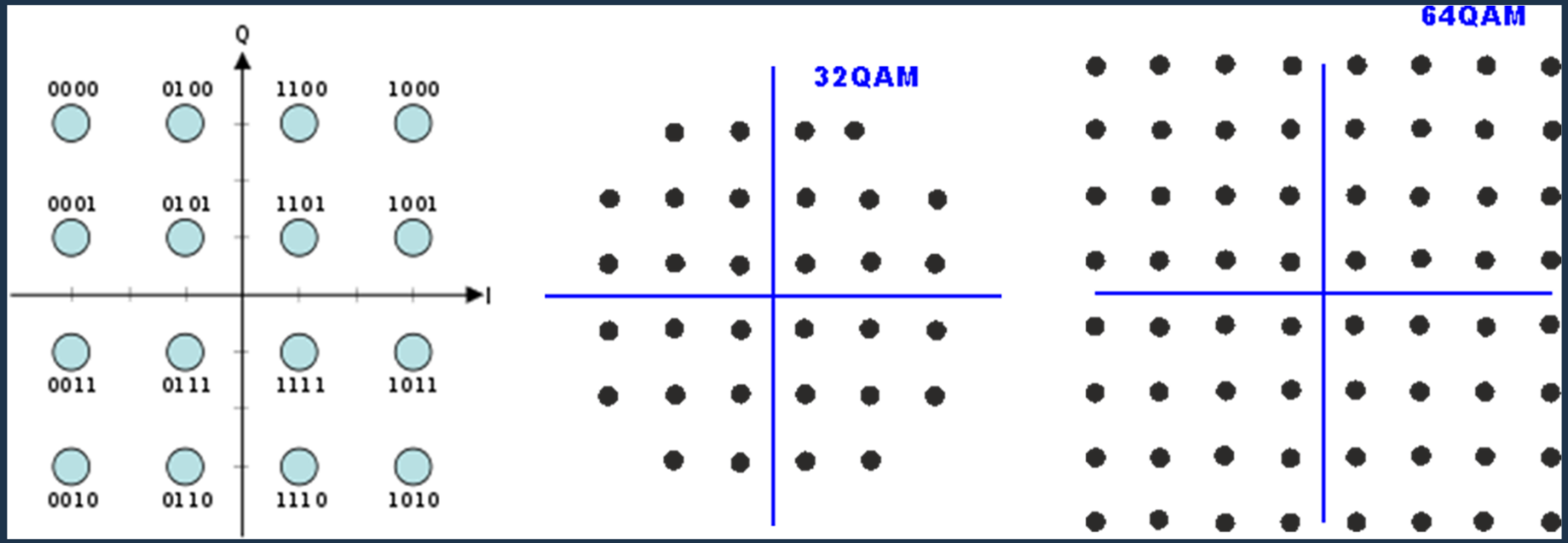
MODULATION CONTINUED



MODULATION CONTINUED



MODULATION CONTINUED



CODING

- Form of Forward Error Correction
- Expressed in x/y format
  - X = Number of Real Data Bits
  - Y = Total Number of Bits Sent
  - Difference equals number of repeated bits
- Current Rates – 1/2, 2/3, 3/4, 5/6

MODULATION CODING SCHEME (MCS)

- Uses Index numbers - .11ac is 0-9
  - Each index number represents
    - Modulation – BPSK, QPSK or XX-QAM
    - Coding rate

										802.11ac
Spatial Streams	Modulation & Coding	Data Rate GI = 800ns 20MHz	Data Rate SGI = 400ns 20MHz	Data Rate GI = 800ns 40MHz	Data Rate SGI = 400ns 40MHz	Data Rate GI = 800ns 80MHz	Data Rate SGI = 400ns 80MHz	Data Rate GI = 800ns 160MHz	Data Rate SGI = 400ns 160MHz	VHT MCS Index
1	BPSK 1/2	6.5	7.2	13.5	15	29.3	32.5	58.5	65	0
1	QPSK 1/2	13	14.4	27	30	58.5	65	117	130	1
1	QPSK 3/4	19.5	21.7	40.5	45	87.8	97.5	175.5	195	2
1	16-QAM 1/2	26	28.9	54	60	117	130	234	260	3
1	16-QAM 3/4	39	43.3	81	90	175.5	195	351	390	4
1	64-QAM 2/3	52	57.8	108	120	234	260	468	520	5
1	64-QAM 3/4	58.5	65	121.5	135	263.3	292.5	526.5	585	6
1	64-QAM 5/6	65	72.2	135	150	292.5	325	585	650	7
1	256-QAM 3/4	78	86.7	162	180	351	390	702	780	8
1	256-QAM 5/6	n/a	n/a	180	200	390	433.3	780	866.7	9

