Difference between
Wi-Fi that works and Wi-Fi that doesn’t

Wi-Fi Always Works...

Things I've Learned about Wireless LAN Design

after teaching hundreds of classes

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wirelessLAN PROFESSIONALS

Wi-Fi is Easy to do wrong…

Why?

If you don’t know even basic best practices or ‘rules’…

Wi-Fi still works…

Following Rules
&
Best Practices

10 – 20 – 30

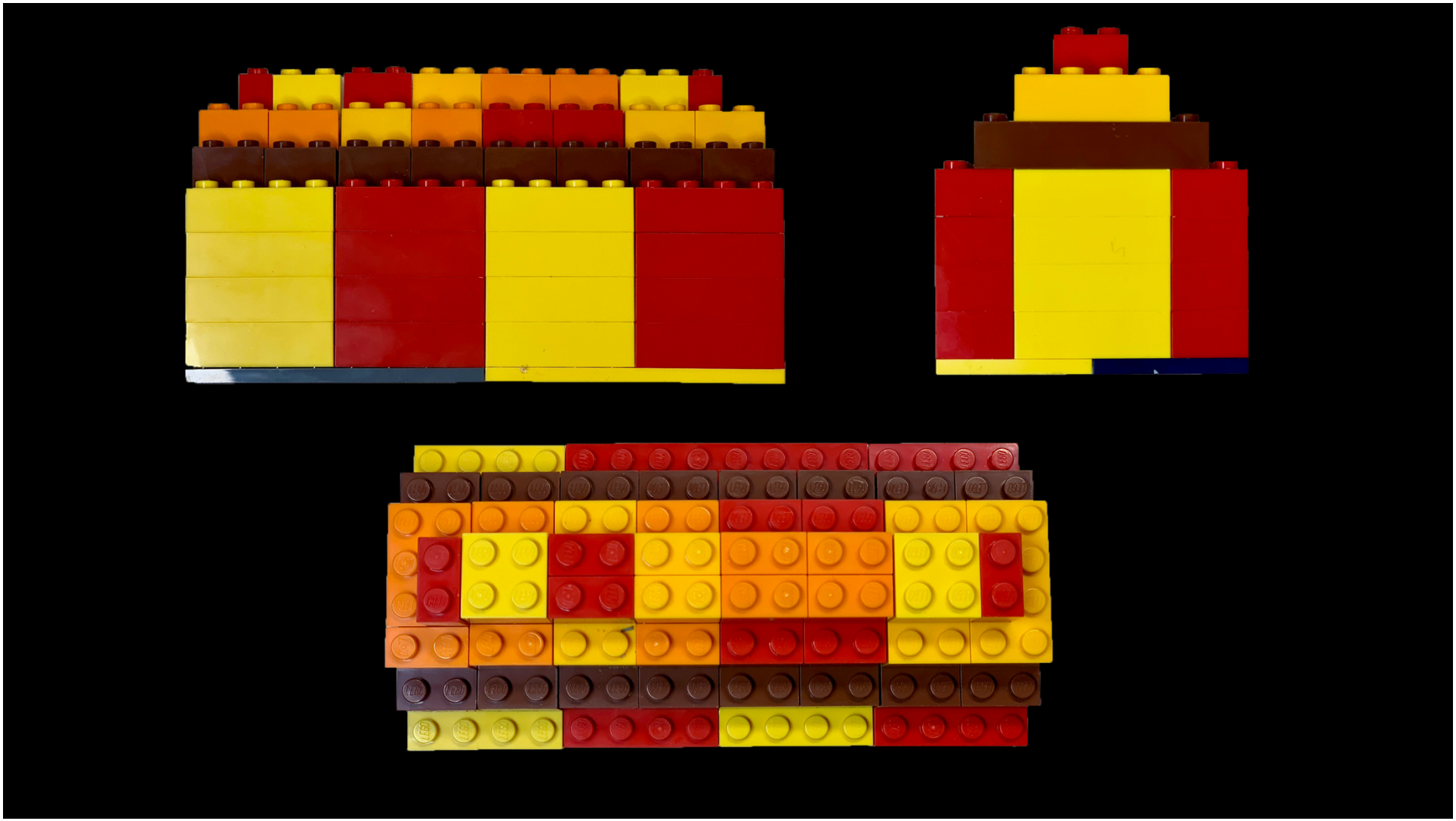
Presentation Rules

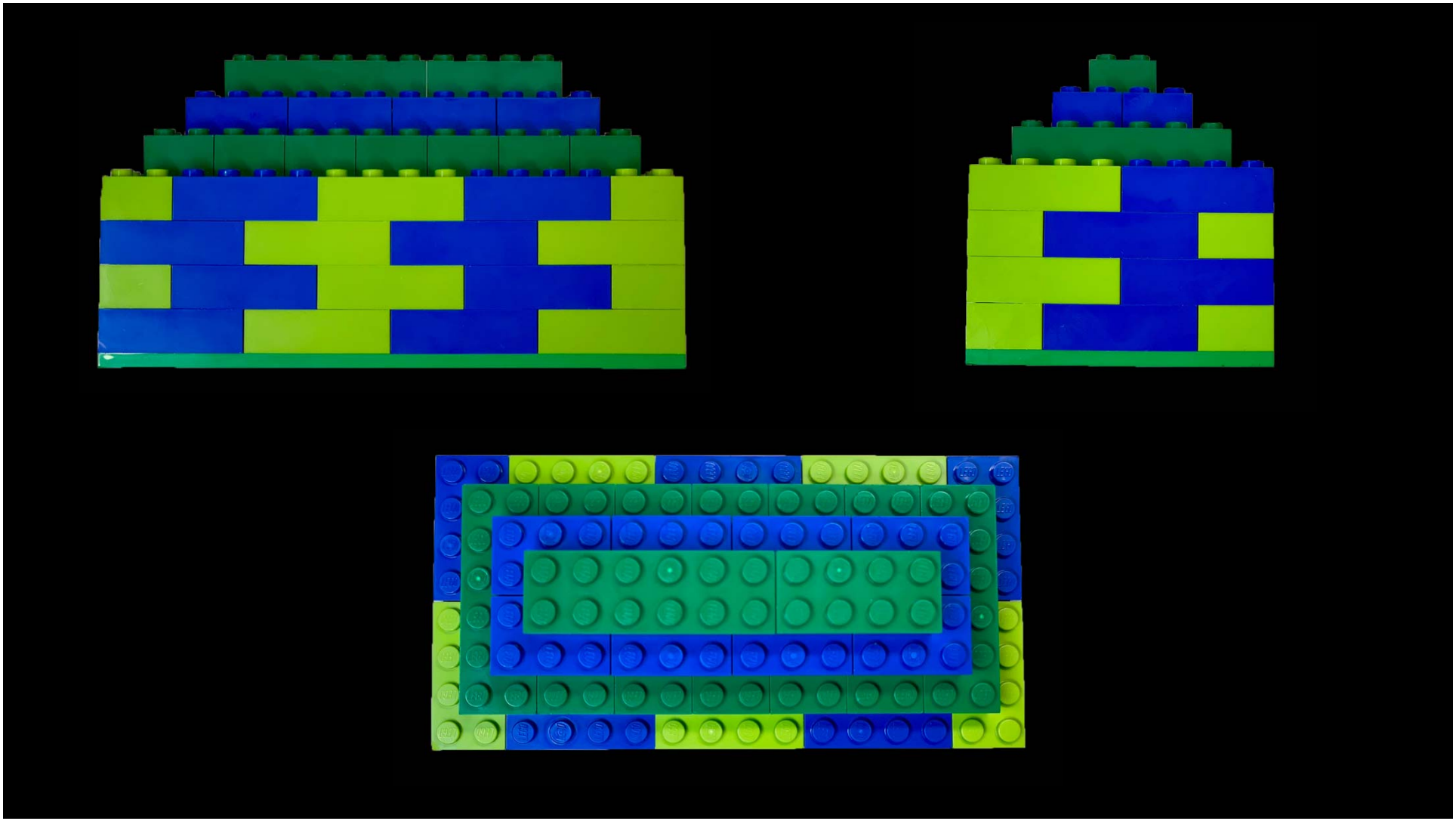
of Guy Kawasaki

Playing with LEGO

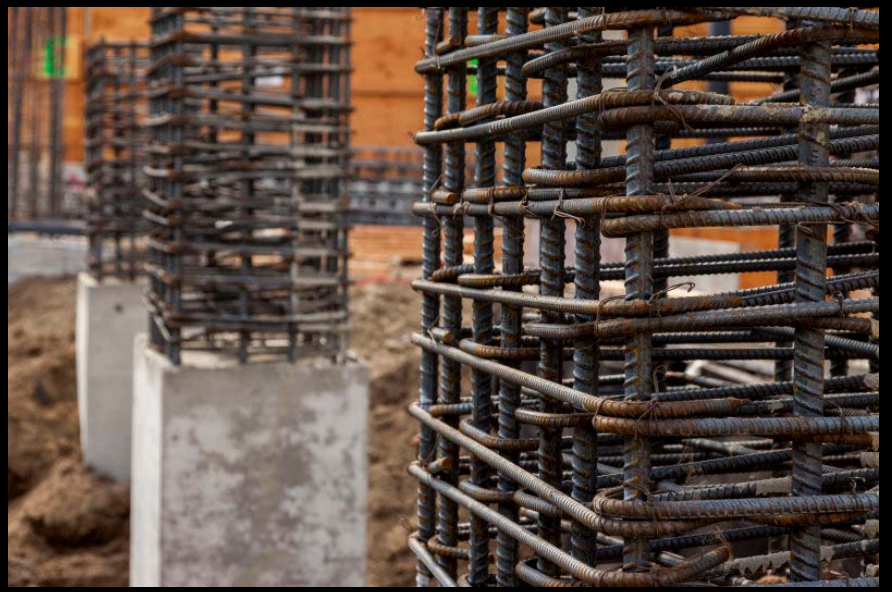
Requirements:

8 x 16 ‘House’
4 Bricks High
Sloped Roof Lengthwise
Limited supply of Bricks





Engineer
Solutions



Wireless LAN Rules to Follow

or sometimes break

Do not say the word ‘Survey’ when you mean ‘Design’

