Operational Practices for Wi-Fi Deployment

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CARIBBEAN CABLE & TELECOMMUNICATIONS ASSOCIATION

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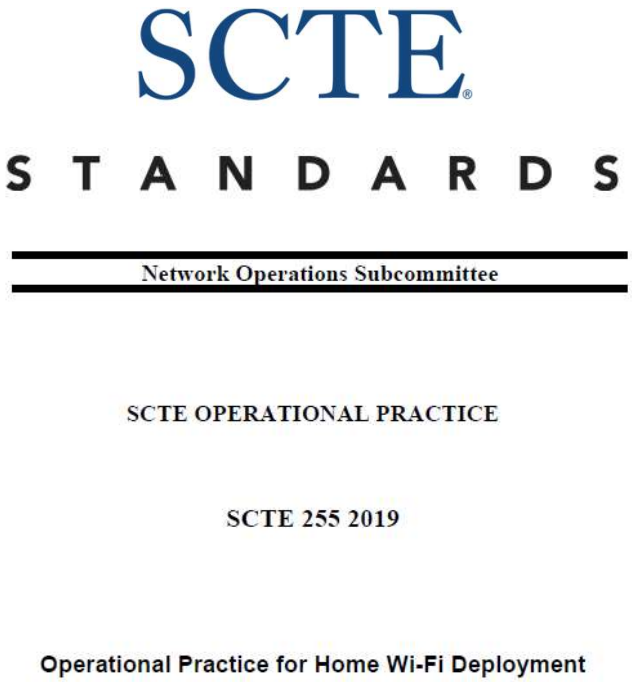
CWNP

Agenda

- Understand the current state of Wi-Fi
- Brief review of Wi-Fi Standards
- Wi-Fi channels and RF operation
- Wi-Fi deployment
- New features of Wi-Fi 6 and Wi-Fi 6E
- Troubleshooting Wi-Fi


SCTE

STANDARDS

Network Operations Subcommittee

SCTE OPERATIONAL PRACTICE

SCTE 255 2019

Operational Practice for Home Wi-Fi Deployment

Deploying and Optimizing the Next Generation Wireless Home

A Technical Paper prepared for SCTE/ISBE by

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SCTE·ISBE CABLE-TEC EXPO 2017 DENVER, CO OCTOBER 17-20
2017 Fall Technical Forum SCTE·ISBE · NCTA · CABLELABS

Figure 15 - 2.4 GHz vs 5 GHz Coverage

One of the big items cited by the MSOs is the lack of a site survey performed at the subscriber premises, just dropping the WGR where the modem is located is not a best practice. This practice may create a sub-optimal location for RF to propagate throughout the premises. Proper attention to the location of WGR and modem are important to the QoE. Following company defined pre-installation steps, such as a site survey reveals information important to determining the location of the WGR.

Also, to note that wireless clients have a lower transmit power than a WGR and or obstacles create issues such as hidden node. A hidden node occurs when two clients cannot "hear" or "see" each other (e.g., obstacles, distance or technology) and their traffic causes collisions at the WGR.

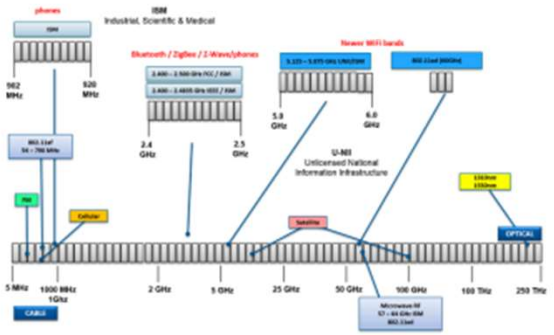


Figure 16 - Wireless Spectrum Used by Operators

Quality of Experience!

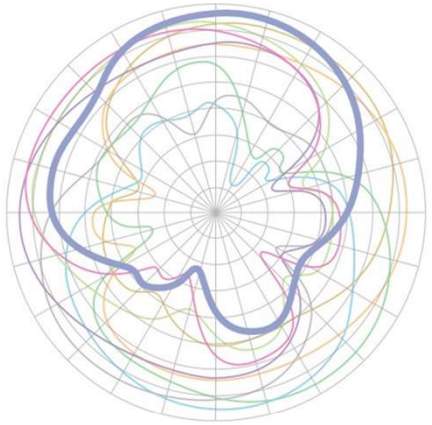
There is **no longer a difference between a Wi-Fi and a wired** telecommunication service.

Each service must provide the **same level of quality of experience**.

What is going in our Industry with Wi-Fi?

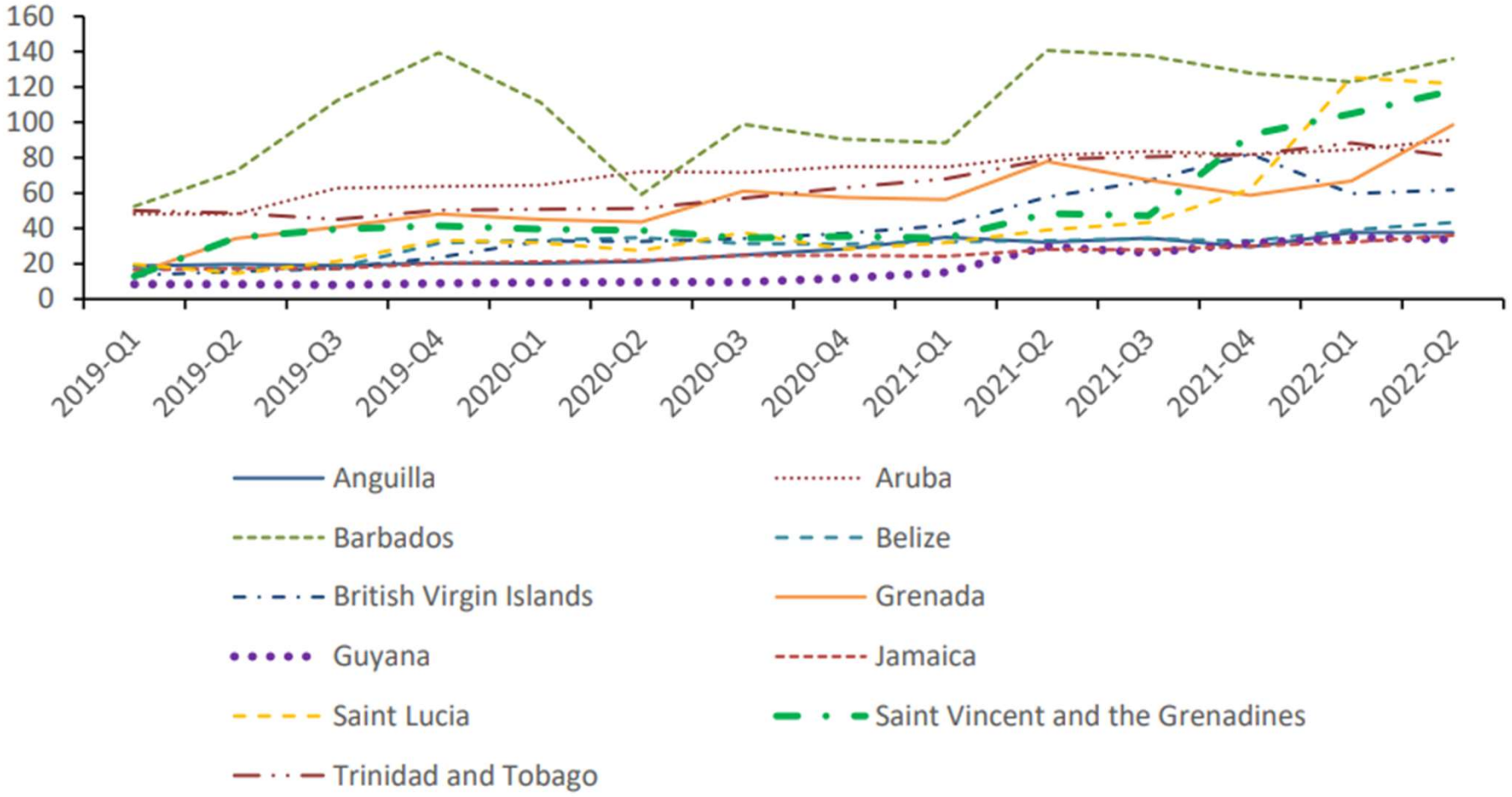
- **Global** Wi-Fi Analytics Market estimated to reach US $39.44 Bn by 2027, CAGR of 20.4% from 2022.
- Successful **Smart City** with Wi-Fi models are already being used in cities.
- 82% of **Latin American population** lives in urban areas. 72% have Internet.
- Operators will **increase deployments** of public Wi-Fi across physical venues. **Managed Wi-Fi** growth will continue to grow.
- Xfinity & Spectrum Mobile pass 8 million Total Subscribers, using **Wi-Fi to offload cellular data**.
- Xfinity has 19 million Wi-Fi hotspots!
- More than 30.9B IoT devices worldwide by 2025

What is going in our Industry with Wi-Fi?

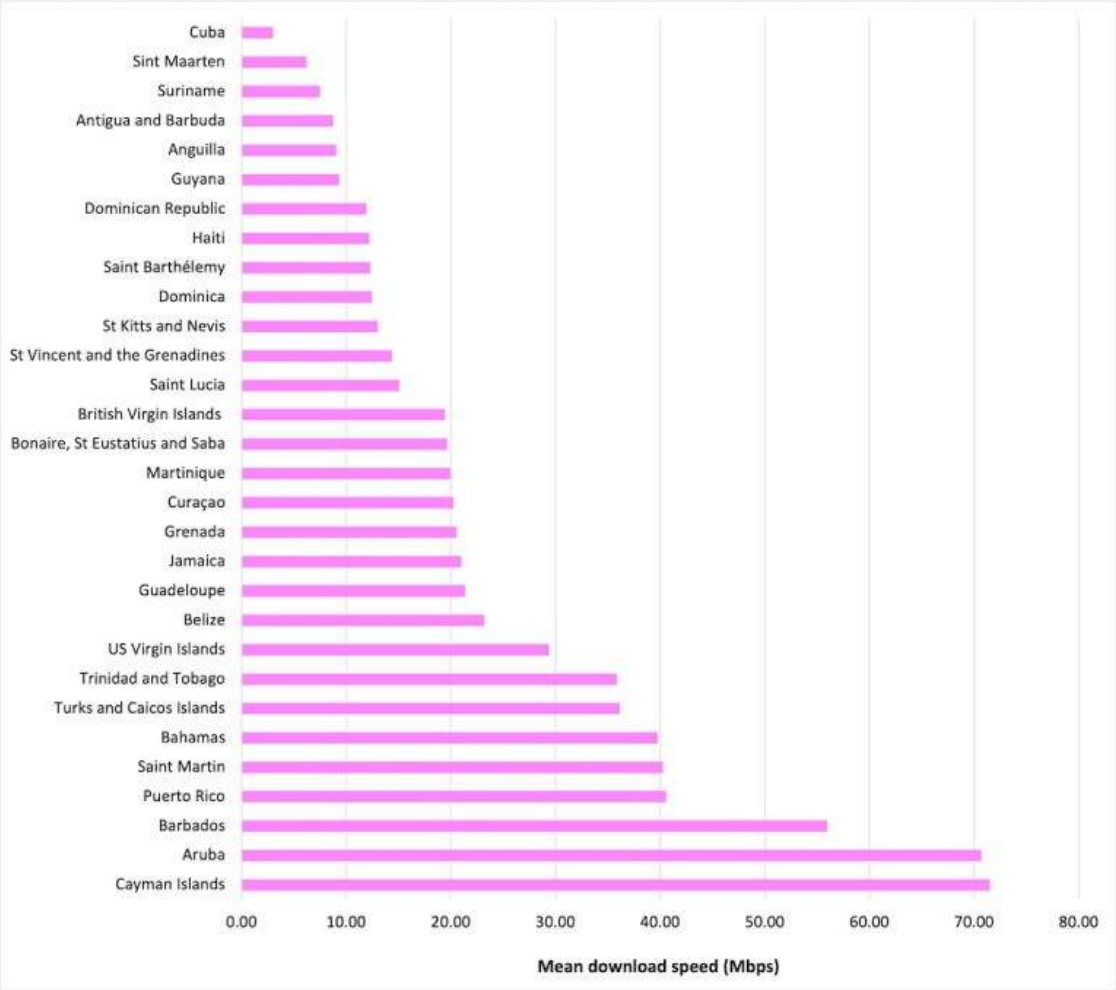


- **Global** Wi-Fi Analytics Market estimated to reach US $39.44 Bn by 2027, CAGR of 20.4% from 2022.
- Successful **Smart City** with Wi-Fi models are already being used in cities. **Santo Domingo DR, Larimar City 1st in Caribbean**!
- 50%+ Internet connectivity in **Caribbean average**.
- Operators will **increase deployments** of public Wi-Fi across physical venues. **Managed Wi-Fi** growth will continue to grow.
- Xfinity & Spectrum Mobile pass 8 million Total Subscribers, using **Wi-Fi to offload cellular data**.
- Xfinity has 19 million Wi-Fi hotspots!
- More than 30.9B IoT devices worldwide by 2025

Average fixed broadband download speeds, 2019-2022 (quarterly) (Mbps)

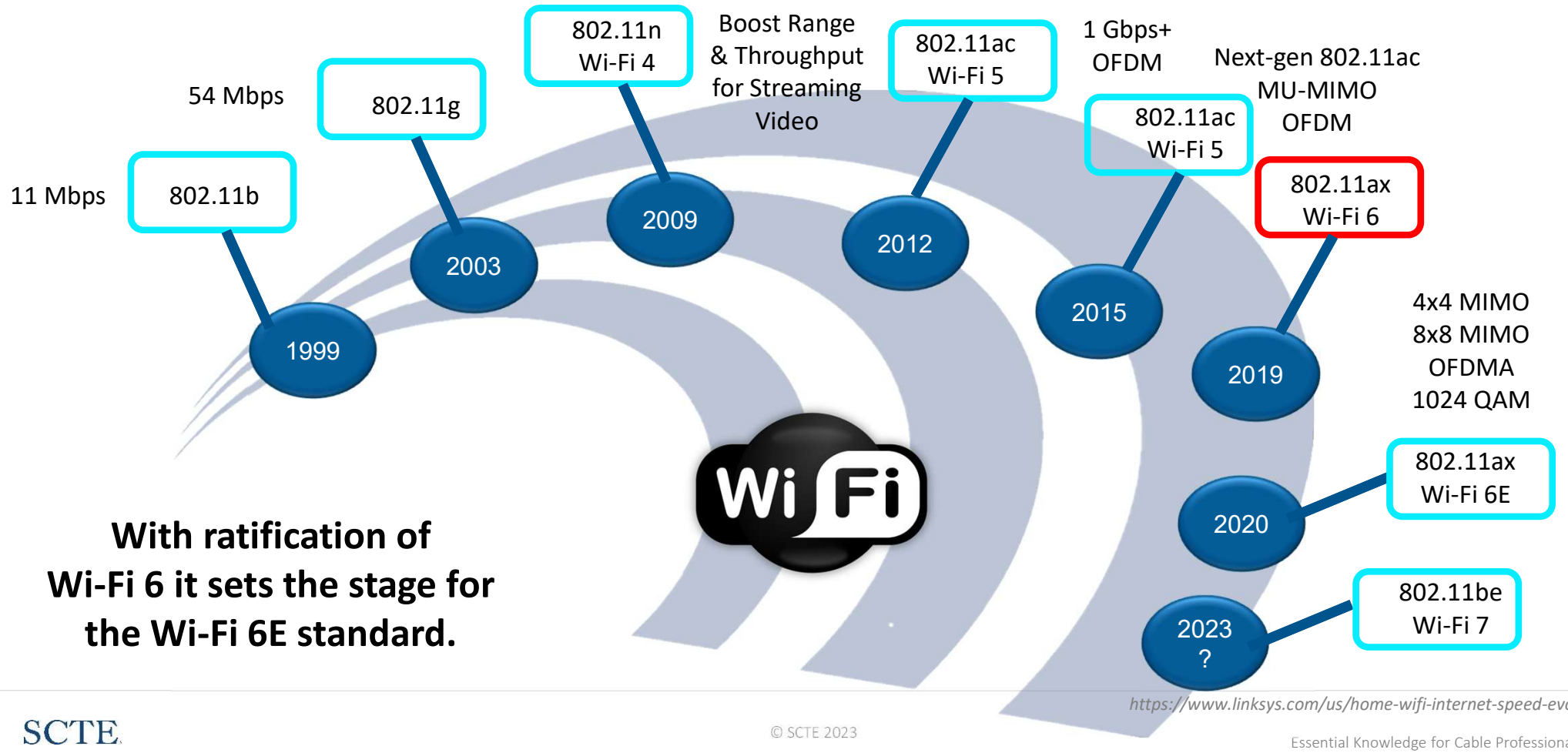


Average Download Speeds (10/2021)



Among the countries with the fastest download speeds and in addition to the Cayman Islands, were the Aruba, with an average download speed of 70.66 Mbps, and Barbados, with 55.92 Mbps.

Evolution of IEEE Wi-Fi



With ratification of Wi-Fi 6 it sets the stage for the Wi-Fi 6E standard.