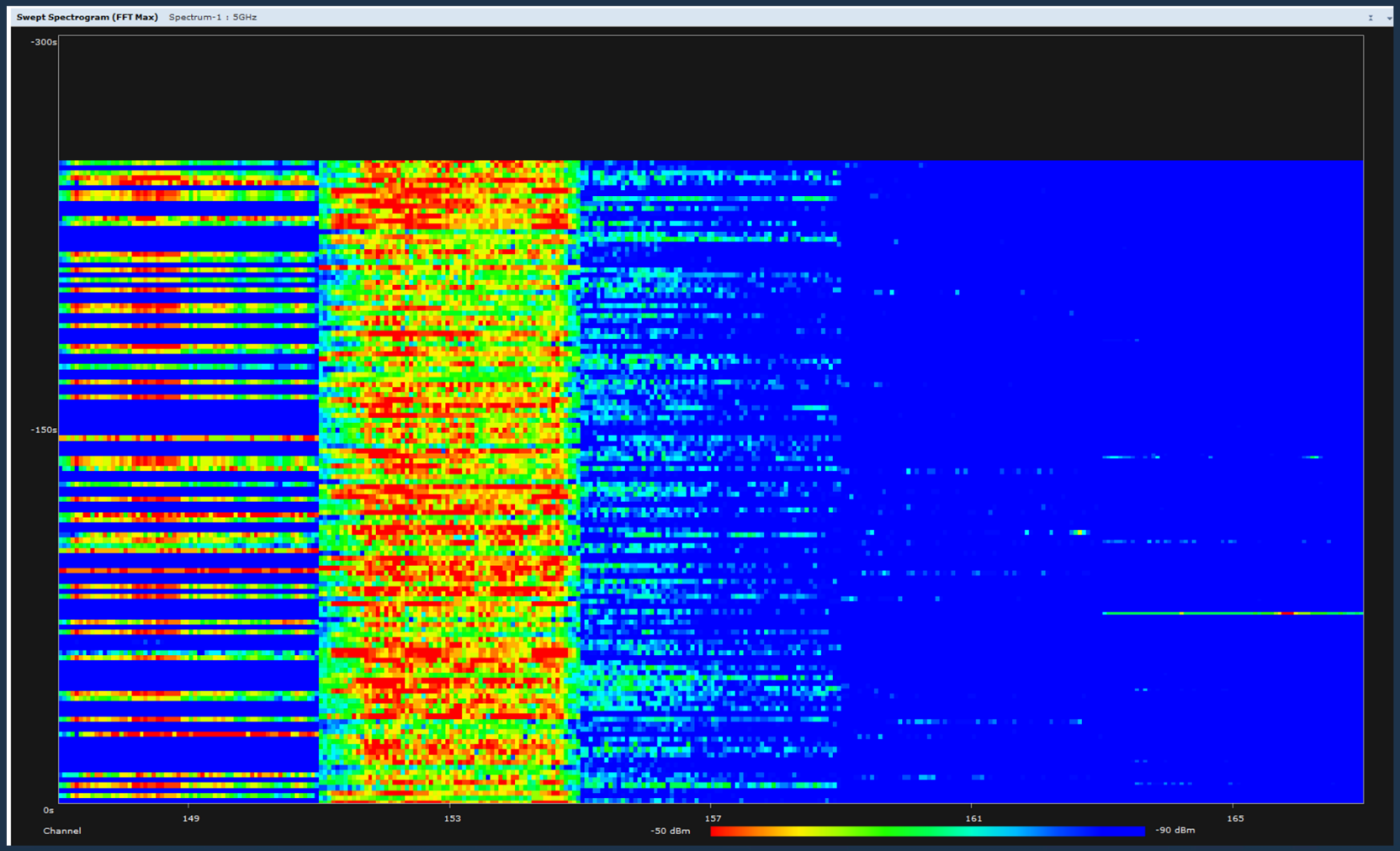
802.11n											802.11ac
HT MCS Index	Spatial Streams	Modulation & Coding	Data Rate GI = 800ns 20MHz	Data Rate SGI = 400ns 20MHz	Data Rate GI = 800ns 40MHz	Data Rate SGI = 400ns 40MHz	Data Rate GI = 800ns 80MHz	Data Rate SGI = 400ns 80MHz	Data Rate GI = 800ns 160MHz	Data Rate SGI = 400ns 160MHz	VHT MCS Index
0	1	BPSK 1/2	6.5	7.2	13.5	15	29.3	32.5	58.5	65	0
1	1	QPSK 1/2	13	14.4	27	30	58.5	65	117	130	1
2	1	QPSK 3/4	19.5	21.7	40.5	45	87.8	97.5	175.5	195	2
3	1	16-QAM 1/2	26	28.9	54	60	117	130	234	260	3
4	1	16-QAM 3/4	39	43.3	81	90	175.5	195	351	390	4
5	1	64-QAM 2/3	52	57.8	108	120	234	260	468	520	5
6	1	64-QAM 3/4	58.5	65	121.5	135	263.3	292.5	526.5	585	6
7	1	64-QAM 5/6	65	72.2	135	150	292.5	325	585	650	7
	1	256-QAM 3/4	78	86.7	162	180	351	390	702	780	8
	1	256-QAM 5/6	n/a	n/a	180	200	390	433.3	780	866.7	9
8	2	BPSK 1/2	13	14.4	27	30	58.5	65	117	130	0
9	2	QPSK 1/2	26	28.9	54	60	117	130	234	260	1
10	2	QPSK 3/4	39	43.3	81	90	175.5	195	351	390	2
11	2	16-QAM 1/2	52	57.8	108	120	234	260	468	520	3
12	2	16-QAM 3/4	78	86.7	162	180	351	390	702	780	4
13	2	64-QAM 2/3	104	115.6	216	240	468	520	936	1040	5
14	2	64-QAM 3/4	117	130.3	243	270	526.5	585	1053	1170	6
15	2	64-QAM 5/6	130	144.4	270	300	585	650	1170	1300	7
	2	256-QAM 3/4	156	173.3	324	360	702	780	1404	1560	8
	2	256-QAM 5/6	n/a	n/a	360	400	780	866.7	1560	1733.3	9