Engineer
WLAN Designs

Do NOT Use
Simplified Marketing Ratios

Know
All Requirements

Design to Meet
All Requirements

You Can NOT design for ALL Wi-Fi Clients

But you may design for one that works for others

Design for LCMI

Least Capable – Most Important

Use Widest Channel until you can’t

Co-Channel Interference

Use the highest Minimum Basic Rate until you can’t

Retry Rates Climb

Use the highest possible Tx Power, until you can't

Average Data Rates Drop

Always Use DFS Channels, until you can't

DFS Events in Logs

Do Not use RRM/ARM/ Channel Fly

Unless you know how to tune it properly

Do Not use same SSID across frequencies

Do Not do one-for-one Access Point replacements

Choose Antennas that covers what you want

while not covering
what you don't

Never Use a Captive Portal for Public Wi-Fi

Customers want
Fast, Free and Frictionless

Do not believe marketing hype

Always do a
Validation
Survey

Always do a
Passive Survey

Do Active Surveys…

Only if you know and can explain limitations and results

Green does not mean good!

If it moves – Wireless
If it doesn't – Wire

Until you can't…

Use
top-of-the-line
Access Points

Do Not Put Access Points in Hallways

Do Not Put Access Points above the ceiling

Do Not put Access Points on the wall like a clock

Do Place
Access Points
as close to
clients as possible

Keep
Access Points
minimum
2 meters away… from
anything

Do Not place Access Points behind/near metal grids/girders

Do Not do ‘weird’ things with Antennas

Design for 5GHz

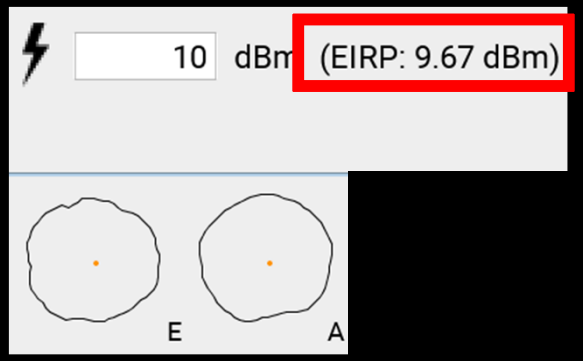
Then turn off two thirds
of 2.4Ghz radios