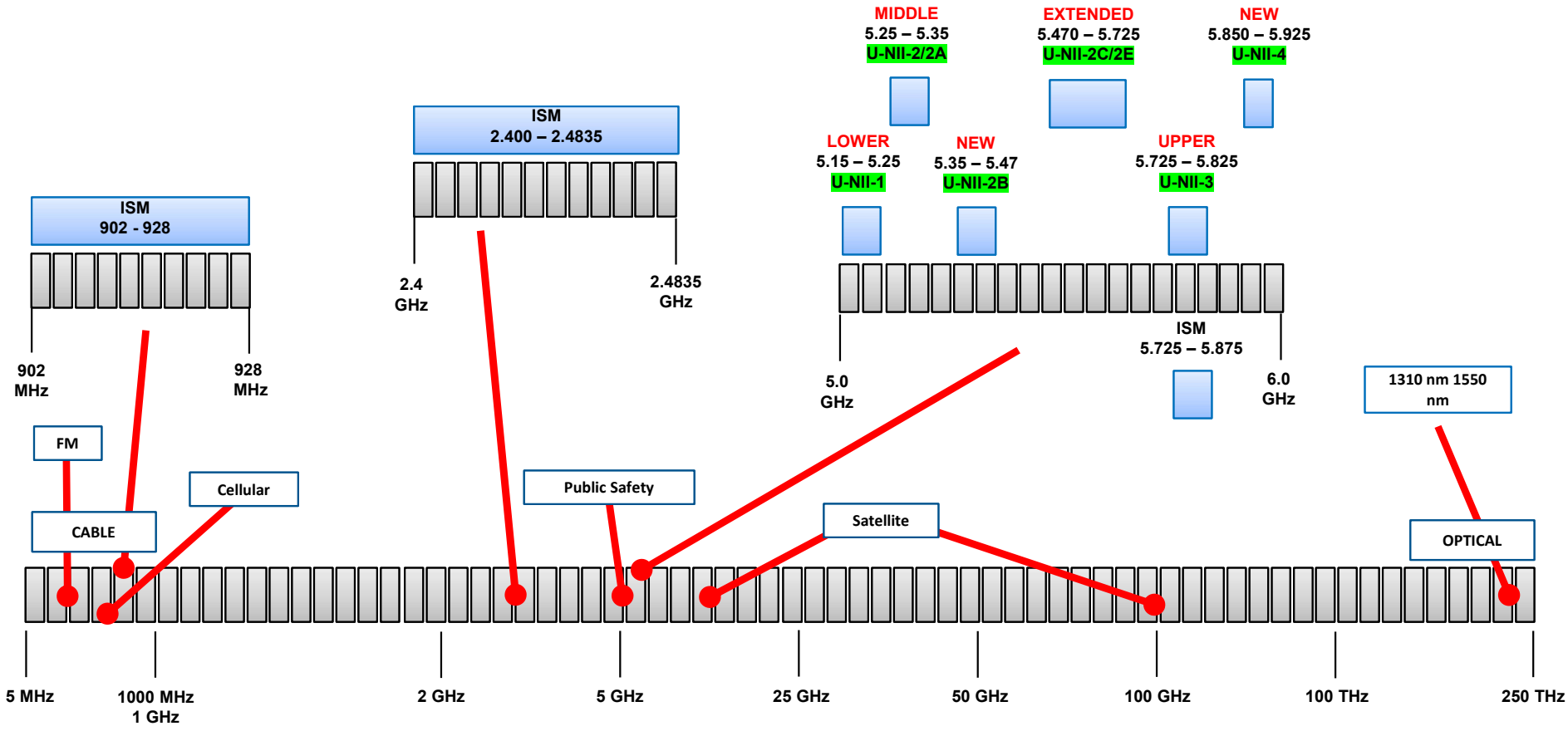
https://www.linksys.com/us/home-wifi-internet-speed-evolution

Tale of the Tape

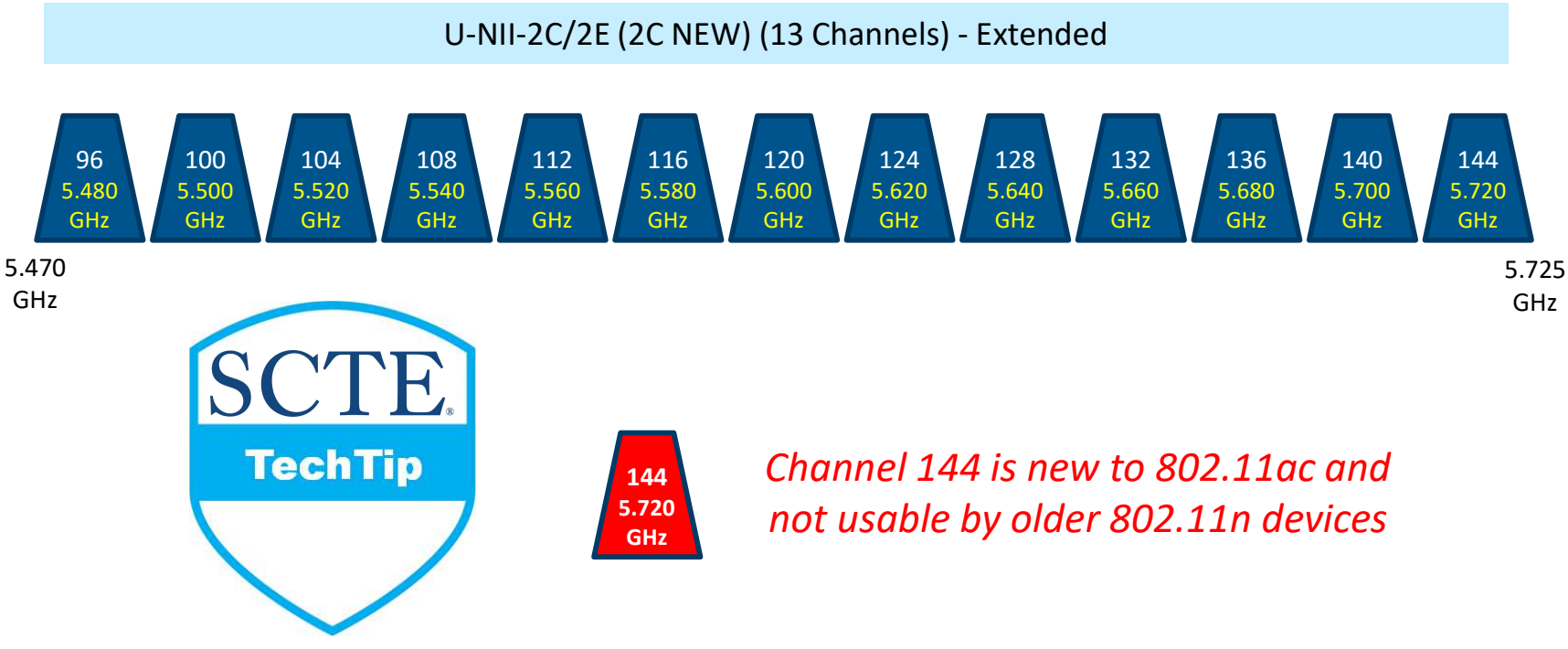
	802.11ac	*802.11ax*
BANDS	5 GHz	2.4 GHz and 5 GHz
CHANNEL BANDWIDTH	20 MHz, 40 MHz, 80 MHz, 80+80 MHz & 160 MHz	20 MHz, 40 MHz, 80 MHz, 80+80 MHz & 160 MHz
FFT SIZES	64, 128, 256, 512	256, 512, 1024, 2048
SUBCARRIER SPACING	312.5 kHz	78.125 kHz
OFDM SYMBOL DURATION	3.2 us + 0.8/0.4 us CP	12.8 us + 0.8/1.6/3.2 us CP
HIGHEST MODULATION	256 QAM	1024 QAM
MULTIPLEXING	OFDM	OFDMA
DATA RATES	433 Mbps (80 MHz, 1 SS) 6,933 Mbps (160 MHz, 8 SS)	600.4 Mbps (80 MHz, 1 SS) 9,607.8 Mbps (160 MHz, 8 SS)

WPA3 Security

Unlicensed National Information Infrastructure (U-NII-1 to U-NII-4)

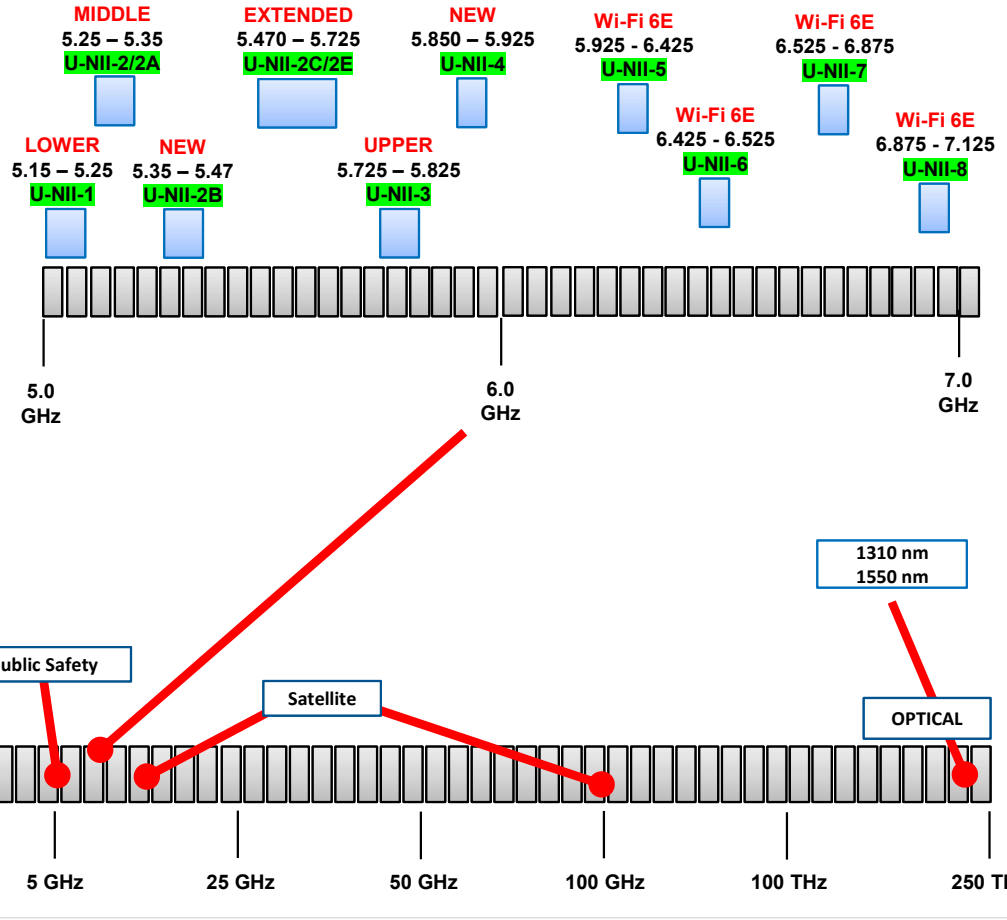


Tip = U-NII-2C/2E

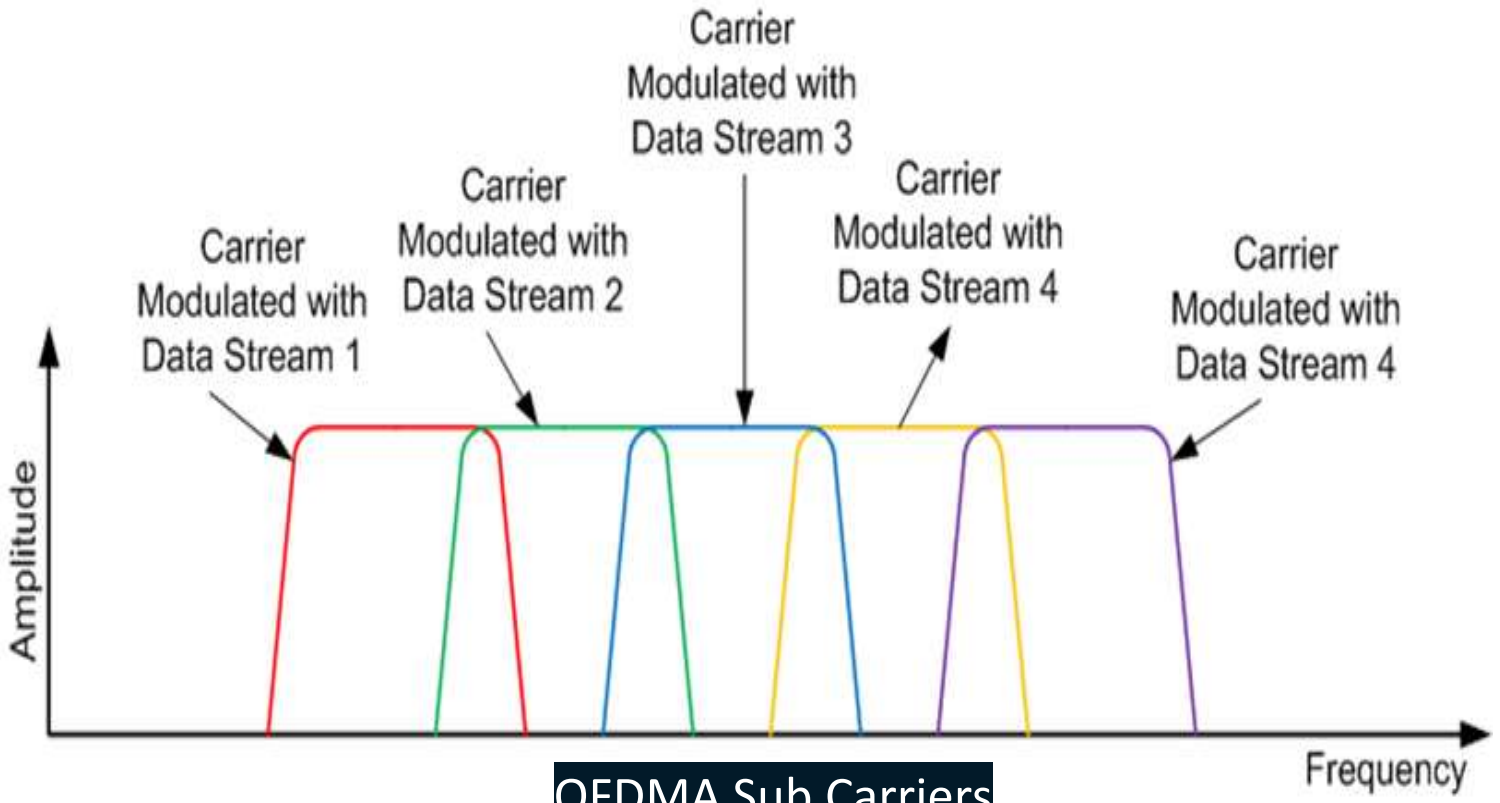


Unlicensed National Information Infrastructure (U-NII-1 to U-NII-8)

Not all devices support all channels!



MULTIPLEXING – OFDM/OFDMA



OFDMA Sub Carriers

Wi-Fi 5 vs Wi-Fi 6

Wi-Fi 5 (802.11ac) OFDM uses **52** data-carrying sub-carriers in a 20 MHz RF channel.

20 MHz
52 sub-carriers

Wi-Fi 6 (802.11ax) OFDM uses **234** data-carrying sub-carriers in a 20 MHz RF channel.

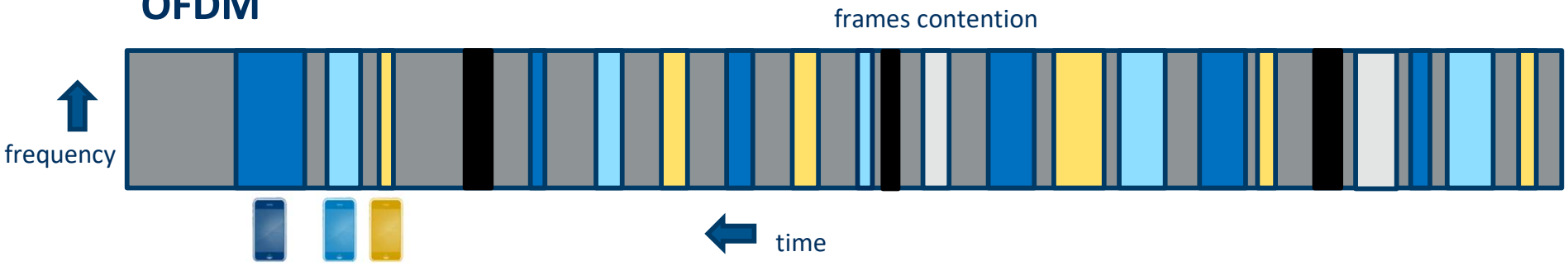
20 MHz
234 sub-carriers

AP is able to track all the sub-carriers simultaneously, and demodulate the symbols independently ('orthogonal').