Service Set Identifier - SSID

- 2 Levels Used
  - Extended Service Set Identifier – ESSID
    - Common Name used to identify the network as a unit – “Corp” or “Guest”
    - Transmitted by every Access Point in the network
  - Basic Service Set Identifier – BSSID
    - Used to identify the individual Access Point (radio) and SSID within its programming
    - Format is MAC address – Ex. aa:12:cc:34:ee:56
    - Each and every BSSID has its own set of Management and Control Frames
    - All Management and Control Frames are:
      - Sent using the lowest Basic (a.k.a. Mandatory) Data Rate
      - Sent using 20MHz wide channels for backwards compatibility

Contention Free Periods

- Used to allow channel bonding in the medium
- Initiated by the Access Point
- Sent using 20MHz wide channel
  - Part of the Management and Control Frame set
  - Attempt to avoid collisions with older clients that can't Channel Bond


Swept Spectrogram (FFT Max)
Spectrum-1 : 5GHz
-300s
-150s
0s
149
153
157
161
165
Channel
-50 dBm
-90 dBm

Key Factors that Affect Performance

- Signal to Noise Ratio (SNR)
- Overlapping Basic Service Sets (OBSS)
- Client Device Capabilities
- Greenfield versus Mixed
- Other Forces

Signal to Noise Ratio

- Higher the number – better the signal quality
- Affected by
  - Attenuation
  - Distance
  - Interference
  - Noise floor
- Manufacturers are using derivatives / calculations – “Air Quality”, “Link Quality”

