

# Things you should know before design wireless network

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# About me

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# What do we think, when talking about wireless network?

Antenna

Band

Frequency

Bandwidth

Interference

Signal to Noise Ratio (SNR)

Client Connection Quality (CCQ)

Multiple Input Multiple Output (MIMO)

Spatial Stream (SS)

Modulation and Coding Scheme (MCS)

Noise Floor Signal

Protocol

Polarization

Hardware-protection (CTS/RTS)

Service Set Identifier (SSID)

Transmission power

Signal Strength

Wireless security (WEP,WPA,WPA2)

Wireless Distribution System (WDS)

Mesh

# Good wireless network?

High signal strength?

High transmission power?

High gain antenna?

# Antenna

Omni antenna/ Dipole antenna



Semi directional antenna/ Sector antenna



Directional antenna / Beam / Dish



# Frequency

มาตรฐานทางเทคนิคของเครื่องโทรคมนาคมและอุปกรณ์

กทช. มท. 1012 - 2551

เครื่องวิทยุคมนาคมที่ใช้เทคโนโลยี Broadband Wireless Access ในลักษณะ Radio Local Area Network

## 1. ขอบข่าย

มาตรฐานทางเทคนิคนี้ ระบุลักษณะทางเทคนิคขั้นต่ำสำหรับเครื่องวิทยุคมนาคมที่ใช้เทคโนโลยี Broadband Wireless Access ในลักษณะ Radio Local Area Network (RLAN) ทั้งที่เป็นชนิดประจำที่ (base unit/access point) และชนิดเคลื่อนที่หรือพกพา (mobile/portable unit) ซึ่งใช้หลักการผสมสัญญาณแบบ Direct Sequence/Frequency Hopping Spread Spectrum หรือหลักการผสมสัญญาณดิจิทัล (Digital Modulation) แบบอื่น ในช่วงความถี่วิทยุดังต่อไปนี้

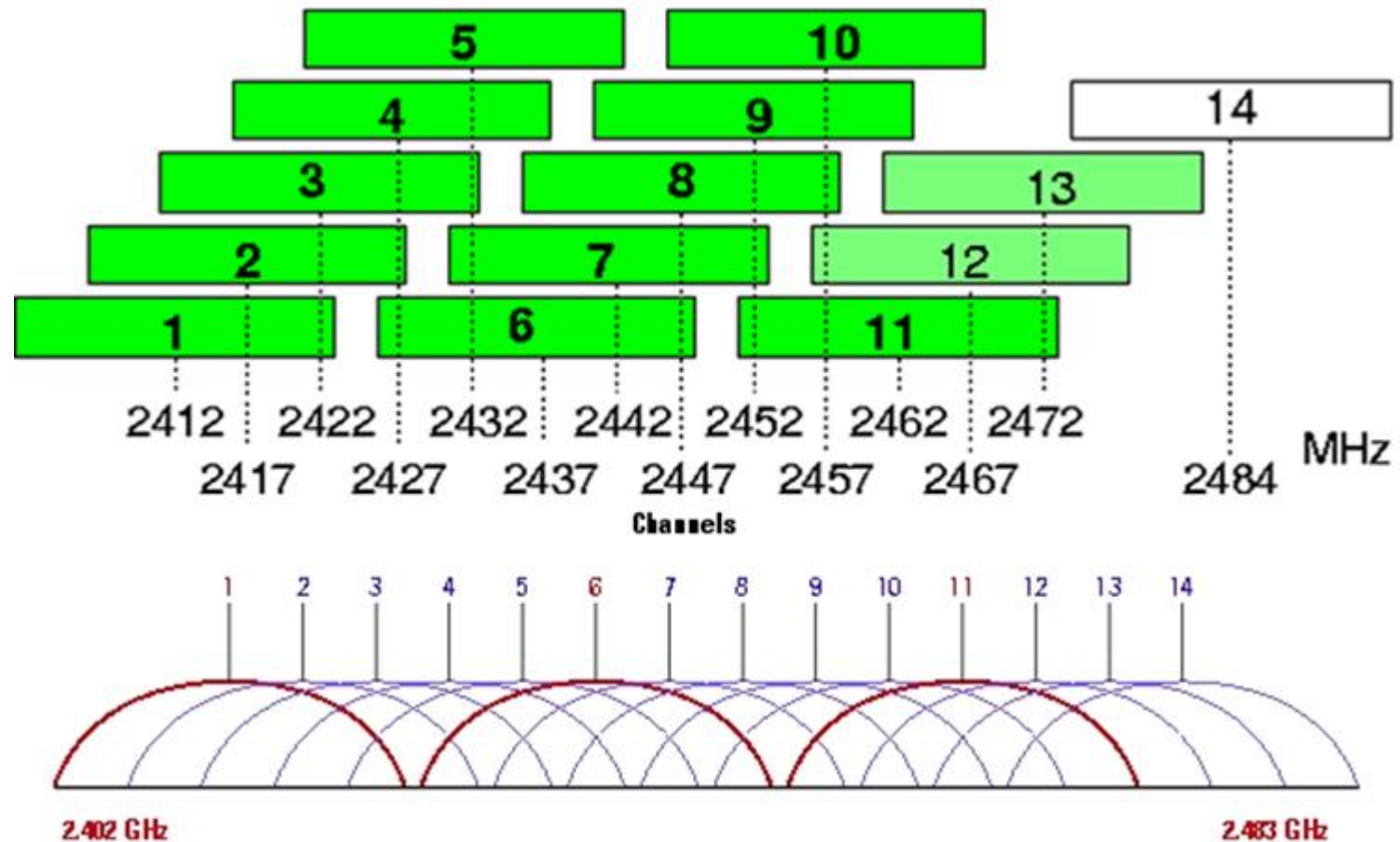
ช่วงความถี่วิทยุ
2.400 – 2.500 GHz
5.150 – 5.350 GHz
5.470 – 5.725 GHz
5.725 – 5.850 GHz