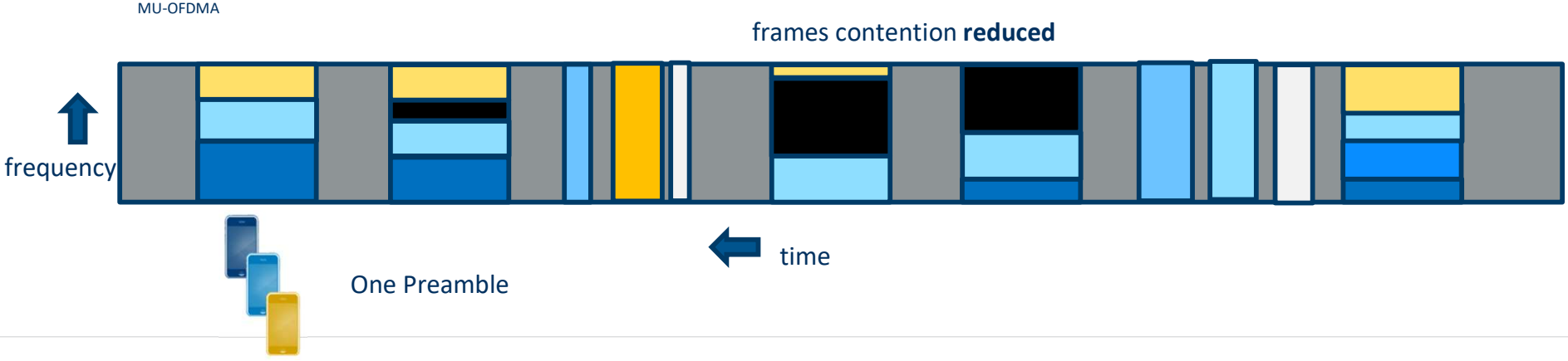
Wi-Fi 6 (OFDMA)

SU-OFDM

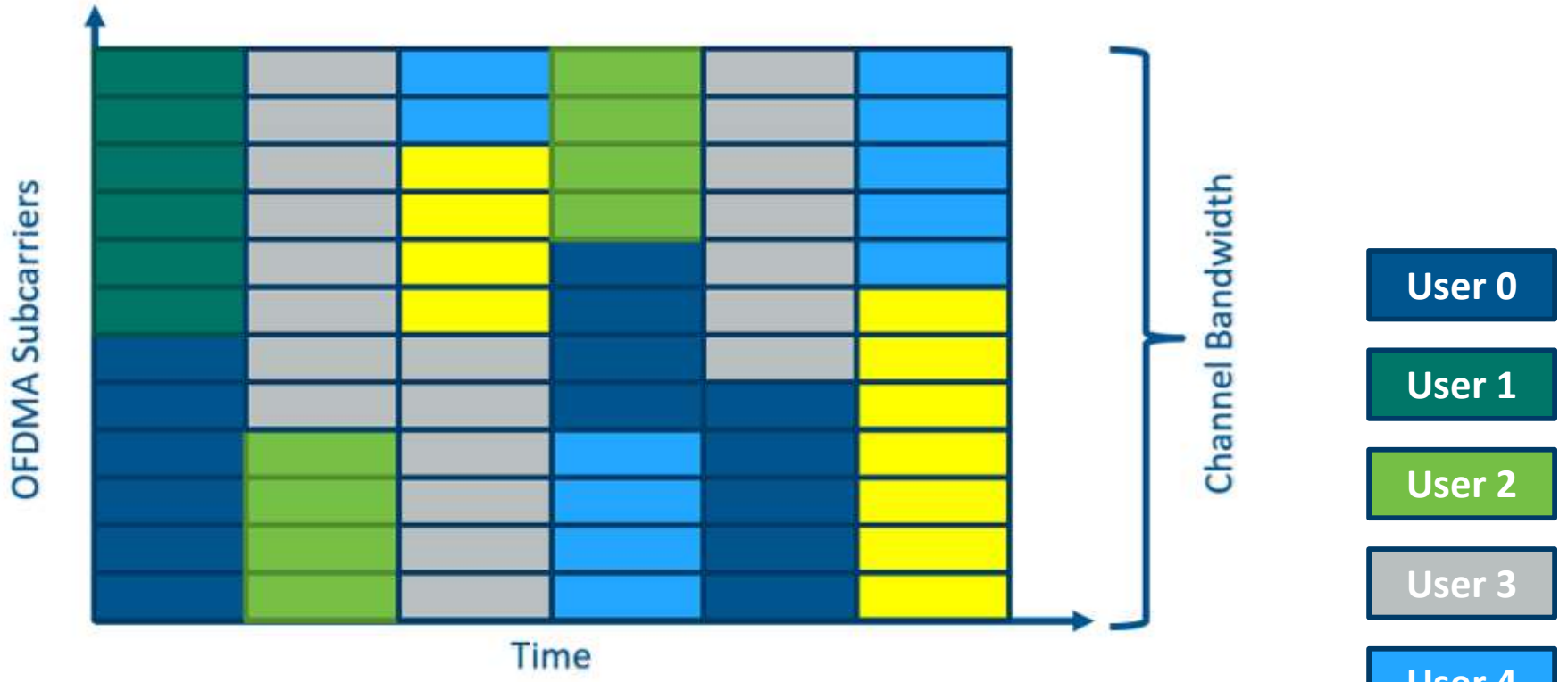
OFDM and OFMA difference lies in contention and preamble overhead reduction!



MU-OFDMA



MULTIPLEXING - OFDMA



OFDMA Sub Carriers vs Time

Deployment - Multi-User MIMO (MU-MIMO) w/ Wi-Fi 6

8x8:8
802.11ac

8 AP to STA

Downstream
"OFDMA"

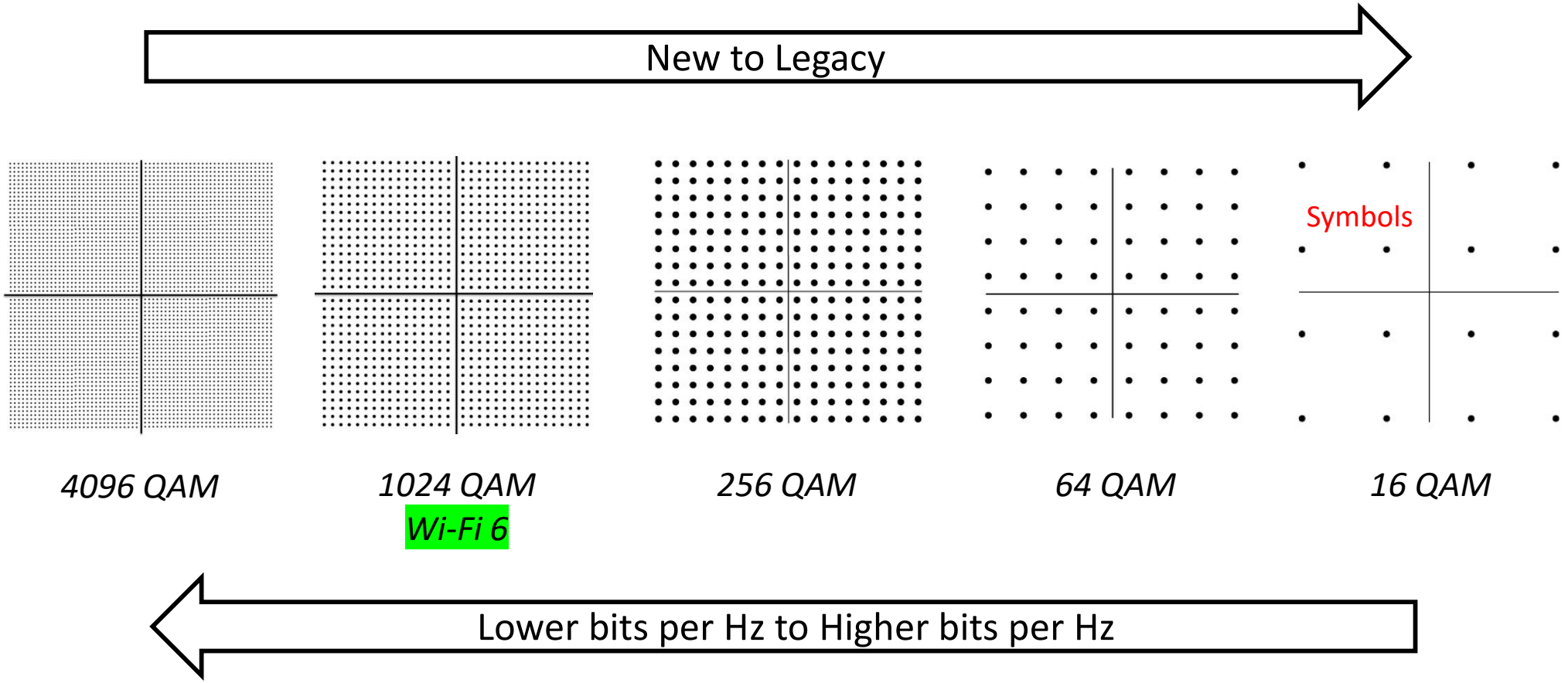
Stream 1
Stream 2
Stream 3
Stream 4
Stream 5
Stream 6
Stream 7
Stream 8

8 STA to AP

Upstream via Trigger Frame
"OFDMA"

Station = STA

Modulation Methods and Techniques

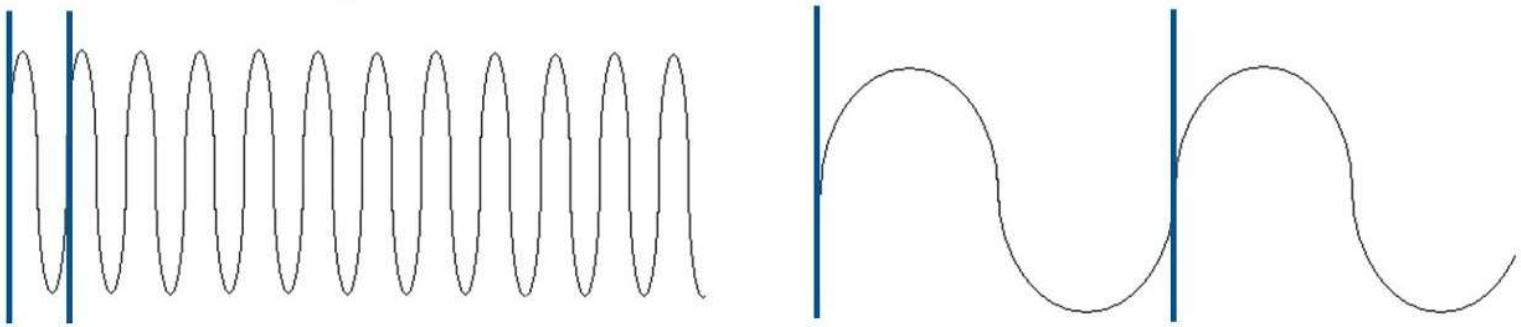


HE Modulation & Coding Scheme: Spatial Streams 1 and 2

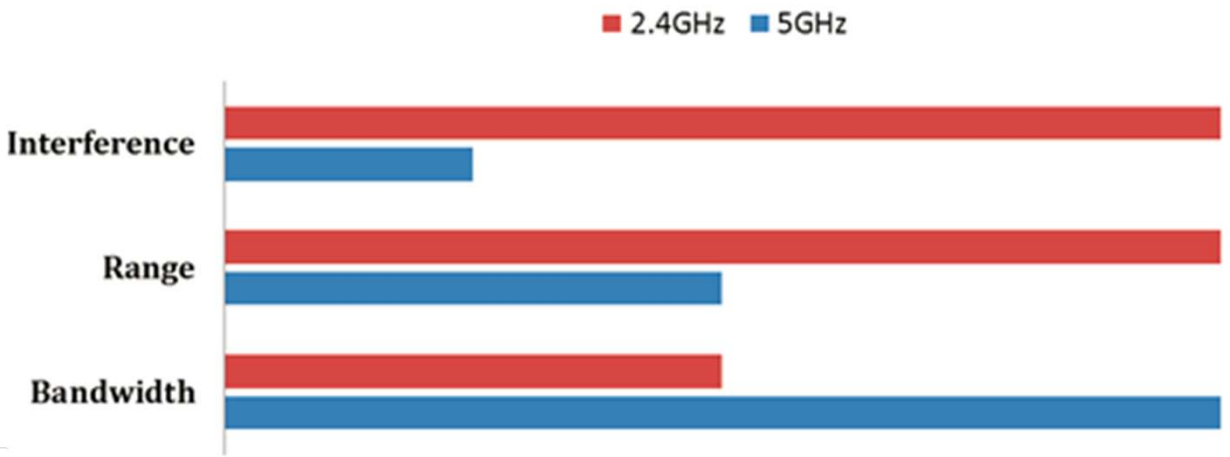
MCS Index	Spatial Stream	Modulation	Coding	OFDM (802.11ax)											
				20MHz			40MHz			80MHz			160MHz		
				0.8µs GI	1.6µs GI	3.2µs GI	0.8µs GI	1.6µs GI	3.2µs GI	0.8µs GI	1.6µs GI	3.2µs GI	0.8µs GI	1.6µs GI	3.2µs GI
0	1	BPSQ	1/2	8.6	8.1	7.3	17.2	16.3	14.6	36.0	34.0	30.6	72.1	68.1	61.3
1	1	QPSK	1/2	17.2	16.3	14.6	34.4	32.5	29.3	72.1	68.1	61.3	144.1	136.1	122.5
2	1	QPSK	3/4	25.8	24.4	21.9	51.6	48.8	43.9	108.1	102.1	91.9	216.2	204.2	183.8
3	1	16-QAM	1/2	34.4	32.5	29.3	68.8	65.0	58.5	144.1	136.1	122.5	288.2	272.2	245.0
4	1	16-QAM	3/4	51.6	48.8	43.9	103.2	97.5	87.8	216.2	204.2	183.8	432.4	408.3	367.5
5	1	64-QAM	2/3	68.8	65.0	58.5	137.6	130.0	117.0	288.2	272.2	245.0	576.5	544.4	490.0
6	1	64-QAM	3/4	77.4	73.1	65.8	154.9	146.3	131.6	324.3	306.3	275.6	648.5	612.5	551.3
7	1	64-QAM	5/6	86.0	81.3	73.1	172.1	162.5	146.3	360.3	340.3	306.3	720.6	680.6	612.5
8	1	256-QAM	3/4	103.2	97.5	87.8	206.5	195.0	175.5	432.4	408.3	367.5	864.7	816.7	735.0
9	1	256-QAM	5/6	114.7	108.3	97.5	229.4	216.7	195.0	480.4	453.7	408.3	960.8	907.4	816.7
10	1	1024-QAM	3/4	129.0	121.9	109.7	258.1	243.8	219.4	540.4	510.4	459.4	1080.9	1020.8	918.8
11	1	1024-QAM	5/6	143.4	135.4	121.9	286.8	270.8	243.8	600.5	567.1	510.4	1201.0	1134.3	1020.8
0	2	BPSQ	1/2	17.2	16.3	14.6	34.4	32.5	29.3	72.1	68.1	61.3	144.1	136.1	122.5
1	2	QPSK	1/2	34.4	32.5	29.3	68.8	65.0	58.5	144.1	136.1	122.5	288.2	272.2	245.0
2	2	QPSK	3/4	51.6	48.8	43.9	103.2	97.5	87.8	216.2	204.2	183.8	432.4	408.3	367.5
3	2	16-QAM	1/2	68.8	65.0	58.5	137.6	130.0	117.0	288.2	272.2	245.0	576.5	544.4	490.0
4	2	16-QAM	3/4	103.2	97.5	87.8	206.5	195.0	175.5	432.4	408.3	367.5	864.7	816.7	735.0
5	2	64-QAM	2/3	137.6	130.0	117.0	275.3	260.0	234.0	576.5	544.4	490.0	1152.9	1088.9	980.0
6	2	64-QAM	3/4	154.9	146.3	131.6	309.7	292.5	263.3	648.5	612.5	551.3	1297.1	1225.0	1102.5
7	2	64-QAM	5/6	172.1	162.5	146.3	344.1	325.0	292.5	720.6	680.6	612.5	1441.2	1361.1	1225.0
8	2	256-QAM	3/4	206.5	195.0	175.5	412.9	390.0	351.0	864.7	816.7	735.0	1729.4	1633.3	1470.0
9	2	256-QAM	5/6	229.4	216.7	195.0	458.8	433.3	390.0	960.8	907.4	816.7	1921.6	1814.8	1633.3