MCS Value Achieved by Clients at Various Signal to Noise Ratio Levels (SNR)

Protocol	Channel	1	2	3	4	5	6	7	8	9	10
802.11b	20MHz	None	None	None	MCS 0	MCS 0	MCS 0	MCS 1	MCS 1	MCS 1	MCS 1
802.11a/g	20MHz	None	MCS 0	MCS 0	MCS 1	MCS 2	MCS 2	MCS 2	MCS 2	MCS 3	MCS 3
802.11n	20MHz	None	MCS 0	MCS 0	MCS 0	MCS 1	MCS 1	MCS 1	MCS 1	MCS 2	MCS 2
802.11n	40MHz	None	None	None	None	MCS 0	MCS 0	MCS 0	MCS 1	MCS 1	MCS 1
802.11ac	20MHz	None	MCS 0	MCS 0	MCS 0	MCS 1	MCS 1	MCS 1	MCS 1	MCS 2	MCS 2
802.11ac	40MHz	None	None	None	None	MCS 0	MCS 0	MCS 0	MCS 1	MCS 1	MCS 1
802.11ac	80MHz	None	None	None	None	None	None	None	MCS 0	MCS 0	MCS 0
802.11ac	160MHz	None	None	None	None	None	None	None	None	None	None

	SNR in dB	11	12	13	14	15	16	17	18	19	20
802.11b	20MHz	MCS 2	MCS 2	MCS 2	MCS 2	MCS 2	MCS 3	MCS 3	MCS 3	MCS 3	MCS 3
802.11a/g	20MHz	MCS 4	MCS 4	MCS 4	MCS 4	MCS 5	MCS 5	MCS 5	MCS 6	MCS 6	MCS 7
802.11n	20MHz	MCS 3	MCS 3	MCS 3	MCS 3	MCS 4	MCS 4	MCS 4	MCS 5	MCS 5	MCS 6
802.11n	40MHz	MCS 1	MCS 2	MCS 2	MCS 3	MCS 3	MCS 3	MCS 3	MCS 4	MCS 4	MCS 4
802.11ac	20MHz	MCS 3	MCS 3	MCS 3	MCS 3	MCS 4	MCS 4	MCS 4	MCS 5	MCS 5	MCS 6
802.11ac	40MHz	MCS 1	MCS 2	MCS 2	MCS 3	MCS 3	MCS 3	MCS 3	MCS 4	MCS 4	MCS 4
802.11ac	80MHz	MCS 1	MCS 1	MCS 1	MCS 1	MCS 2	MCS 2	MCS 3	MCS 3	MCS 3	MCS 3
802.11ac	160MHz	MCS 0	MCS 0	MCS 0	MCS 1	MCS 1	MCS 1	MCS 1	MCS 2	MCS 2	MCS 3

	SNR in dB	21	22	23	24	25	26	27	28	29	30
802.11b	20MHz	MCS 3	MCS 3	MCS 3	MCS 3	MCS 3	MCS 3	MCS 3	MCS 3	MCS 3	MCS 3
802.11a/g	20MHz	MCS 7	MCS 7	MCS 7	MCS 7	MCS 7	MCS 7	MCS 7	MCS 7	MCS 7	MCS 7
802.11n	20MHz	MCS 6	MCS 6	MCS 6	MCS 6	MCS 7	MCS 7	MCS 7	MCS 7	MCS 7	MCS 7
802.11n	40MHz	MCS 5	MCS 5	MCS 6	MCS 6	MCS 6	MCS 6	MCS 6	MCS 7	MCS 7	MCS 7
802.11ac	20MHz	MCS 6	MCS 6	MCS 6	MCS 6	MCS 7	MCS 7	MCS 7	MCS 7	MCS 8	MCS 8
802.11ac	40MHz	MCS 5	MCS 5	MCS 6	MCS 6	MCS 6	MCS 6	MCS 6	MCS 7	MCS 7	MCS 7
802.11ac	80MHz	MCS 4	MCS 4	MCS 4	MCS 5	MCS 5	MCS 6	MCS 6	MCS 6	MCS 6	MCS 6
802.11ac	160MHz	MCS 3	MCS 3	MCS 3	MCS 4	MCS 4	MCS 4	MCS 5	MCS 5	MCS 6	MCS 6