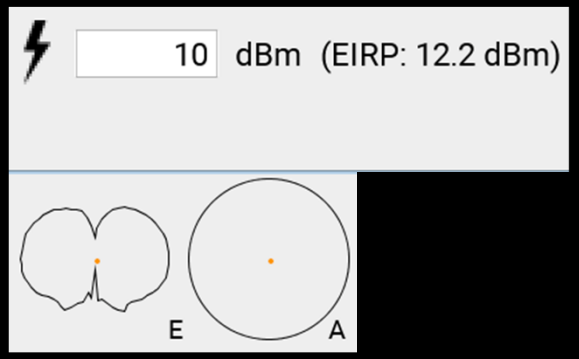
Use Only
Channels
1, 6, and 11

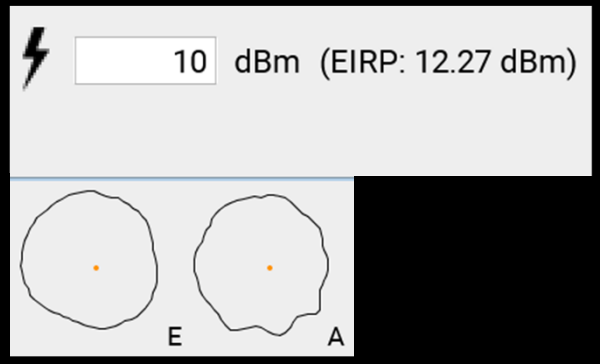
Do Not
Bond Channels
in 2.4GHz

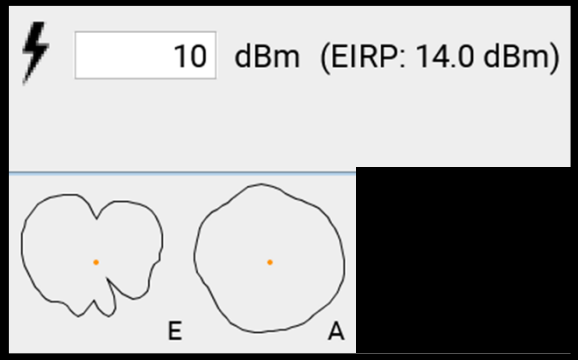
Choose
Access Point BEFORE
Predictive Design

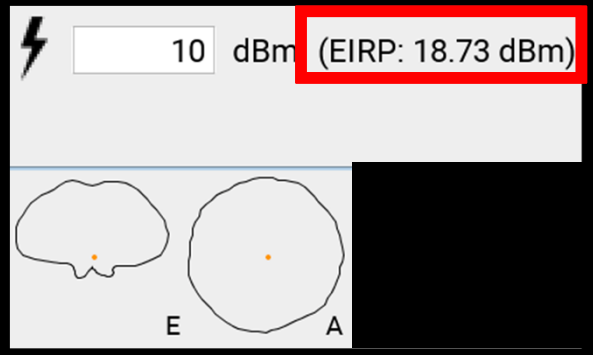
Comparable Access Points











Two Access Points in same area with CCI/CCA have capacity of ONE

Co-Channel Interference

- Two or more Access Points in the same area with RSSI above CCA Preamble Detect Threshold
- Share the medium – resulting in capacity of a single Access Point
- Thus not adding any more capacity

Change in number of Access Points

MAY

change your Capacity

Change in
Client Device Type
WILL
Change your Capacity

Access Point – 3x3:3 – 1,300 Mbps Capacity

Tablet – 1x1:1 – 65-raw/30-TCP Mbps Draw
Target Application Requires 2 Mbps
Each Tablet uses 2 Mbps/30 Mbps = 6.66% Airtime

200 Tablets need 200 X 6.66% = 1,332% or 14 Airtimes
(14 Radios)

Access Point – 3x3:3 – 1,300 Mbps Capacity

Laptop – 2x2:2 – 300-raw/150-TCP Mbps Draw
Target Application Requires 2 Mbps
Each Laptop uses 2 Mbps/150 Mbps = 1.3% Airtime

200 Laptops need 200 X 1.3% = 260% or 3 Airtimes
(3 Radios)

Access Point – 3x3:3 – 1,300 Mbps Capacity

100 Laptops need 100 X 1.3% = 130%
100 Tablets need 100 X 6.66% = 666%
Total for all 200 devices = 796%
At 80% efficiency – 796% / 80% = 995% for 10 Airtimes
(10 Radios)

Learn & Understand

Things you should just Know!