Frequency

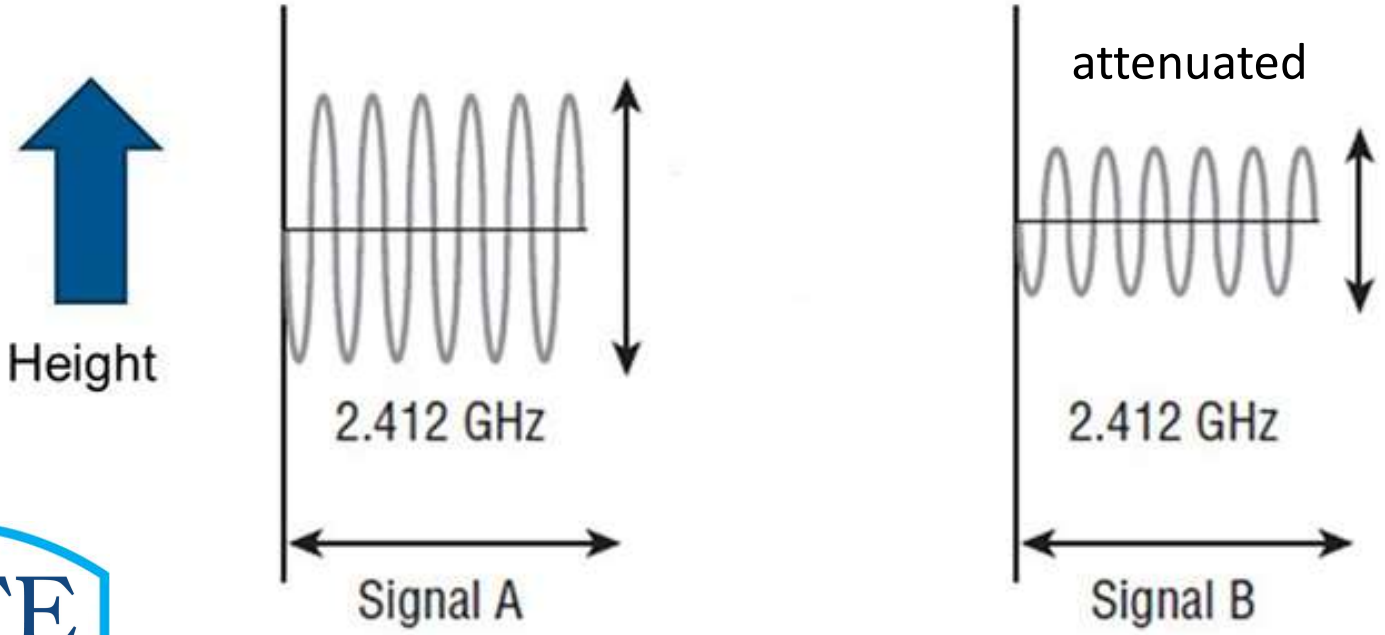
Higher frequencies have shorter wavelengths



Lower frequencies have longer wavelengths

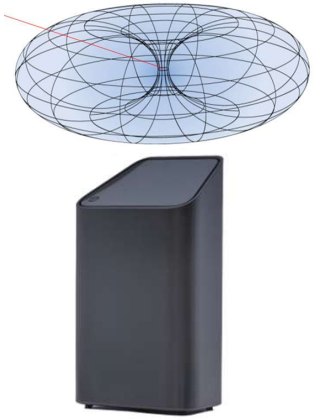


Amplitude

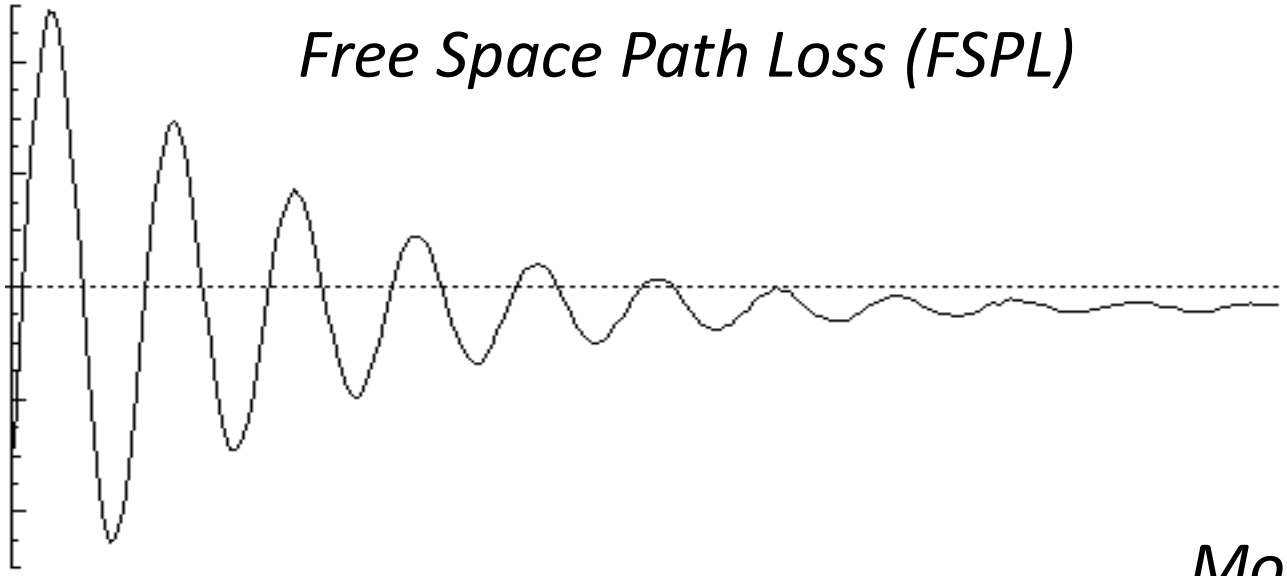


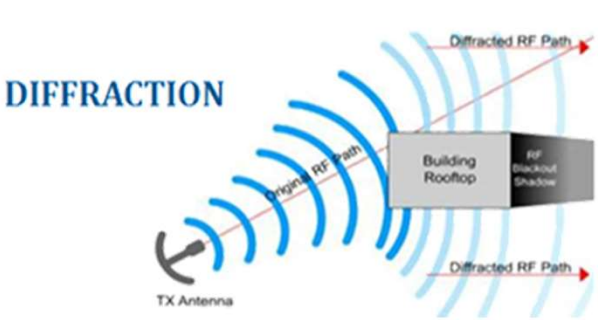
+3 dB doubles the power!
(100 mW is now 200 mW)

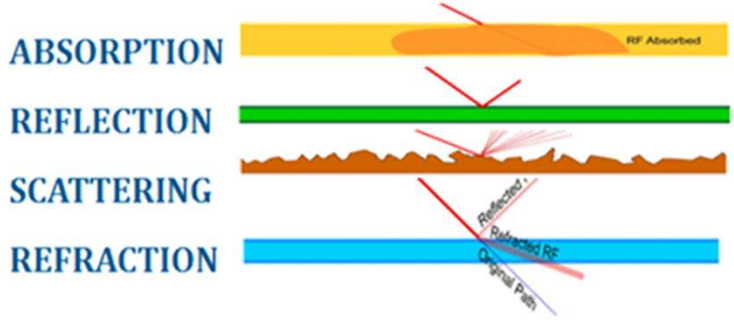
RF Loss



Free Space Path Loss (FSPL)

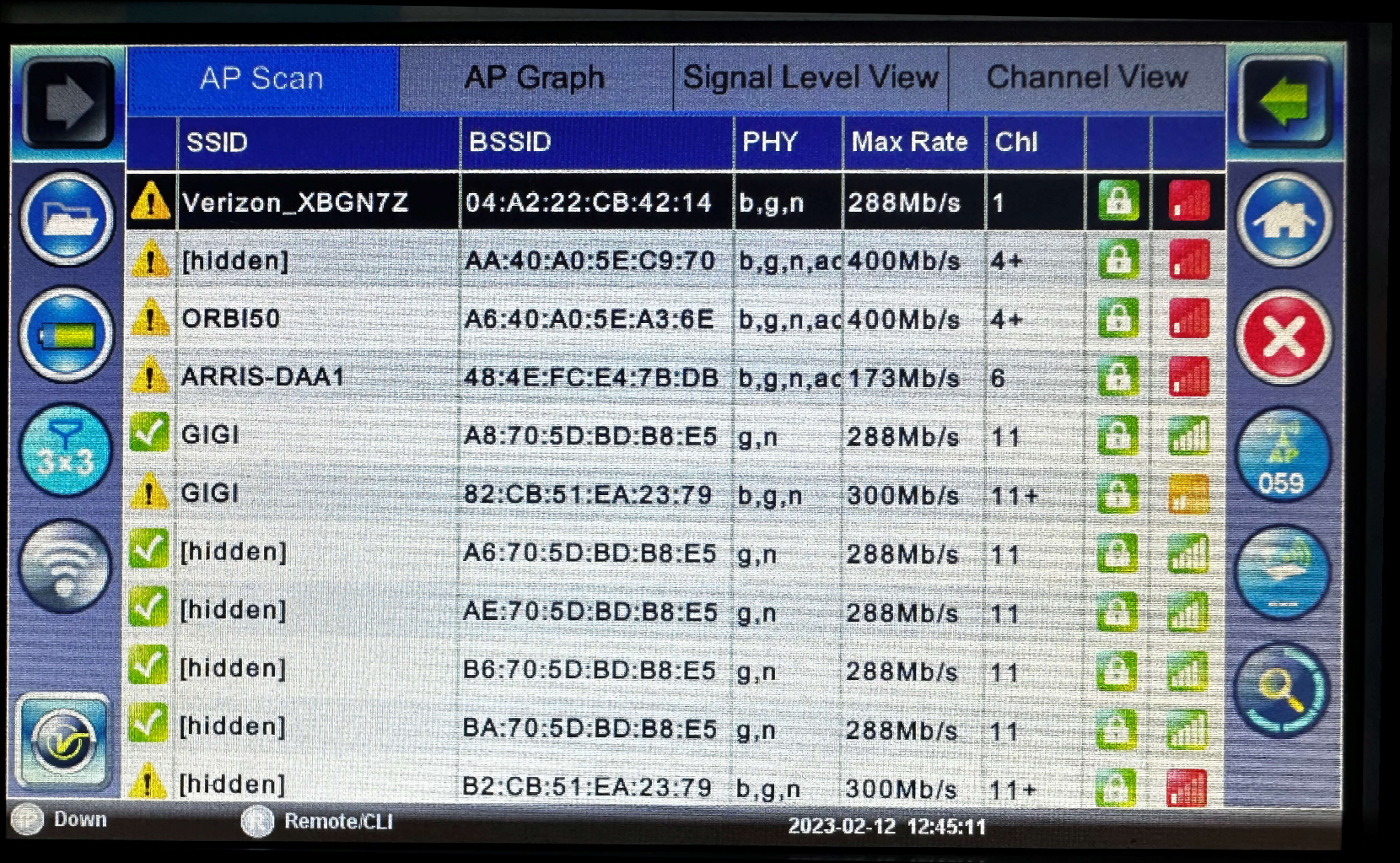


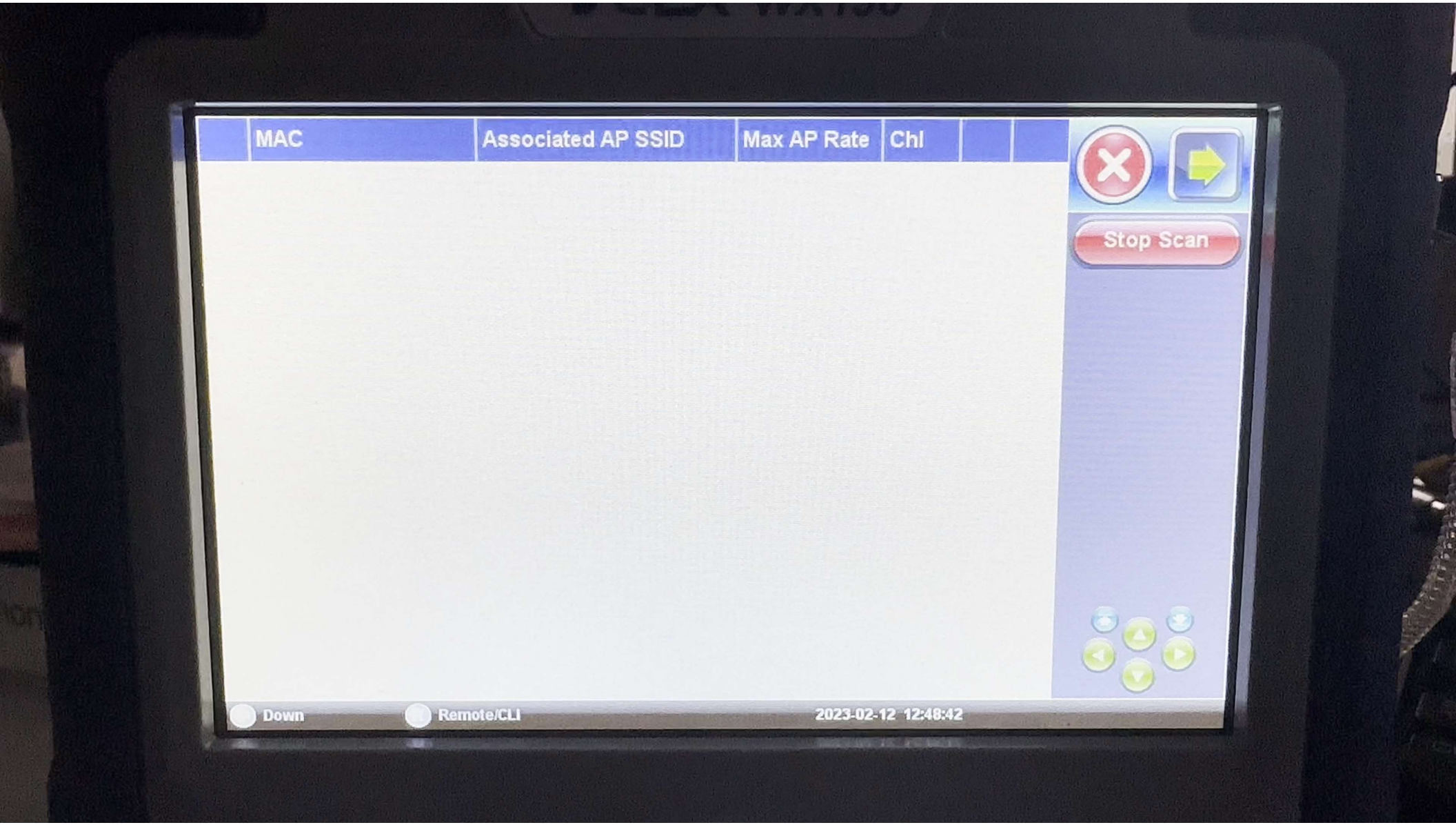




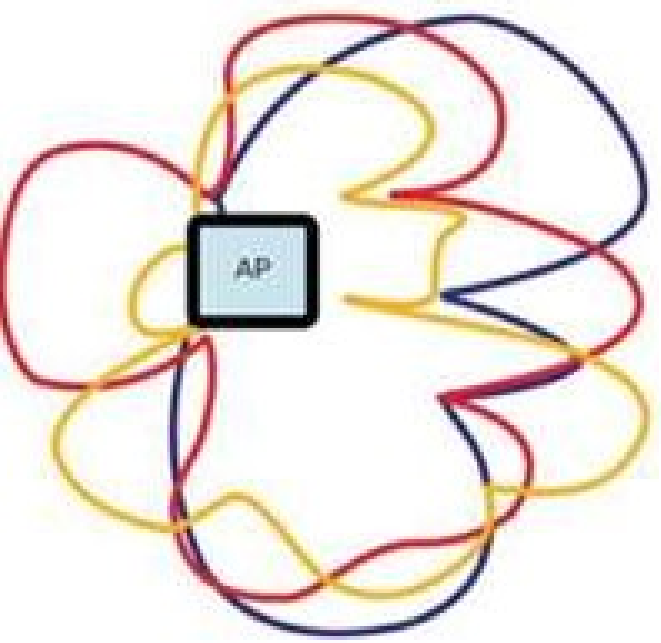
More RF is lost through objects such as walls, glass and flooring.

What is your Wi-Fi Channel Power?