การแสดงความสอดคล้องตามมาตรฐานทางเทคนิคนี้ ให้ใช้หลักการรับรองตนเองของผู้ประกอบการ ตามที่กำหนดไว้ในหมวด 4 ของประกาศคณะกรรมการกิจการโทรคมนาคมแห่งชาติ เรื่อง การตรวจสอบและรับรองมาตรฐานของเครื่องโทรคมนาคมและอุปกรณ์

# Wireless IEEE802.11 protocol

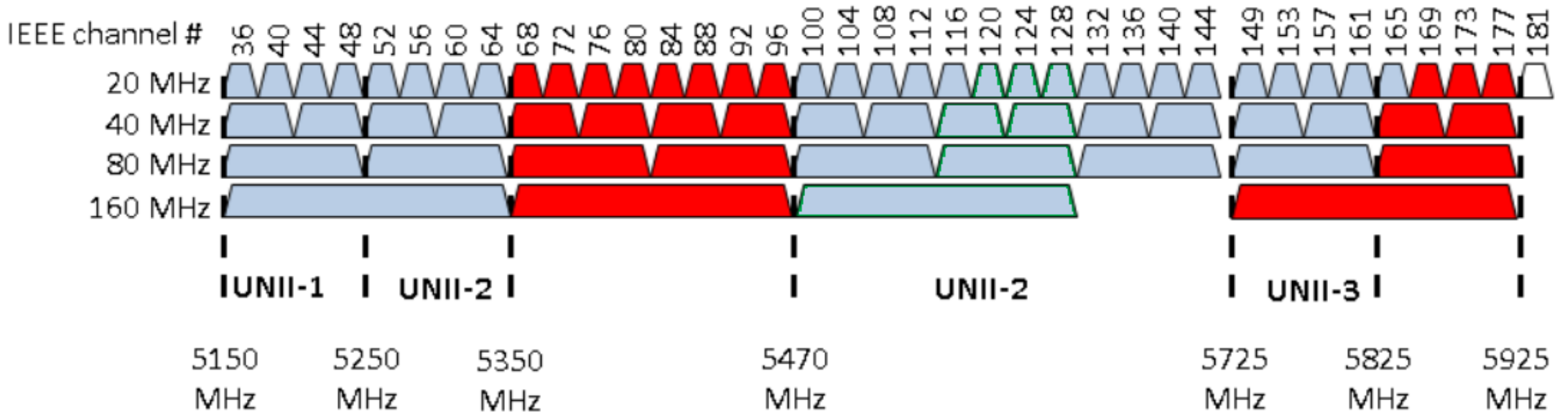
IEEE	Band	Bandwidth	Datarate	Spatial Stream
802.11a	5 GHz	20 MHz	54 Mbps	1
802.11b	2.4 GHz	22 MHz	11 Mbps	1
802.11g	2.4 GHz	20 MHz	54 Mbps	1
802.11n	2.4/5 GHz	20/40 MHz	450 Mbps	3
802.11ac wave1	5 GHz	20/40/80 MHz	1,300 Mbps	3