Coverage is Easy

2.4GHz and 5GHz
Go Same Distance

Receive Aperture

Know how to quickly convert dBm to mW

In your head!

Association is to Wireless

What a Link-Light
is to Wire

Lowering Tx Power does NOT fix CCI/CCA Issues

Turning Off Radios Does

Coverage
is to Wireless

what Connectivity
is to Wire

Clean Air Doesn’t

Increasing Tx Power

One-Way Improved RSSI

Increasing Antenna Gain

Two-Way
Improved RSSI

Double the Distance
Quarter the Power

2X distance → -6dB

+6dB → 2X Distance

Lowering Minimum Basic Rates does Not shrink cell size

Preambles sent at BPSK

KNOW

Your PHY

KNOW

Modulation Techniques

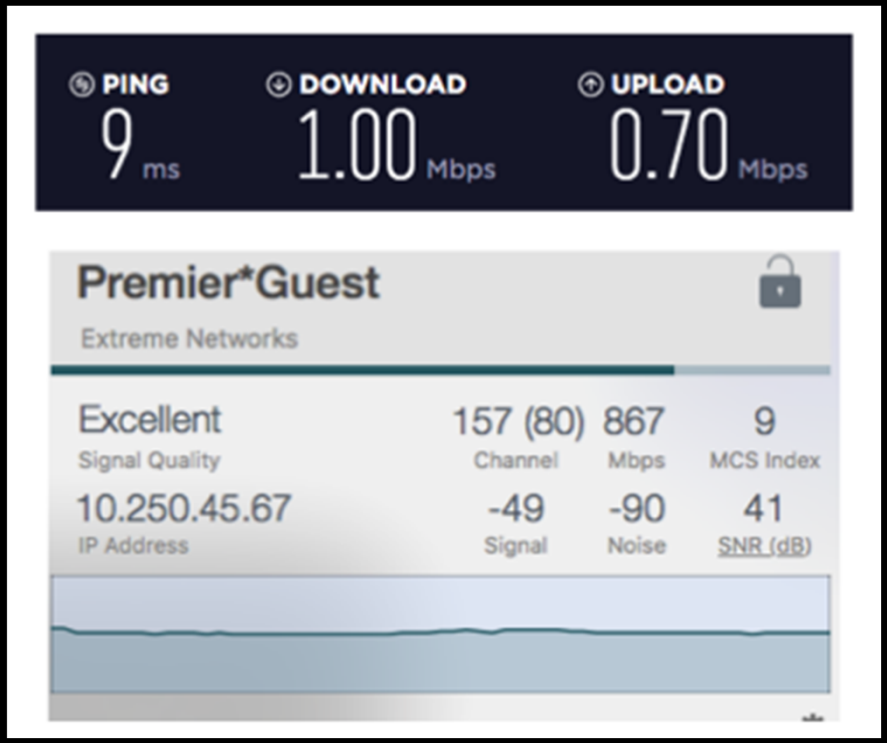
KNOW

Your Protocol

Know a Client's RF vs Wired Situation

MCS, Data Rates,
IP Address, Throughput

Many Wi-Fi Issues Aren’t



Know How to Use Professional Tools

All 802.11 Transmitters choose

Modulation, Coding,
Channel Width, Guard Interval

for each frame

KNOW

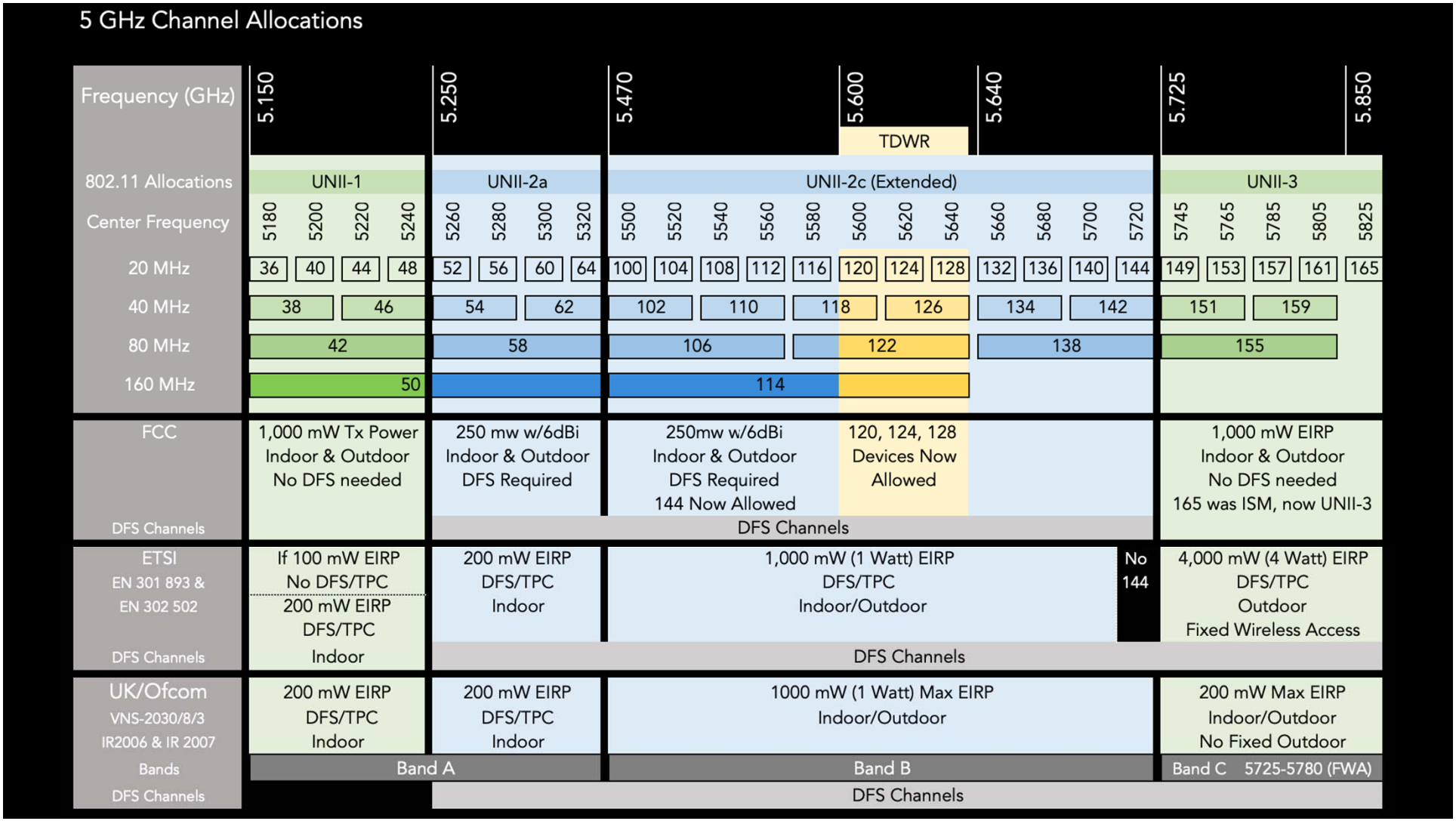
How 802.11 Tx Choose MCS

802.11n HT and 802.11ac VHT MCS, SNR and RSSI

HT MCS	VHT MCS	Modulation	Coding	20MHz				40MHz				80MHz				160MHz			
				Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI	Data Rate		Min. SNR	RSSI
				800ns	400ns			800ns	400ns			800ns	400ns			800ns	400ns		
1 Spatial Stream																			
0	0	BPSK	1/2	6.5	7.2	2	-82	13.5	15	5	-79	29.3	32.5	8	-76	58.5	65	11	-73
1	1	QPSK	1/2	13	14.4	5	-79	27	30	8	-76	58.5	65	11	-73	117	130	14	-70
2	2	QPSK	3/4	19.5	21.7	9	-77	40.5	45	12	-74	87.8	97.5	15	-71	175.5	195	18	-68