MAC
Associated AP SSID
Max AP Rate
Chl
Stop Scan
Down
Remote/CLI
2023-02-12 12:48:42

Implicit vs Explicit Beam Forming



User 1

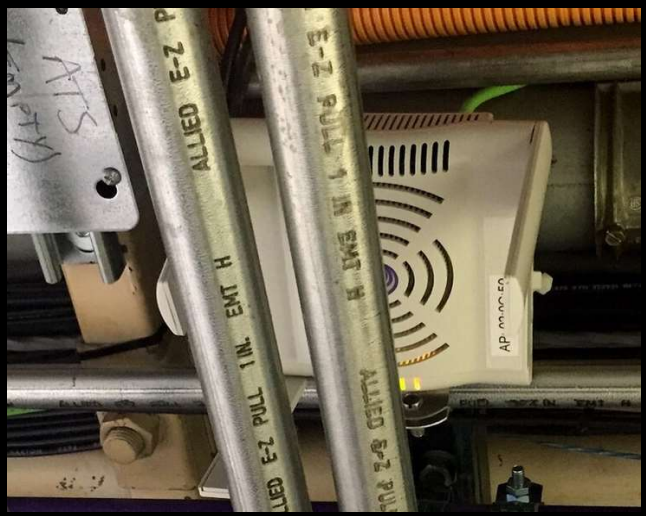
User 2

User 3

Without BF

With BF

Avoid Bad Wi-Fi



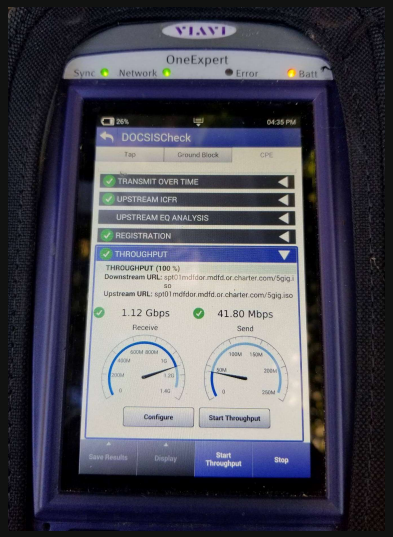
Installation Steps

- ❑ Perform RF Site Survey w/ customer
- ❑ Qualify the drop and bond to the premises
- ❑ Verify premises wiring/cabling
- ❑ Install the CM/AP/GWR
- ❑ Verify successful modem or ONT initialization and provisioning
- ❑ Verify Wi-Fi services
- ❑ Connect client to the Internet
- ❑ Review services / Educate the Customer

Image: Cable Guy

Installation Steps - Qualify the Drop

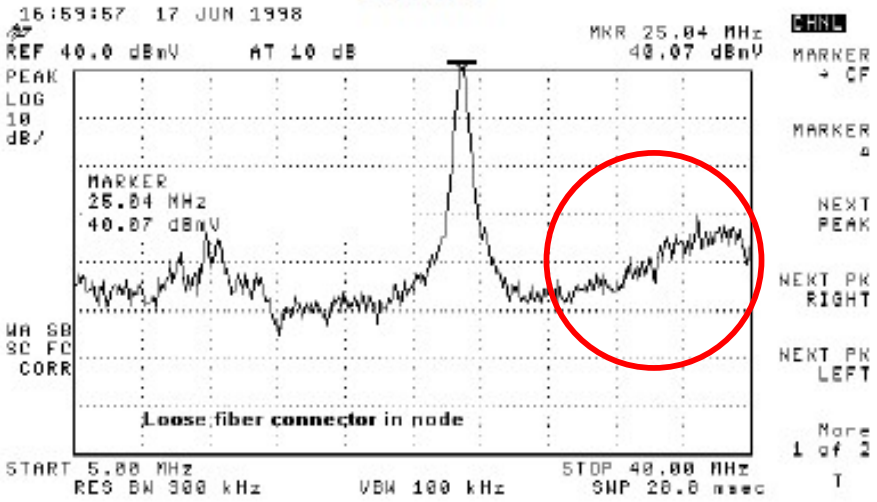
HFC



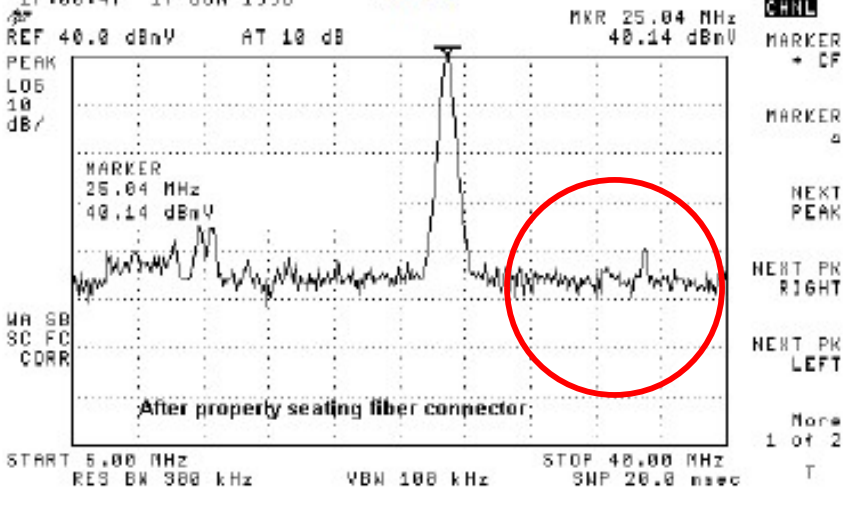
FTTx

Optical Network with Poor Connection

Before



After



Source: Viavi 2020

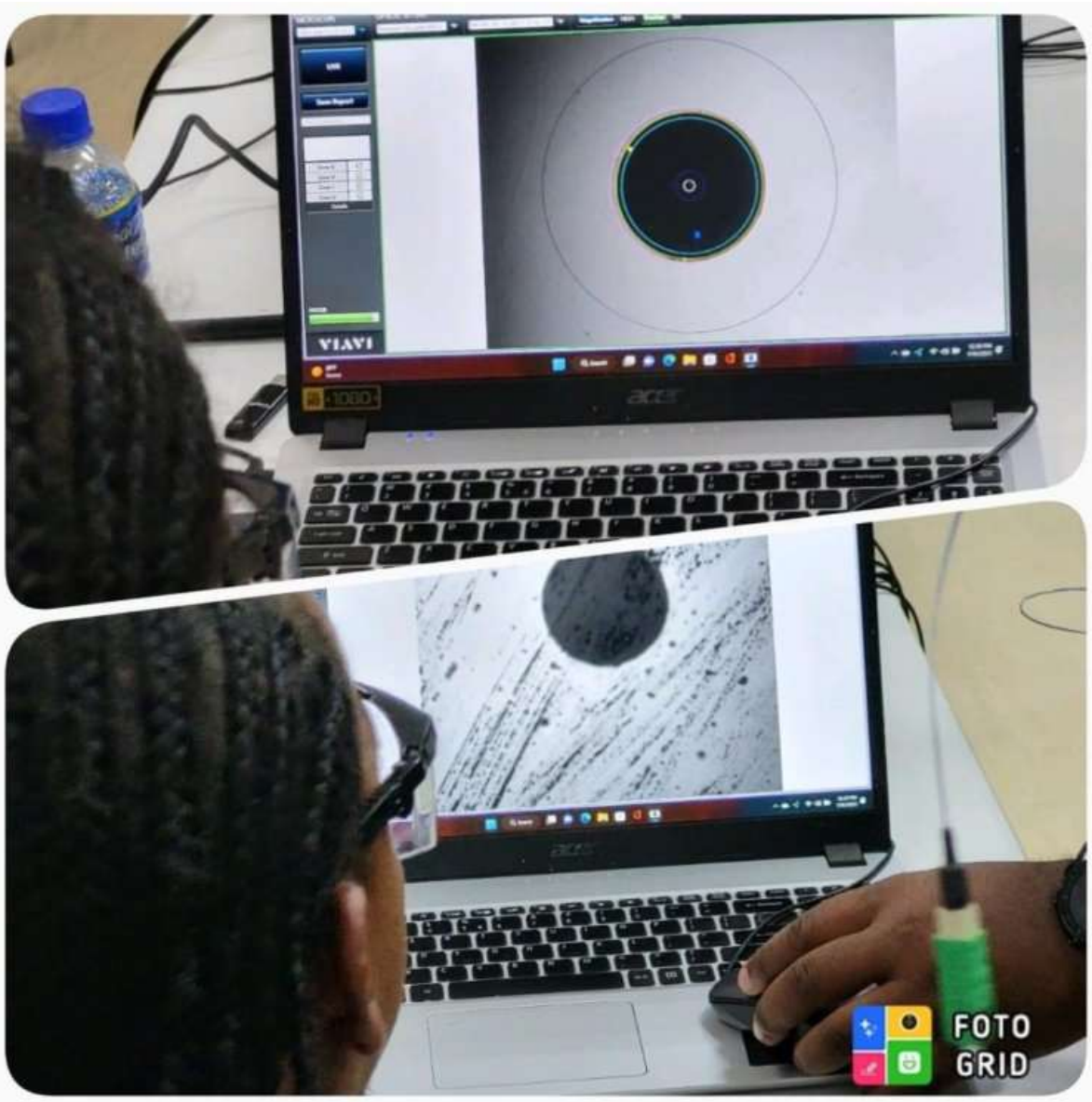


FOTO
GRID

Cabling Issues with mGig Connections

IEEE 802.3bz Ethernet operates at 10 Gbps, ½ at 5 Gbps and ¼ at 2.5 Gbps (MGBASE-T)

Category	Maximum Rated Capacity
1	Analog and digital voice and low-speed data applications
2	Voice, ISDN and medium-speed data up to **4 Mbps**
3	Voice, HSD and LAN traffic up to **16 Mbps**
4	Long-distance LAN traffic up to **20 Mbps**
5	Up to **100 Mbps** LAN technologies (Fast Ethernet), 100 m, 100 MHz
5e	Up to **1,000 Mbps** LAN technologies (GigE), 100 m, 350 MHz (beyond 1 GigE NBASE-T)
6	Up to **10,000 Mbps** LAN technologies (10 GigE) 55 m, 250 MHz (MGBASE-T)
6e	Up to **10,000 Mbps** LAN technologies (10 GigE) 55 m, 250 MHz (MGBASE-T / Data Center)
6a	Up to **10,000 Mbps** LAN technologies (10 GigE) 100 m, 500 MHz (MGBASE-T)

Installation Steps - Install the CM/AP/GWR and EasyMESH Standard Products

- Using site survey data, install Wi-Fi devices.
- Verify successful modem initialization and provisioning.

Installation Steps - Verify Wi-Fi Services & Connectivity

Test Laptop

~950 Mbps

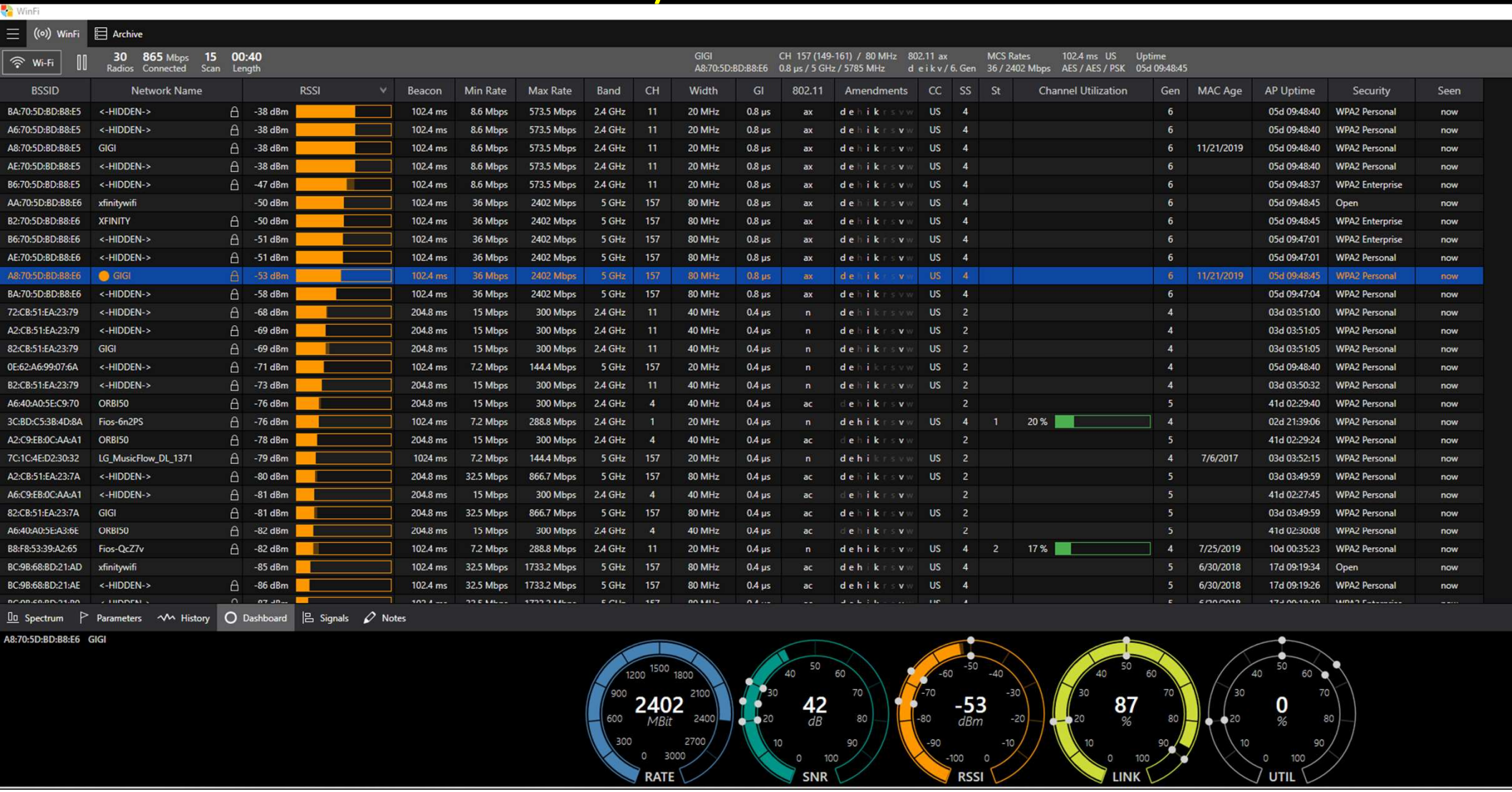
1.5 Gbps

Wi-Fi TV
802.11n
150 Mbps
HD only

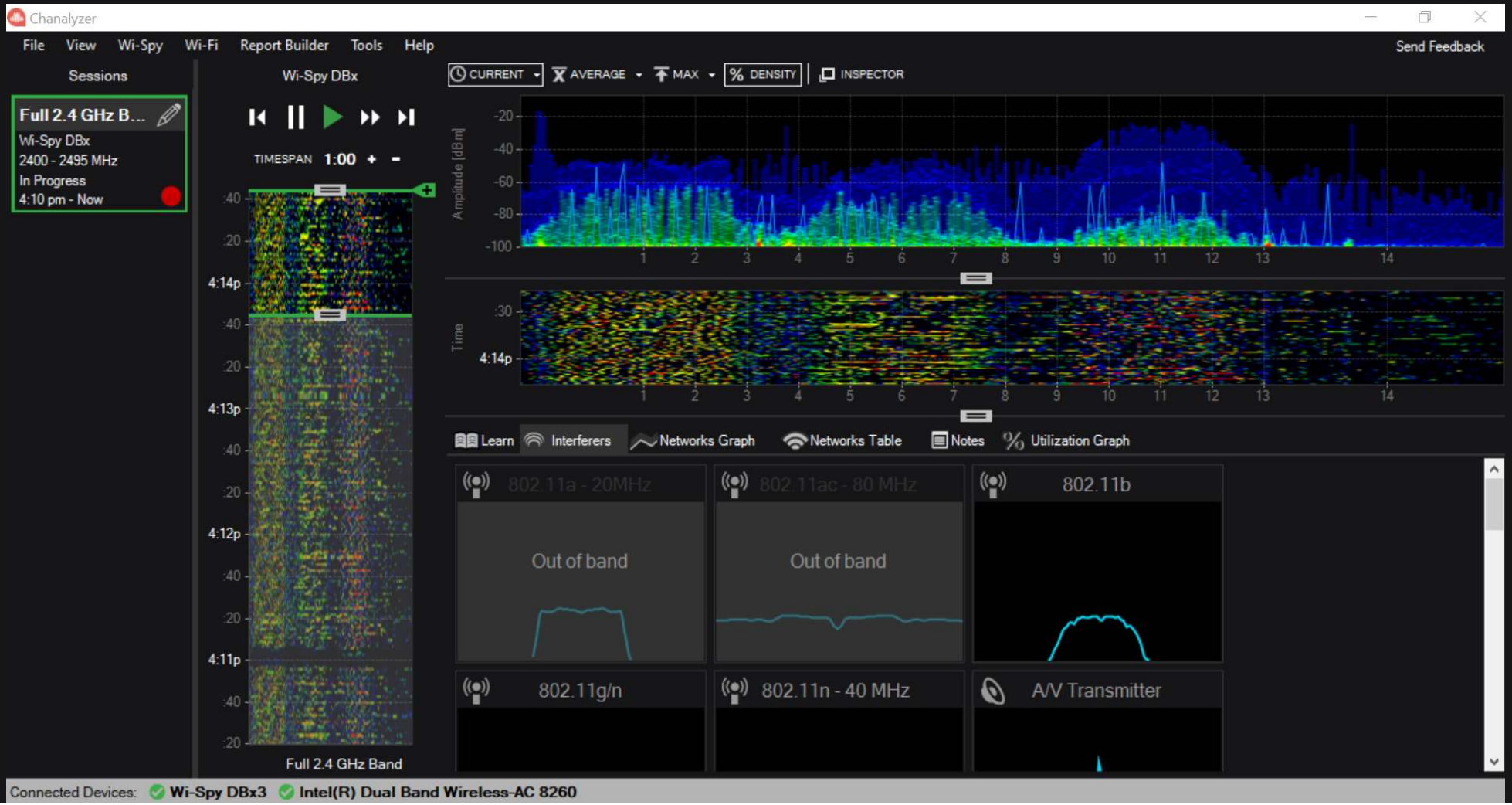
Samsung Galaxy
1x1, 2x2
802.11ac
433 - 866 Mbps

Wi-Fi 5
802.11ac
1.3 Gbps

What is your RSSI value?