# In 2.4Ghz band





# In 5GHz band



-  Currently available
-  Next channels

# Transmission Power

## 2. มาตรฐานทางเทคนิค

### 2.1 มาตรฐานทางเทคนิคด้านคลื่นความถี่ (Radio Frequency Requirements)

มาตรฐานทางเทคนิคด้านคลื่นความถี่ของเครื่องวิทยุคมนาคมที่ใช้เทคโนโลยี Broadband Wireless Access ในลักษณะ Radio Local Area Network (RLAN) ให้เป็นไปตามที่กำหนดไว้ดังต่อไปนี้

#### 2.1.1 กำลังส่ง (output power)

กำลังส่งของเครื่องวิทยุคมนาคม จะต้องไม่เกินค่าที่กำหนดไว้ ดังต่อไปนี้

ช่วงความถี่วิทยุ (GHz)	กำลังส่ง e.i.r.p (วัตต์)	ความหนาแน่นกำลังส่ง e.i.r.p density
2.400 – 2.500	0.1	-
5.150 – 5.350	0.2	10 mW/MHz (0.25 mW/25 kHz)
5.470 – 5.725	1.0	50 mW/MHz
5.725 – 5.850	1.0	-

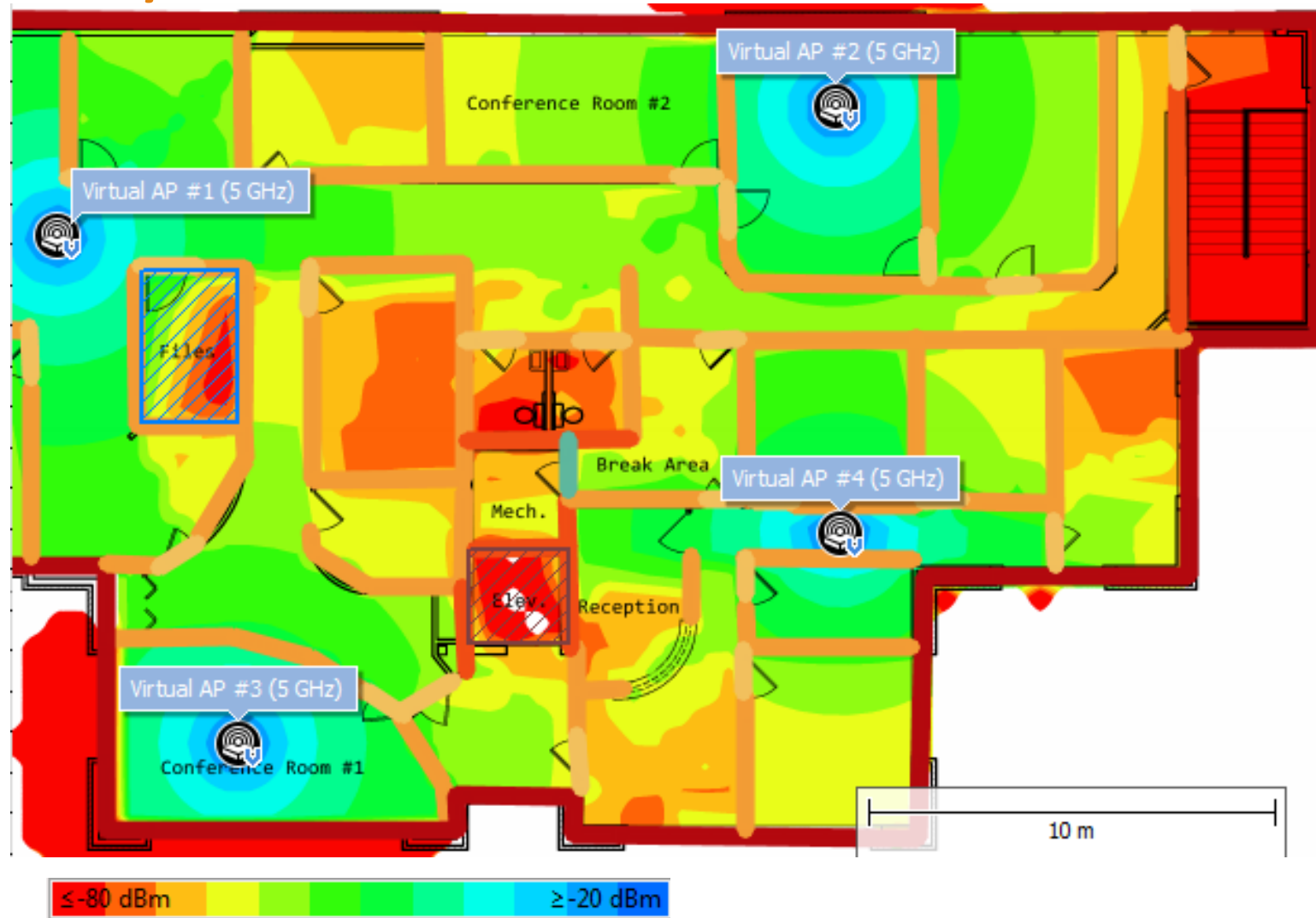
หมายเหตุ กำลังส่งในที่นี้ หมายถึง e.i.r.p during the transmission burst which corresponds to the highest power, if power control is implemented