Modulation Key

None = Grey

BPSK = Red

QPSK = Orange

16-QAM = Yellow

64-QAM = Blue

256-QAM = Green

802.11 Type Key

802.11b

802.11ag

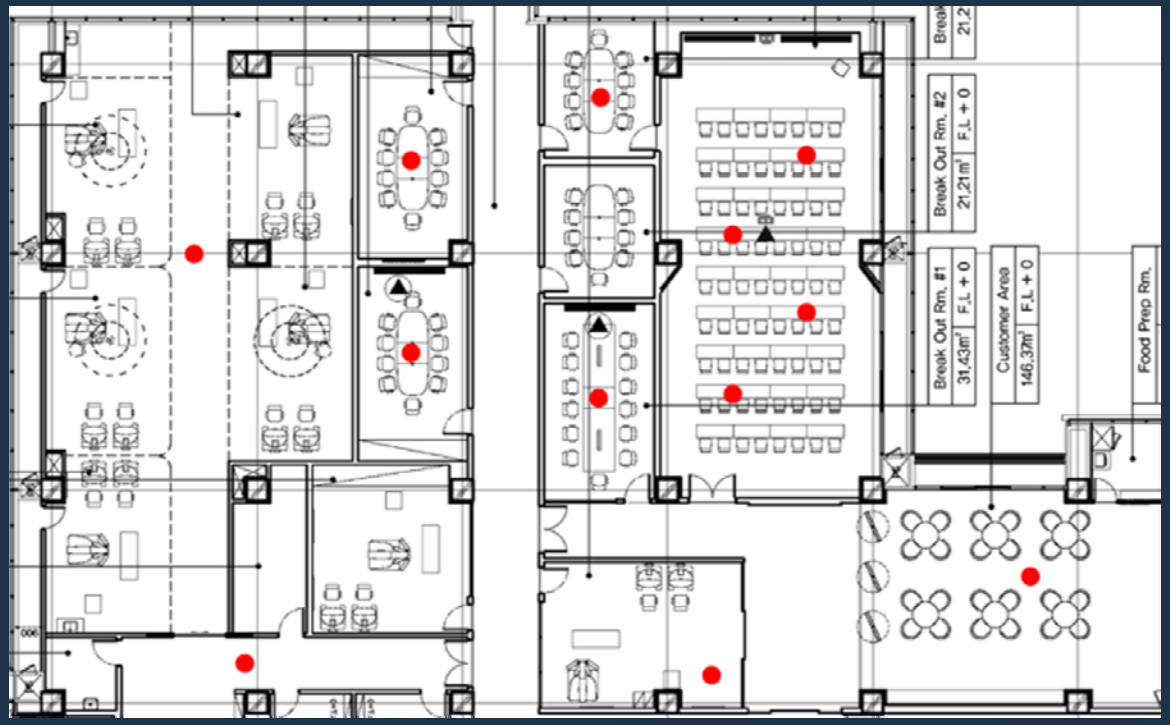
802.11n

802.11ac

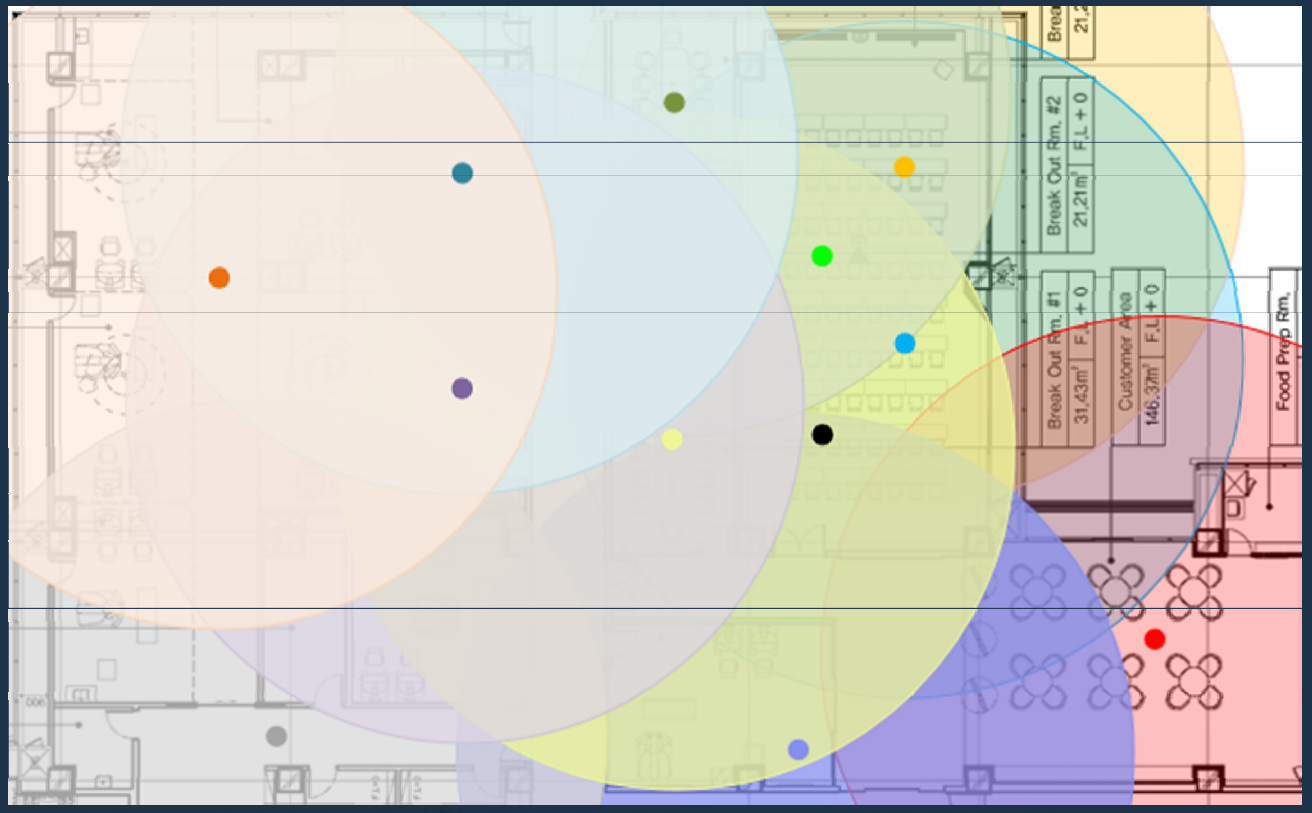
Overlapping Basic Service Sets (OBSS)

- What is it?
  - When AP density is high
  - When number of access points exceed available channels within "earshot"
  - By-product is CCI & ACI
  - Further exacerbated with channel bonding
  - Can occur due to client device location as well