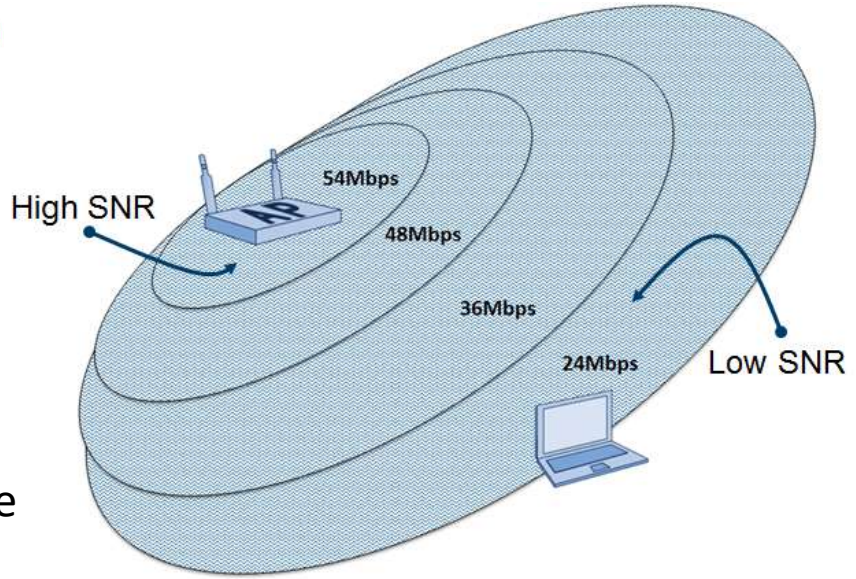


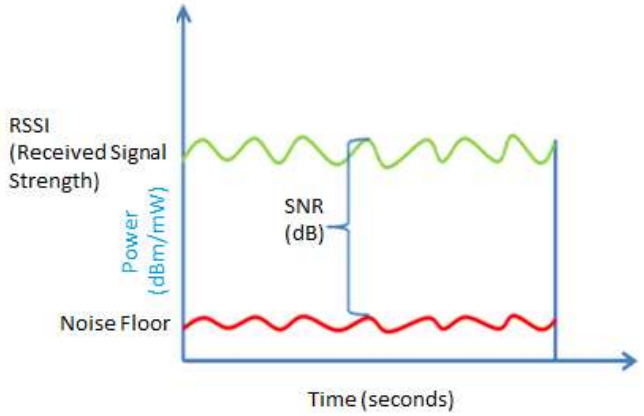
Post Site Survey



Common Causes of Wi-Fi Failure

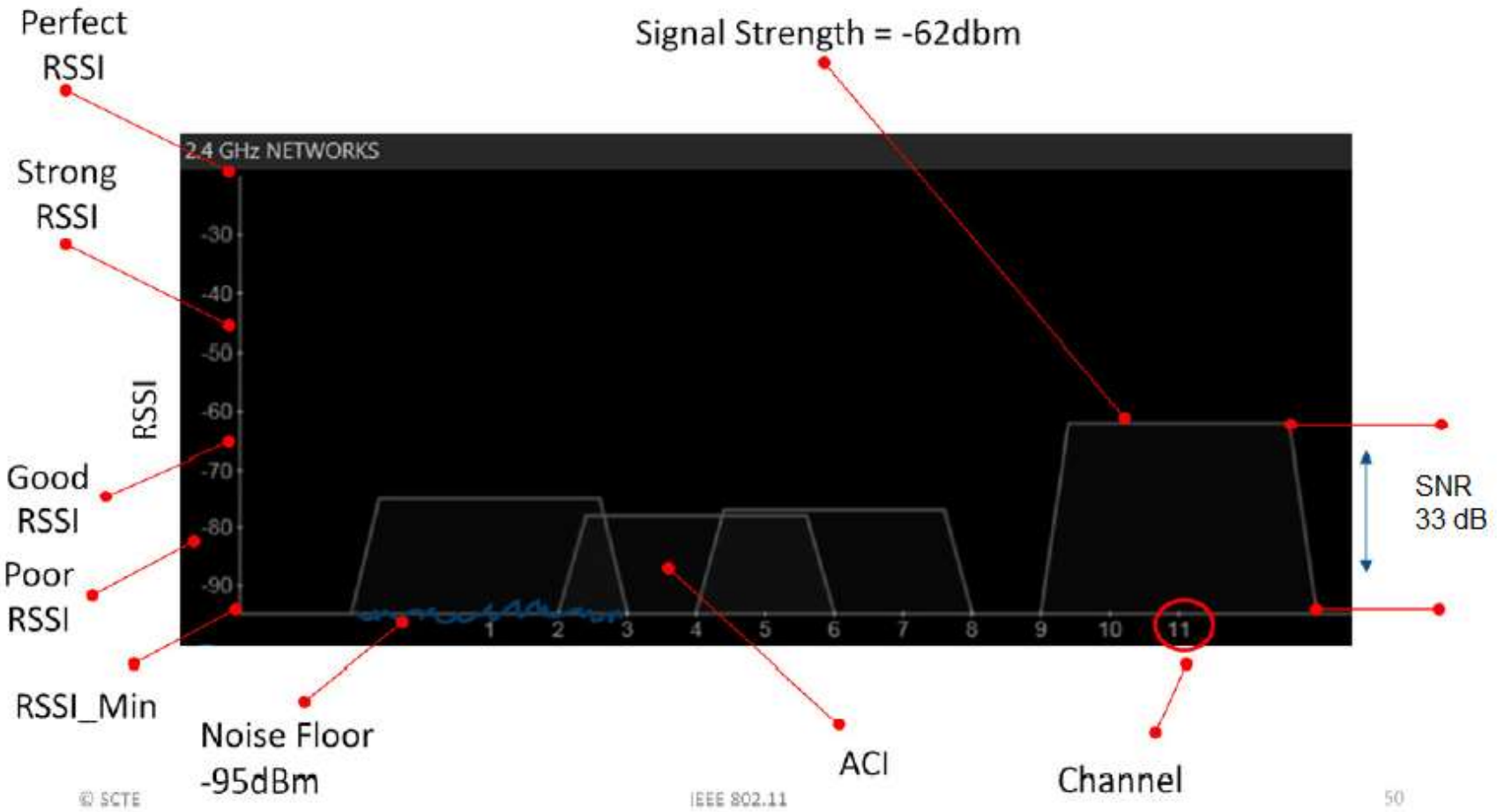
- High number of users on a single AP, latency
- RF propagation issues, building materials
- Security mismatches/unknown password
- DHCP not working
- Distance from an AP, low S/N or low RSSI
- ISM band channel limitation, co-channel interference
- High multi-path environment
- Standards capability of the client
- Power surges or firmware on AP significantly out of date
- Channel Bonding in the ISM band
- Hidden node
- RFI, CCI, ACI issues





Netgear Nighthawk® Tri-Band Wi-Fi 6E Router

Wi-Fi Metrics



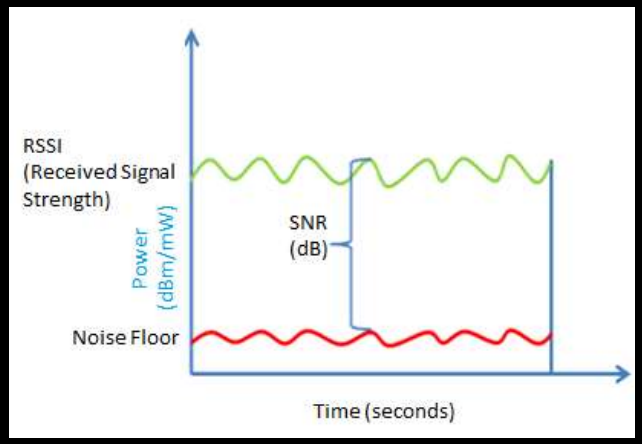
Wi-Fi Metrics: RSSI

BSSID	Network Name	RSSI	Beacon	Min Rate	Max Rate	Band	CH	Width	GI	802.11
7C:9A:54:4D:B6:78	xfinitywifi	-52 dBm	102.4 ms	32.5 Mbps	1733.2 Mbps	5 GHz	44	80 MHz	0.4 µs	ac
A0:40:A0:5E:C9:73	ORBI50	-79 dBm	204.8 ms	32.5 Mbps	866.7 Mbps	5 GHz	48	80 MHz	0.4 µs	ac
7C:1C:4E:D2:30:32	LG_MusicFlow_DL_1371	-69 dBm	1024 ms	7.2 Mbps	144.4 Mbps	5 GHz	157	20 MHz	0.4 µs	n
7C:9A:54:4D:B6:76	GIGI	-50 dBm	102.4 ms	32.5 Mbps	1733.2 Mbps	5 GHz	44	80 MHz	0.4 µs	ac
1A:1E:19:16:32:7E	GIGI	-53 dBm	204.8 ms	32.5 Mbps	866.7 Mbps	5 GHz	44	80 MHz	0.4 µs	ac
82:CB:51:EA:23:7A	GIGI	-79 dBm	204.8 ms	32.5 Mbps	866.7 Mbps	5 GHz	157	80 MHz	0.4 µs	ac
72:F8:53:0E:35:C0	Fios-QcZ7v	-79 dBm	102.4 ms	36 Mbps	2402 Mbps	5 GHz	140	80 MHz	0.8 µs	ax
7C:9A:54:4D:B6:7C	<-HIDDEN->	-52 dBm	102.4 ms	32.5 Mbps	1733.2 Mbps	5 GHz	44	80 MHz	0.4 µs	ac
72:F8:53:0E:35:C3	<-HIDDEN->	-79 dBm	102.4 ms	36 Mbps	2402 Mbps	5 GHz	140	80 MHz	0.8 µs	ax
6A:F8:53:39:A2:65	<-HIDDEN->	-79 dBm	102.4 ms	36 Mbps	2402 Mbps	5 GHz	52	80 MHz	0.8 µs	ax

-65 dBm or better

GIGI = - 49 dBm

Wi-Fi Metrics: Signal to Noise



WinFi | Archive | Forum

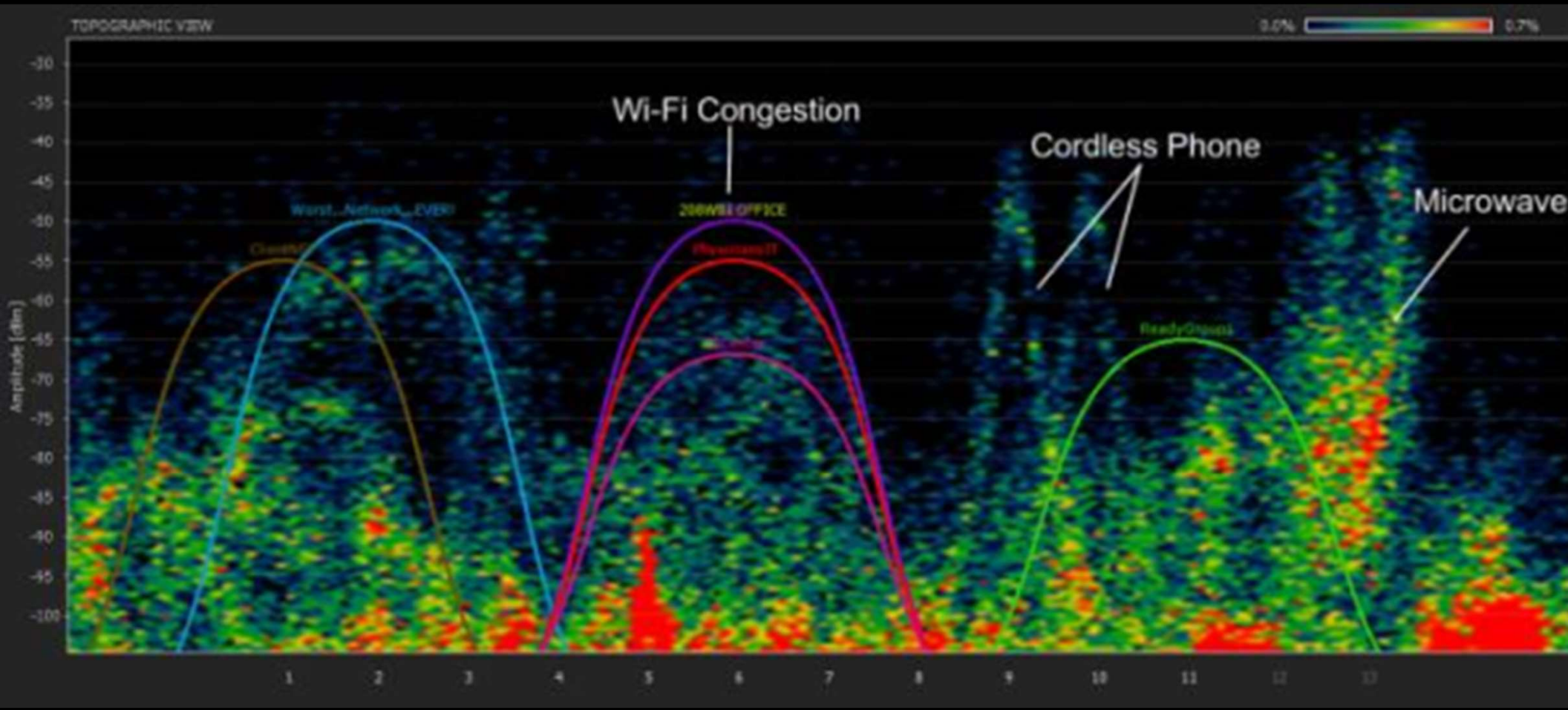
Wi-Fi | 31 Radios | 234 Mbps Connected | 2 Scan | 00:12 Length

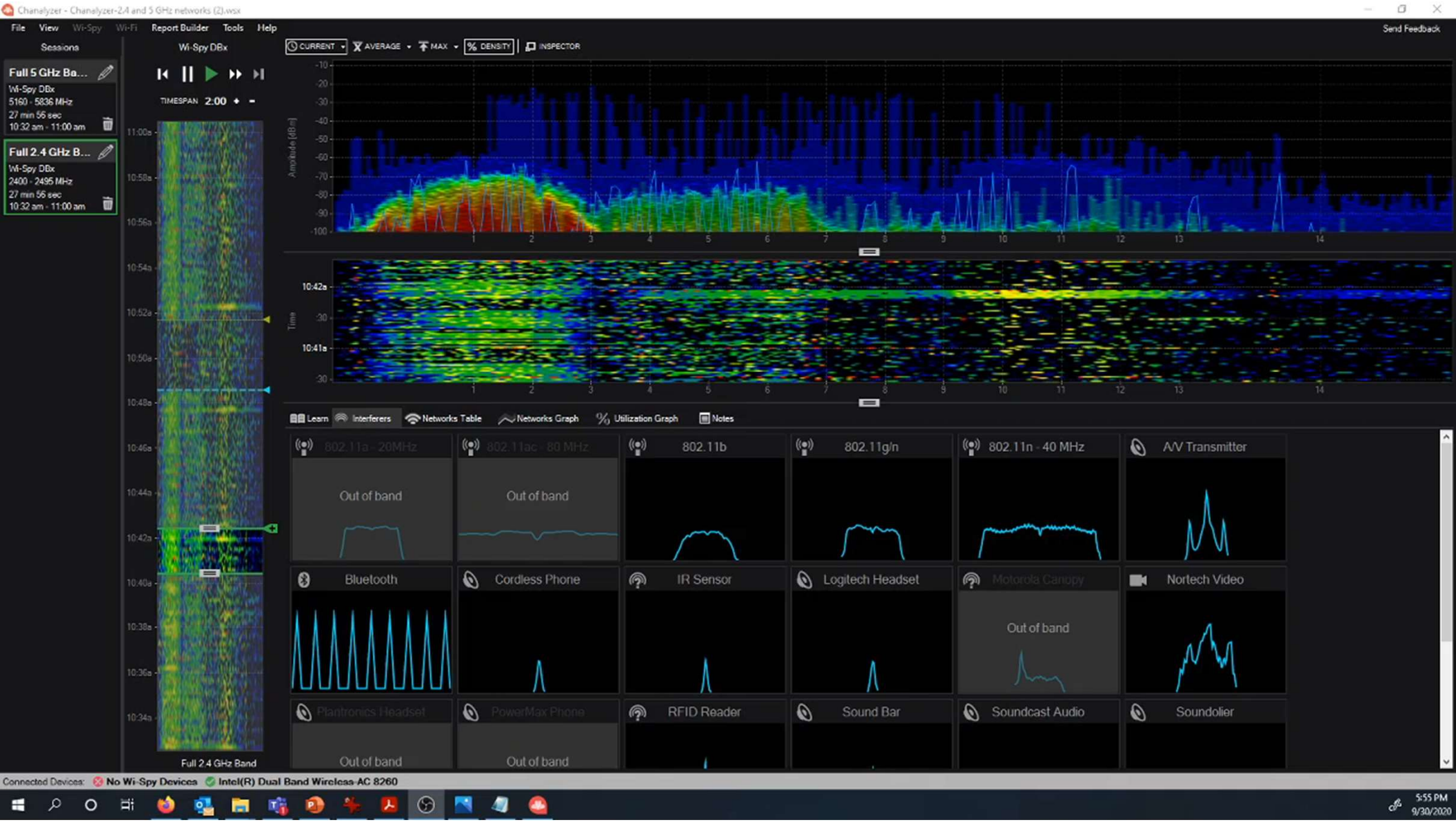
BSSID	Network Name	Vendor Name	Band	CH	Signal Quality	RSSI	SNR
7C:9A:54:4D:B6:73	<-HIDDEN->	Technicolor CH USA Inc.	2.4 GHz	6	92 %	-42 dBm	59 dB
7C:9A:54:4D:B6:6F	<-HIDDEN->	Technicolor CH USA Inc.	2.4 GHz	6	92 %	-42 dBm	59 dB
7C:9A:54:4D:B6:6E	GIGI	Technicolor CH USA Inc.	2.4 GHz	6	92 %	-42 dBm	59 dB
7C:9A:54:4D:B6:74	<-HIDDEN->	Technicolor CH USA Inc.	2.4 GHz	6	92 %	-42 dBm	59 dB
7C:9A:54:4D:B6:71	<-HIDDEN->	Technicolor CH USA Inc.	2.4 GHz	6	92 %	-42 dBm	59 dB
4A:1E:19:16:32:7D	<-HIDDEN->		2.4 GHz	11	88 %	-50 dBm	48 dB
7C:9A:54:4D:B6:7A	XFINITY	Technicolor CH USA Inc.	5 GHz	44	88 %	-50 dBm	45 dB
7C:9A:54:4D:B6:79	<-HIDDEN->	Technicolor CH USA Inc.	5 GHz	44	88 %	-50 dBm	45 dB
1A:1E:19:16:32:7D	GIGI		2.4 GHz	11	88 %	-50 dBm	48 dB
7C:9A:54:4D:B6:70	xfinitywifi	Technicolor CH USA Inc.	2.4 GHz	6	88 %	-49 dBm	52 dB
7C:9A:54:4D:B6:76	GIGI	Technicolor CH USA Inc.	5 GHz	44	88 %	-50 dBm	45 dB
1A:1E:19:16:32:7E	GIGI		5 GHz	44	86 %	-54 dBm	41 dB
3A:1E:19:16:32:7E	<-HIDDEN->		5 GHz	44	85 %	-55 dBm	40 dB
7C:1C:4E:D2:30:32	LG_MusicFlow_DL_1371	LG Innotek	5 GHz	157	70 %	-69 dBm	32 dB
A2:CB:51:EA:23:79	<-HIDDEN->		2.4 GHz	6	62 %	-72 dBm	26 dB
82:CB:51:EA:23:79	GIGI		2.4 GHz	6	62 %	-72 dBm	26 dB
0E:62:A6:99:07:6A	<-HIDDEN->		2.4 GHz	6	53 %	-75 dBm	26 dB
72:CB:51:EA:23:79	<-HIDDEN->		2.4 GHz	6	50 %	-76 dBm	22 dB
B2:CB:51:EA:23:79	<-HIDDEN->		2.4 GHz	6	46 %	-77 dBm	21 dB
62:F8:53:39:A2:67	<-HIDDEN->		5 GHz	132	40 %	-79 dBm	16 dB
A0:40:A0:5E:C9:72	<-HIDDEN->	Netgear	5 GHz	157	40 %	-79 dBm	16 dB
A6:C9:EB:0C:AA:A1	<-HIDDEN->		2.4 GHz	4	40 %	-79 dBm	22 dB
A6:40:A0:5E:C9:70	ORBI50		2.4 GHz	4	40 %	-79 dBm	22 dB
B8:F8:53:39:A2:66	Fios-QcZ7v	Arcadyan Corporation	5 GHz	132	40 %	-79 dBm	16 dB
72:CB:51:EA:23:7A	<-HIDDEN->		5 GHz	157	40 %	-79 dBm	16 dB
72:F8:53:0E:35:C3	<-HIDDEN->		5 GHz	140	40 %	-79 dBm	16 dB