# Key RF relationship

AP -> Client



# Site survey



# Key RF relationship

AP -> Client



Client -> AP



# On AP

Interface	MAC Address	Tx Rate	Rx Rate	Tx Signal	Rx Signal	Uptime	Tx/Rx Packets	Tx/Rx Bytes	Comment
AP-mobile-11	C0:D9:62:76:D6:B0	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-54	03:04:07....	24 897/17 793	27.8 MiB/2942.1 ...	
AP-mobile-11	38:B1:DB:C8:53:53	58.5Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-55	01:58:20....	54 723/42 289	59.1 MiB/5.1 MiB	
AP-mobile-11	24:FD:52:9A:55:AD	52Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-48	01:13:24....	21 118/15 775	21.8 MiB/2861.3 ...	
AP-mobile-11	00:24:D6:15:53:C6	130Mbps-20MHz/2S	65Mbps-20MHz/1S	0	-48	01:11:43....	2 067/4 433	465.4 KB/1094.3...	
AP-mobile-11	B8:76:3F:58:35:7F	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-35	00:23:00....	151 769/18 594	217.6 MiB/1309.6...	
AP-mobile-11	00:21:6A:51:97:86	65Mbps-20MHz/1S	78Mbps-20MHz/2S	0	-29	00:17:42....	4 856/4 393	6.2 MiB/668.3 KiB	
AP-mobile-11	C0:14:3D:C4:F0:7F	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-53	00:17:30....	2 202/5 068	379.8 KB/462.9 ...	
AP-mobile-11	20:7C:8F:59:54:82	130Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-49	00:11:38....	13 732/11 580	11.2 MiB/1399.5 ...	
AP-mobile-11A	00:88:65:93:56:2E	18Mbps	135Mbps-40MHz/1S	0	-61	00:01:57....	49/98	47.22 B/7.7 KiB	
AP-mobile-12A	48:E9:F1:98:10:09	12Mbps	135Mbps-40MHz/1S	0	-39	00:04:53....	34/90	5.6 KB/9.9 KiB	
AP-mobile-13A	A4:5E:60:C1:D6:FD	130Mbps-20MHz/2S	162Mbps-40MHz/2S	0	-61	02:10:50....	621 564/358 721	747.0 MiB/42.2 MiB	
AP-mobile-13A	C8:E0:EB:BB:89:D1	135Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-47	00:10:10....	2 121/1 723	2347.3 KiB/222.6 ...	
AP-mobile-14A	04:0C:CE:D5:F6:D2	270Mbps-40MHz/2S	270Mbps-40MHz/2S	0	-42	02:57:17....	17 424/13 298	18.9 MiB/4027.4 ...	
AP-mobile-15	00:1F:3C:0C:1F:7F	48Mbps	54Mbps	0	-52	02:53:45....	40 769/32 799	49.0 MiB/2928.4 ...	
AP-mobile-15	78:DD:08:CA:4F:19	135Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-37	02:29:42....	74 988/51 336	91.8 MiB/6.0 MiB	
AP-mobile-15	6C:71:D9:77:C4:D9	135Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-52	02:20:20....	24 275/30 431	19.4 MiB/5.8 MiB	
AP-mobile-15	28:C2:DD:86:28:F9	108Mbps-40MHz/1S	65Mbps-20MHz/1S	0	-59	01:15:14....	32 791/16 522	38.7 MiB/2803.6 ...	
AP-mobile-15	E0:AC:CB:9D:99:B0	117Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-60	01:13:05....	1 563/1 738	881.9 KB/253.8 ...	
AP-mobile-15	44:6D:57:57:6A:C6	58.5Mbps-20MHz/1S	135Mbps-40MHz/1S	0	-55	01:11:09....	106 007/31 981	142.1 MiB/3093.1 ...	
AP-mobile-15	10:F6:81:F9:4E:C5	48Mbps	52Mbps-20MHz/1S	0	-52	01:10:37....	4 501/4 185	4000.4 KiB/563.5...	