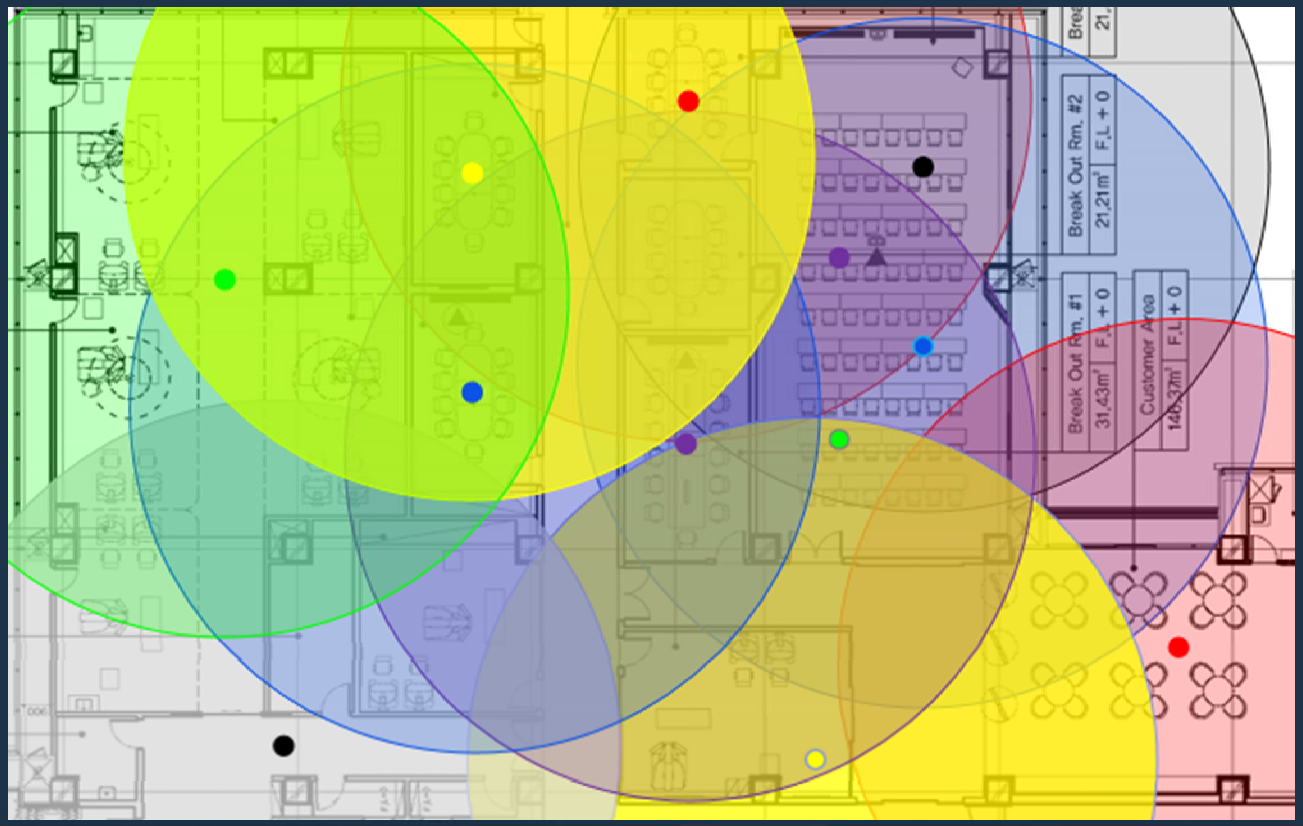
High Density Design = Many Users / High Throughput



USING 20MHZ OR 40MHZ (WITH DFS) CHANNELS



USING 80MHZ WIDE (WITH DFS) CHANNELS



Duty Cycle / Airtime / Utilization

- How long any one TX is taking up the RF
- TX from attenuated devices “take longer” than one closer to the RX
- When channel bonding, increase utilization as you decrease channel diversity
- Remember this is for both Access Points and Client devices
- More “cars on the road” means “less overall speed”

Greenfield versus Mixed

- Definition – All or Some
- Mixed environments are most common, even in Enterprise
- Can’t control Guest / Visiting Client
- Sometimes little control over Corporate Owned
  - Healthcare
  - Where cost is king

Outside Forces

- Client Devices
  - Hardware support for Channels and Capabilities (Ex. MU-MIMO)
  - Driver Challenges
- Neighboring Networks
- Manufacturer options