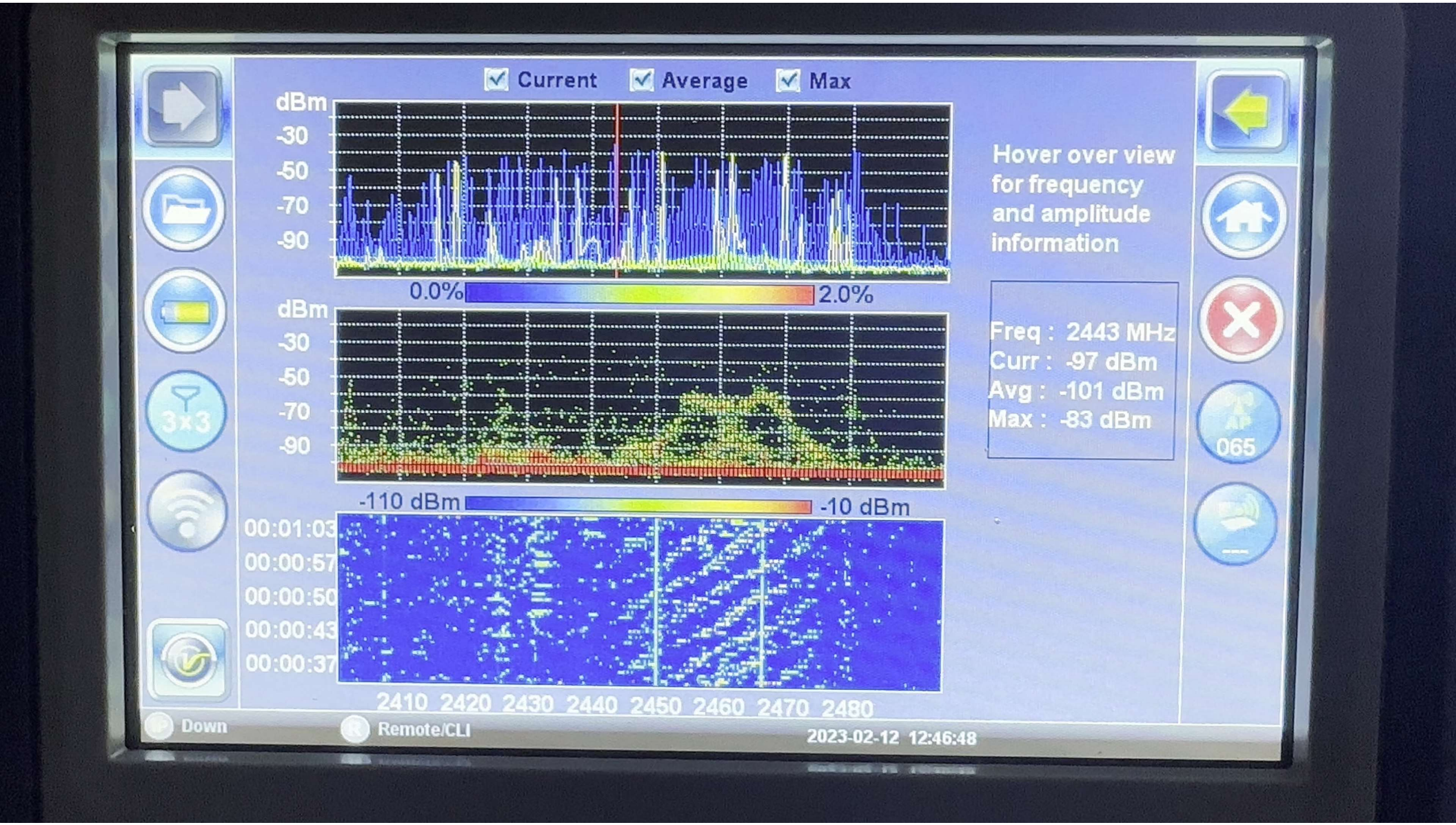
S/N 25 dB or >

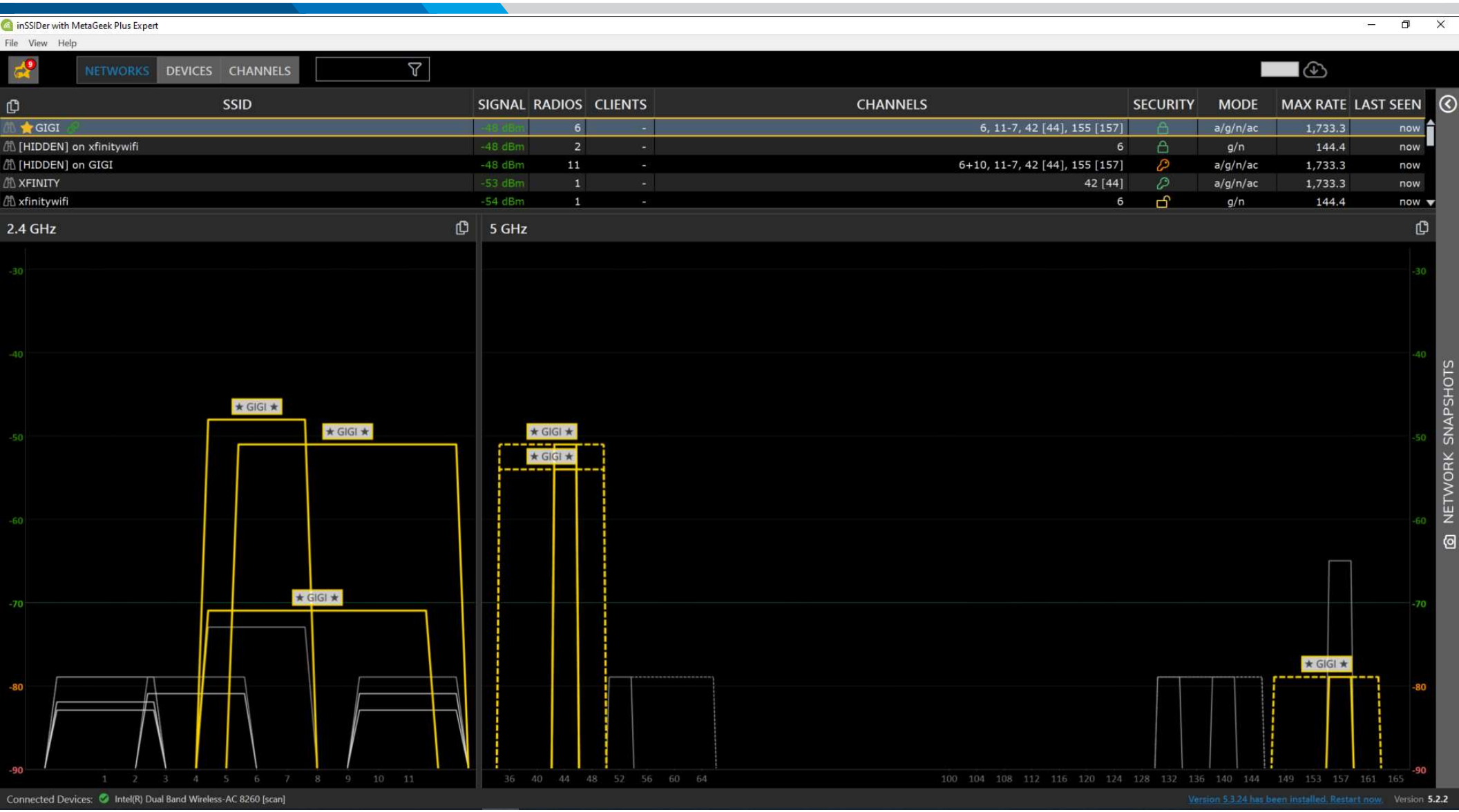
GIGI = - 45 dB

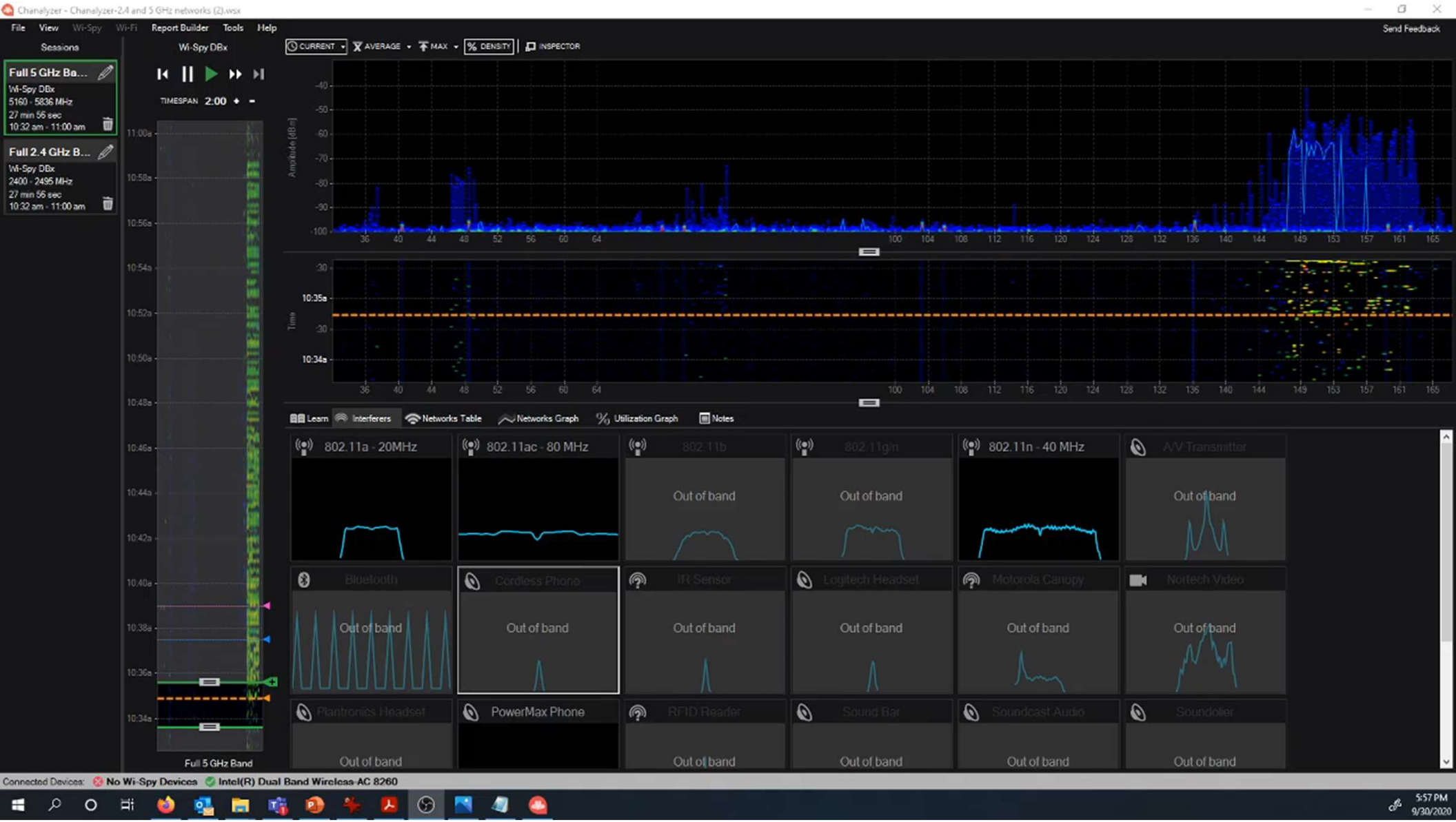
Wi-Fi Metrics: 2.4 GHz




Chanalyzer - Chanalyzer-2.4 and 5 GHz networks (2).wsx
File View Wi-Spy Wi-Fi Report Builder Tools Help
Send Feedback
Sessions
Wi-Spy DBx
CURRENT AVERAGE MAX DENSITY INSPECTOR
Full 5 GHz Ba...
Wi-Spy DBx
5160 - 5836 MHz
27 min 56 sec
10:32 am - 11:00 am
Full 2.4 GHz B...
Wi-Spy DBx
2400 - 2495 MHz
27 min 56 sec
10:32 am - 11:00 am
TIMESPAN 2:00
Amplitude (dBm)
Time
Learn Interferers Networks Table Networks Graph Utilization Graph Notes
802.11a - 20MHz
Out of band
802.11ac - 80 MHz
Out of band
802.11b
802.11g/n
802.11n - 40 MHz
A/V Transmitter
Bluetooth
Cordless Phone
IR Sensor
Logitech Headset
Motorola Canopy
Out of band
Nortech Video
Plantronics Headset
Out of band
PowerMax Phone
Out of band
RFID Reader
Sound Bar
Soundcast Audio
Soundolier
Full 2.4 GHz Band
Connected Devices: No Wi-Spy Devices Intel(R) Dual Band Wireless-AC 8260
5:55 PM
9/30/2020