3	3	16-QAM	1/2	26	28.9	11	-74	54	60	14	-71	117	130	17	-68	234	260	20	-65
4	4	16-QAM	3/4	39	43.3	15	-70	81	90	18	-67	175.5	195	21	-64	351	390	24	-61
5	5	64-QAM	2/3	52	57.8	18	-66	108	120	21	-63	234	260	24	-60	468	520	27	-57
6	6	64-QAM	3/4	58.5	65	20	-65	121.5	135	23	-62	263.3	292.5	26	-59	526.5	585	29	-56
7	7	64-QAM	5/6	65	72.2	25	-64	135	150	28	-61	292.5	325	31	-58	585	650	34	-55
	8	256-QAM	3/4	78	86.7	29	-59	162	180	32	-56	351	390	35	-53	702	780	38	-50
	9	256-QAM	5/6			31	-57	180	200	34	-54	390	433.3	37	-51	780	866.7	40	-48
2 Spatial Streams																			
8	0	BPSK	1/2	13	14.4	2	-82	27	30	5	-79	58.5	65	8	-76	117	130	11	-73
9	1	QPSK	1/2	26	28.9	5	-79	54	60	8	-76	117	130	11	-73	234	260	14	-70
10	2	QPSK	3/4	39	43.3	9	-77	81	90	12	-74	175.5	195	15	-71	351	390	18	-68
11	3	16-QAM	1/2	52	57.8	11	-74	108	120	14	-71	234	260	17	-68	468	520	20	-65
12	4	16-QAM	3/4	78	86.7	15	-70	162	180	18	-67	351	390	21	-64	702	780	24	-61
13	5	64-QAM	2/3	104	115.6	18	-66	216	240	21	-63	468	520	24	-60	936	1040	27	-57
14	6	64-QAM	3/4	117	130.3	20	-65	243	270	23	-62	526.5	585	26	-59	1053	1170	29	-56
15	7	64-QAM	5/6	130	144.4	25	-64	270	300	28	-61	585	650	31	-58	1170	1300	34	-55
	8	256-QAM	3/4	156	173.3	29	-59	324	360	32	-56	702	780	35	-53	1404	1560	38	-50
	9	256-QAM	5/6			31	-57	360	400	34	-54	780	866.7	37	-51	1560	1733.3	40	-48

KNOW

Regional Frequency Spectrum Rules


5 GHz Channel Allocations
Frequency (GHz)
5.150
5.250
5.470
5.600
TDWR
5.640
5.725
5.850
802.11 Allocations
UNII-1
UNII-2a
UNII-2c (Extended)
UNII-3
Center Frequency