The Real Deal

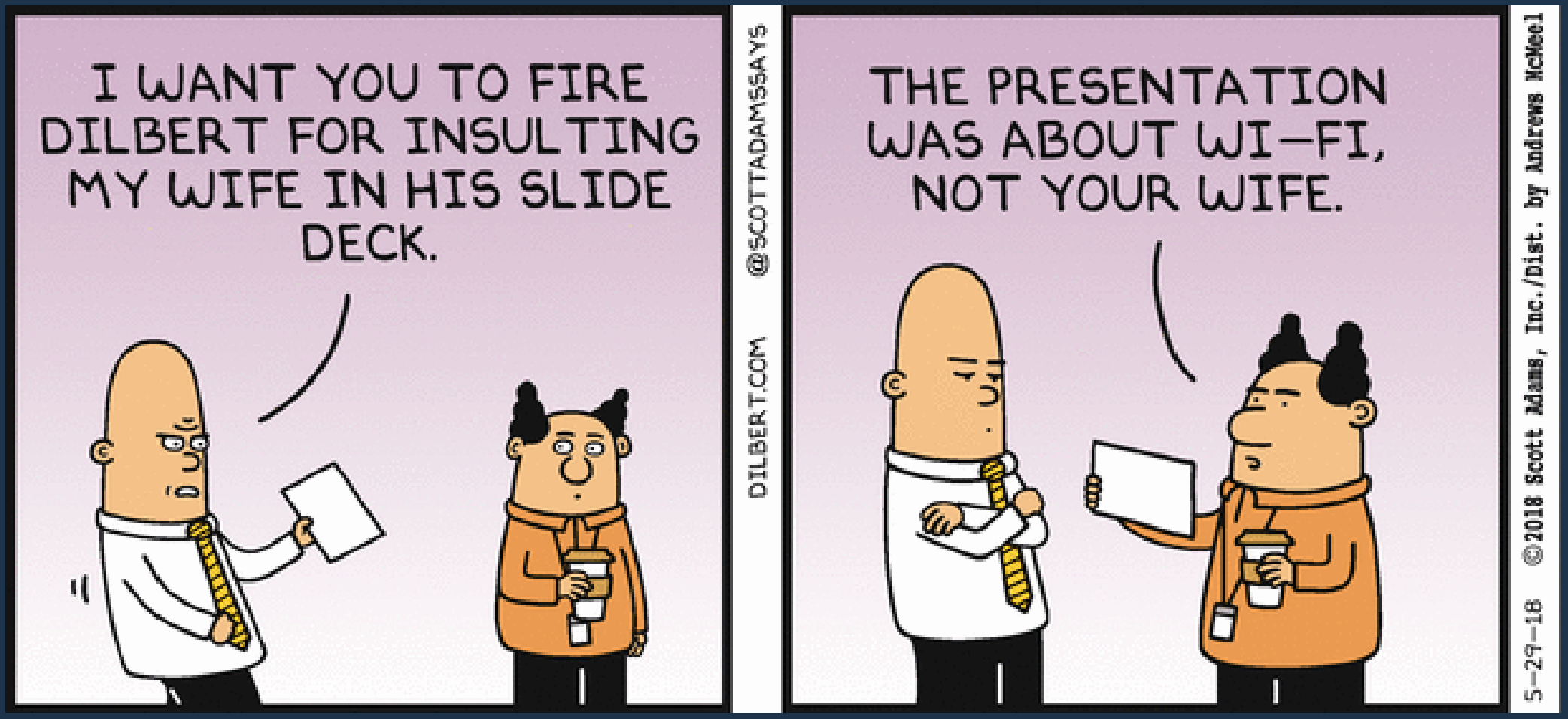
- Depending on Environment use of Channel Bonding will be limited
  - 20MHz – always
  - 40MHz – sometimes depending on AP density
  - 80MHz+ - not likely
- Designs are moving to more users in condensed areas
  - Increases OBSS likelihood
- Can't control all devices in the environment
  - Capabilities Need to be equal
  - Hardware and Driver support

THE CLAIMS

- Deliver increased scale and coverage.
  - ☒ Coverage isn't increased
  - ⊟ Depends on what they mean by "scale"
- Offers a significant boost in performance.
  - ☑ Compared to .11a/b/g
  - ⊟ Compared .11n, not so much
- Offers up to 7Gbps of throughput.
  - ☒ Only in very few cases

The Claims

- Can handle up to XXXX users per radio.
  - ✅ Newer capabilities and hardware have increase capacity
  - ➖ Efficiency is hampered with large numbers of devices
- MU-MIMO can talk to multiple clients simultaneously.
  - ❌ Only in Downlink Direction
  - ❌ Not all Manufacturers support
- To deploy you need multigigabit links to the Access Points.
  - ❌ Half-duplex medium and limited wireless speeds even with .11ac



My Contact Info

rsteiner@airopath.com

@rick_wifi_guy

https://www.linkedin.com/in/richard-rick-steiner-5874566

https://rickwifiguy.wordpress.com

www.airopath.com