Current
Average
Max
dBm
-30
-50
-70
-90
0.0%
2.0%
dBm
-30
-50
-70
-90
-110 dBm
-10 dBm
00:01:03
00:00:57
00:00:50
00:00:43
00:00:37
2410 2420 2430 2440 2450 2460 2470 2480
Hover over view for frequency and amplitude information
Freq : 2443 MHz
Curr : -97 dBm
Avg : -101 dBm
Max : -83 dBm
3x3
AP
065
Down
Remote/CLI
2023-02-12 12:46:48


inSSIDer with MetaGeek Plus Expert
File View Help
NETWORKS DEVICES CHANNELS
SSID SIGNAL RADIOS CLIENTS CHANNELS SECURITY MODE MAX RATE LAST SEEN
GIGI -48 dBm 6 - 6, 11-7, 42 [44], 155 [157] a/g/n/ac 1,733.3 now
[HIDDEN] on xfinitywifi -48 dBm 2 - 6 g/n 144.4 now
[HIDDEN] on GIGI -48 dBm 11 - 6+10, 11-7, 42 [44], 155 [157] a/g/n/ac 1,733.3 now
XFINITY -53 dBm 1 - 42 [44] a/g/n/ac 1,733.3 now
xfinitywifi -54 dBm 1 - 6 g/n 144.4 now
2.4 GHz
5 GHz
-30
-40
-50
-60
-70
-80
-90
★ GIGI ★
1 2 3 4 5 6 7 8 9 10 11
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
NETWORK SNAPSHOTS
Connected Devices: Intel(R) Dual Band Wireless-AC 8260 [scan]
Version 5.3.24 has been installed. Restart now.
Version 5.2.2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Full 5 GHz Ba...
Wi-Spy DBx
5160 - 5836 MHz
27 min 56 sec
10:32 am - 11:00 am
Full 2.4 GHz B...
Wi-Spy DBx
2400 - 2495 MHz
27 min 56 sec
10:32 am - 11:00 am
TIMESPAN 2:00
CURRENT AVERAGE MAX DENSITY INSPECTOR
Amplitude (dBm)
Time
10:35a
10:34a
Learn Interferers Networks Table Networks Graph Utilization Graph Notes
802.11a - 20MHz
802.11ac - 80 MHz
802.11b
802.11g/n
802.11n - 40 MHz
A/V Transmitter
Bluetooth
Cordless Phone
IR Sensor
Logitech Headset
Motorola Canopy
Nortech Video
Plantronics Headset
PowerMax Phone
RFID Reader
Sound Bar
Soundcast Audio
Soundolier
Out of band
Full 5 GHz Band
Connected Devices: No Wi-Spy Devices Intel(R) Dual Band Wireless-AC 8260
5:57 PM
9/30/2020

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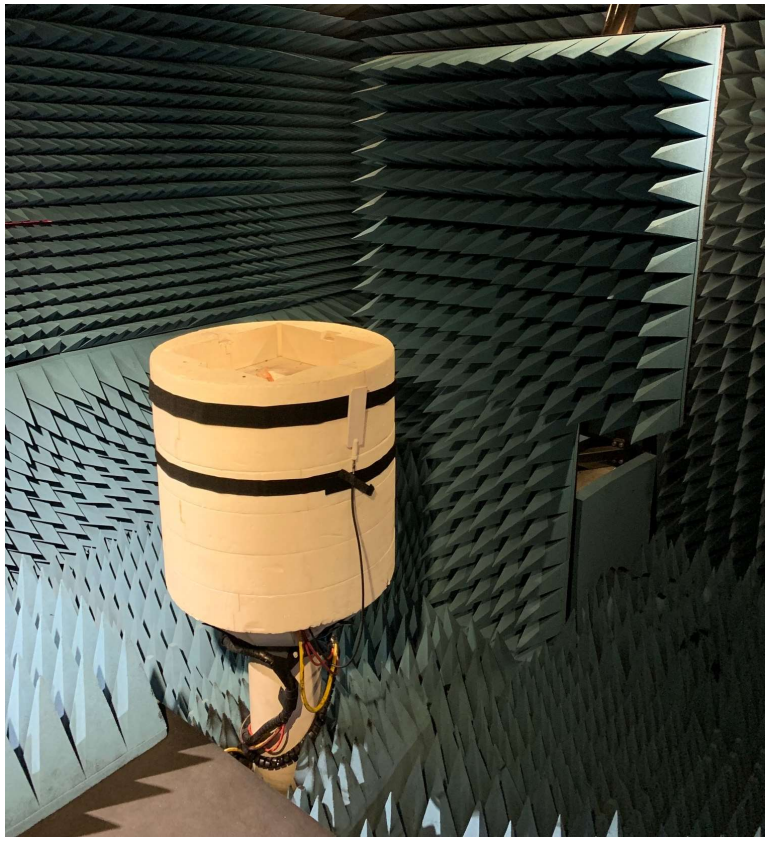
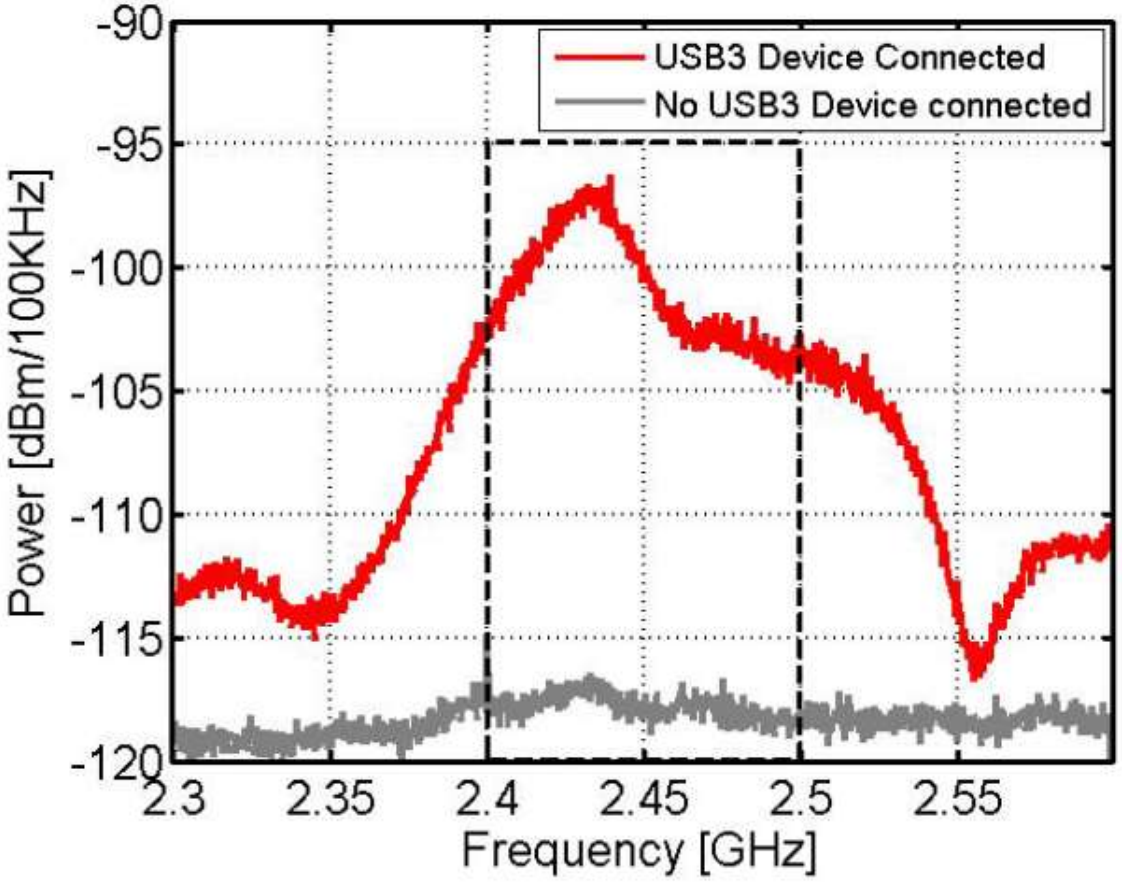
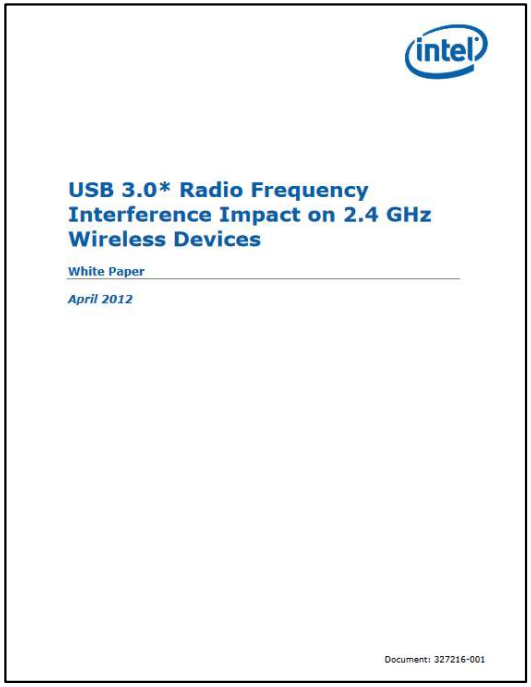
- Radar signal generation



USB Noise from External Hard Disk or Memory Stick



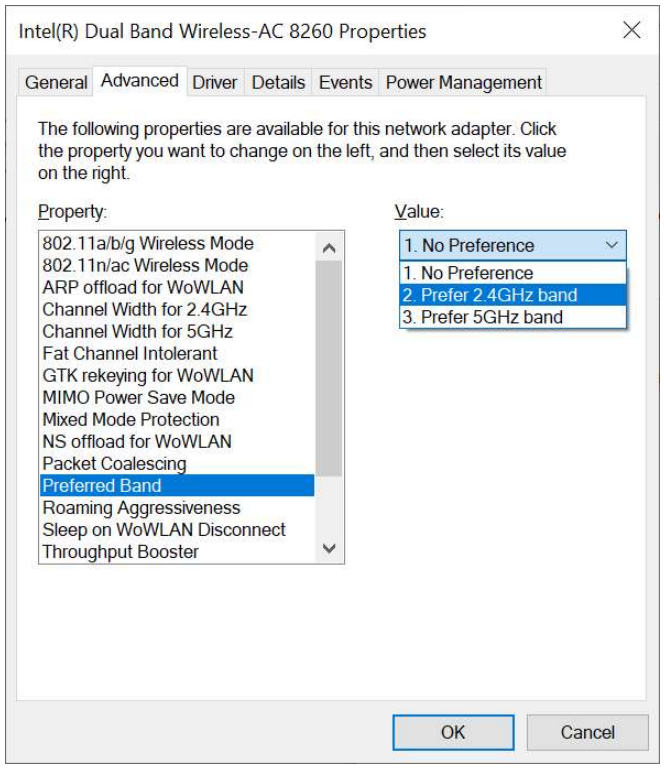

USB 3.0* Radio Frequency Interference Impact on 2.4 GHz Wireless Devices

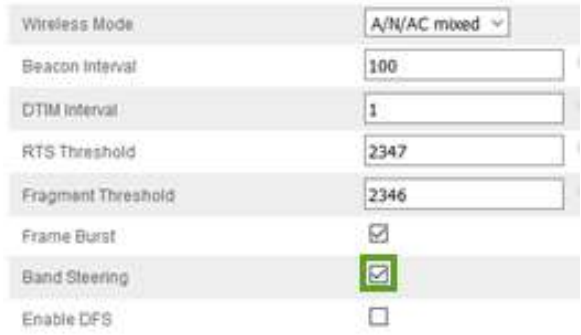
White Paper

April 2012

Document: 327216-001

Band Steering Concern





The Impact of Wi-Fi 7 on Cable Networks

A Technical Paper prepared for SCTE by

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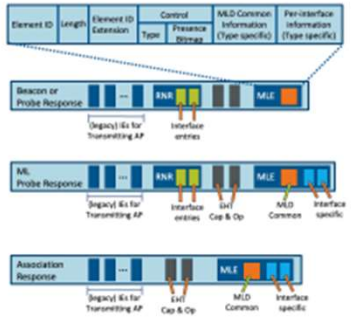

Figure 7 – Multi-Link Frames

Another important aspect of the multi-link channel access operation is the power-saving ability. Having multiple RF radios sending and receiving frames is not an efficient use of power, especially on battery-powered handheld devices. 802.11be will use the traffic indication map (TIM) and the target wake time (TWT) features to address this.

TIM uses beacons to inform the STAs that the AP has information for them. TIM uses an STA ID that is stored in a bitmap. In that bitmap, there is a bit that indicates if there is data for that STA. A binary one indicates there is, and the STA must wake up. A binary zero means there is no data for the STA, and it can stay in snooze mode. For TIM to work with MLDs, a link indication field is added to the bitmap. The link indication informs the STA which link has the data waiting for it.

TWT is based on a TWT schedule that is negotiated between the AP and the client. The TWT schedule includes the wake-up time, the wake interval, and the wake duration for the clients. With multilink, the MLD will negotiate the TWT schedule for each link with the AP. If all links follow the same schedule, then the MLD only needs to negotiate one TWT schedule.

4.2. Low Complexity AP Coordination

Environments such as MDUs where multiple APs are using the same channel and transmitting unique service set identifiers (SSIDs) create the potential for a high amount of Wi-Fi interference. Each AP is a basic service set (BSS), and when they overlap, this creates overlapping BSS (OBSS) interference, which impacts the quality of the wireless signal.

AP coordination can significantly improve Wi-Fi performance in these environments. Due to the complexity of AP coordination, the 802.11be task group split the features into two parts. Release one establishes the technologies used for low-complexity AP coordination, and release two sets the standards for advanced AP coordination. The AP coordination proposed in the 802.11be amendment identifies requirements for primary AP and secondary APs. These APs can be connected via cabling, but they do

Conclusion

- Wi-Fi is critical for customers
- Know the Wi-Fi to install, troubleshoot and educate your customers
- Know the common ways to troubleshoot Wi-Fi networks
- Leverage the SCTE recommend practices 255 and the Wi-Fi professional certifications
- Benchmark the CPE before putting in the field (Kyrio)

THANK YOU!

Presenter: Steve Harris

sharris@scte.org

February 2023

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Carrier Grade WiFi

Steven R. Harris
Senior Director, Advanced Network Technology Education and Engineering, SCTE
sharris@scte.org

Steve Harris is an internationally experienced telecommunication, high tech and information technology system engineering professional with a proven track record of success. Many years of experience operating in areas of wireless, facilities, MPEG, IPv4/v6, routing (CCNP/CCIP), inter-VLAN, FHRP, DOCSIS, Ethernet, premises networks, coding and Linux systems. Directly responsible for the tremendous growth in technical instructor led, hybrid and virtual training programs that deliver measurable results for our stakeholders. A successful leader that has developed strong business acumen and diverse expertise in sales, operations, training and technology.

Twenty years ago who would have imagined a world with wireless smartphones smarter than supercomputers, razor thin untethered tablets that support hundreds of apps, and smart TVs leveraging 100 Mbps+ Internet connections? Wireless connected devices have infiltrated our subscriber's daily lives and it's hard to image how earlier generations were able to keep in touch without the technology that is so mainstream. This popularity has put competitive pressure on cable operators to support wireless connectivity not only in the premises but also in the community.

For many cable operators, wireless demand is the driving force in the development of carrier grade WiFi at the premises and in the community. Carrier grade WiFi must support 90% coverage in the premises, stream four HD programs simultaneously, a data rate of 40 Mbps and an eco-system owned by the operator. However, WiFi is often self-managed by our subscribers and prone to "self-inflicted" wounds, creating an inconsistent environment that cannot provide all the benefits and data rates required. In addition, operators are adding community WiFi networks by expanding the latest IEEE 802.11 amendments for faster roaming and improved authentication protocols. Finally, cable operators are working together to establish roaming agreements, expanding the WiFi footprint across the globe.

The modern premises network is expanding beyond six WiFi connected devices, expected to be more than twenty in a four short years. Wireless in the premises is more than just WiFi, other IEEE 802.15.4 technologies maybe used such as ZigBee, Bluetooth 4.0, WirelessHART and 6LowPAN. The WiFi network of the future will consume more data bits than ever before by streaming ultra and high definition video. According to many experts the internet of things (IoT) continues to grow exponentially, adding another increase of devices at the premises.

Given the end to end responsibility of the operator to provide the best in class Internet service, there is an immediate need for the creation of carrier grade WiFi networks leveraging eRouters. The current approach where WiFi devices are not benchmarked by the operator may deliver an inconsistent experience. One of the big items cited by many cable operators is the lack of a site survey performed at the subscriber premises, just dropping the WiFi gateway next to a modem is not a best practice. A major factor in the success of WiFi is strong RF propagation and sufficient coverage. As for RF propagation, this is determined by clear line of sight (LoS) along with the combined effects of common RF behaviors. Behaviors such as free space path loss (FSPL), absorption, reflection, diffraction, multipath, and antenna polarization all weaken a WiFi signal. Subscribers who migrate a WiFi network to the 5 GHz range will lose coverage, since higher frequencies like 5 GHz attenuate more than lower frequencies like 2.4 GHz.

Cable operators need a managed WiFi device in the premises that provides the best in class experience. The device is known as the eRouter, naturally vendors have their own marketing name for the device. The eRouter needs the capability to perform continuous RF measurement, mitigate issues, optimize coverage and provide visibility for the operator after the install. Many WiFi devices typically do not choose the best RF channel; tools like dynamic channel allocation (DCA), transmit power control (TPC), RF channel filtering and the detection non-WiFi interference are critical. Another concern is the lack of support for the entire index of modulation and coding schemes (MCS) used in 802.11n/ac, thus reducing data throughput of the device. When it comes to larger premises; operators may require multiple eRouters, wireless RF extenders, or MoCA to WiFi devices.

Technology will evolve and the carrier grade WiFi story will continue to grow. As for WiFi technologies, impedance matching the technology so they support the same 802.11 standard will improve the experience. Tomorrow's technology will include rich features to mitigate RF behaviors, along with additional support of the 802.11 specification. The cable workforce needs to be geared up to mitigate RF behaviors, describe 802.11 capabilities, recognize interoperability requirements; and customer service knowledge to educate our subscribers about their WiFi experience. If you are interested in learning more about wireless, WiFi or to participate in our working group please email information@scte.org or visit http://www.scte.org.

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