5180 5200 5220 5240 5260 5280 5300 5320 5500 5520 5540 5560 5580 5600 5620 5640 5660 5680 5700 5720 5745 5765 5785 5805 5825
20 MHz
36 40 44 48 52 56 60 64 100 104 108 112 116 120 124 128 132 136 140 144 149 153 157 161 165
40 MHz
38 46 54 62 102 110 118 126 134 142 151 159
80 MHz
42 58 106 122 138 155
160 MHz
50 114
FCC
1,000 mW Tx Power
Indoor & Outdoor
No DFS needed
250 mw w/6dBi
Indoor & Outdoor
DFS Required
250mw w/6dBi
Indoor & Outdoor
DFS Required
144 Now Allowed
120, 124, 128
Devices Now
Allowed
1,000 mW EIRP
Indoor & Outdoor
No DFS needed
165 was ISM, now UNII-3
DFS Channels
DFS Channels
ETSI
EN 301 893 &
EN 302 502
If 100 mW EIRP
No DFS/TPC
200 mW EIRP
DFS/TPC
Indoor
200 mW EIRP
DFS/TPC
Indoor
1,000 mW (1 Watt) EIRP
DFS/TPC
Indoor/Outdoor
No
144
4,000 mW (4 Watt) EIRP
DFS/TPC
Outdoor
Fixed Wireless Access
DFS Channels
DFS Channels
UK/Ofcom
VNS-2030/8/3
IR2006 & IR 2007
200 mW EIRP
DFS/TPC
Indoor
200 mW EIRP
DFS/TPC
Indoor
1000 mW (1 Watt) Max EIRP
Indoor/Outdoor
200 mW Max EIRP
Indoor/Outdoor
No Fixed Outdoor
Bands
Band A
Band B
Band C 5725-5780 (FWA)
DFS Channels
DFS Channels

Does it Meet Requirements?

RF Requirements

- Frequency Allocations
- RSSI Primary (Coverage)
- RSSI Secondary (Overlap)
- Co-Channel Interference
- Device to Radio Ratios
- Special High Density Areas
- Protection Modes

Non-RF Requirements

- Jitter, Latency, Packet Loss, MOS
- Beacon Interval, DTIM Interval
- End to End QoS
- WMM Access Categories
- Codec Choice
- Distributed Forwarding

That’s All Folks!

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