AP-mobile-15	20:16:D8:C7:3D:B3	135Mbps-40MHz/1S	108Mbps-40MHz/1S	0	-57	00:59:34....	73 171/42 397	102.4 MiB/3040.2...	
AP-mobile-15	14:10:9F:E7:16:5E	65Mbps-20MHz/1S	130Mbps-20MHz/2S	0	-55	00:58:00....	138 260/117 912	137.4 MiB/16.0 MiB	
AP-mobile-15	90:48:9A:3F:C7:CB	58.5Mbps-20MHz/1S	121.5Mbps-40MHz/1S	0	-56	00:34:45....	9 466/10 493	6.7 MiB/2943.1 KiB	
AP-mobile-15	8C:A9:82:7B:EB:DA	58.5Mbps-20MHz/1S	58.5Mbps-20MHz/1S	0	-66	00:29:50....	594/2 910	155.9 KB/317.5 ...	
AP-mobile-15	B0:10:41:E1:39:21	121.5Mbps-40MHz/1S	108Mbps-40MHz/1S	0	-59	00:24:12....	1 234/2 331	1085.2 KiB/267.5...	
AP-mobile-15	C0:CB:38:07:12:2C	135Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-64	00:13:55....	807/1 877	447.9 KB/185.6 ...	
AP-mobile-15	50:7A:55:15:95:39	65Mbps-20MHz/1S	26Mbps-20MHz/1S	0	-51	00:08:28....	879/921	697.3 KiB/107.0 ...	
AP-mobile-15A	64:76:BA:95:8D:6E	117Mbps-80MHz/2S	162Mbps-40MHz/2S	0	-58	00:04:00....	158/337	17.8 KB/46.1 KiB	
AP-mobile-15A	3C:15:C2:EA:69:62	117Mbps-80MHz/2S	216Mbps-40MHz/2S	0	-58	00:02:28....	180/490	17.8 KB/46.6 KiB	
AP-mobile-21A	EC:22:80:72:B9:FF	234Mbps-80MHz/2S	234Mbps-80MHz/2S	0	-58	00:43:00....	240 964/161 207	258.6 MiB/33.0 MiB	
AP-mobile-22A	7C:D1:C3:7A:BB:F4	270Mbps-40MHz/2S	270Mbps-40MHz/2S	0	-37	01:29:46....	177 717/166 682	141.1 MiB/139.9 ...	
AP-mobile-22A	10:40:F3:99:F6:6C	130Mbps-20MHz/2S	243Mbps-40MHz/2S	0	-42	00:10:08....	268/458	40.0 KB/52.0 KiB	
AP-mobile-22A	AC:3C:08:82:B8:1F	121.5Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-37	00:05:28....	751/907	667.2 KiB/150.0 ...	
AP-mobile-23	24:EC:99:4D:1A:99	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-28	03:04:54....	198 201/110 754	275.4 MiB/7.5 MiB	
AP-mobile-23	E0:B9:A5:67:63:F3	58.5Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-53	02:59:13....	229 928/132 388	299.0 MiB/12.1 MiB	
AP-mobile-23	C0:18:85:0E:27:23	52Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-42	02:35:23....	36 213/24 729	41.8 MiB/2718.0 ...	
AP-mobile-23	AC:B5:7D:5B:CD:01	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-46	02:29:43....	41 902/40 615	44.5 MiB/9.8 MiB	
AP-mobile-23	60:57:18:67:A6:83	130Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-46	02:07:15....	288 134/87 829	385.7 MiB/7.1 MiB	
AP-mobile-23	70:F1:A1:0F:C8:EC	65Mbps-20MHz/1S	78Mbps-20MHz/2S	0	-34	01:25:33....	7 611/14 052	7.4 MiB/1286.5 KiB	
AP-mobile-23	34:36:3B:D3:91:86	130Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-38	01:18:41....	1 371/1 753	385.4 KB/371.4 ...	
AP-mobile-23	60:57:18:B9:ED:53	117Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-39	00:22:06....	1 103/1 794	778.8 KB/176.4 ...	
AP-mobile-23	70:14:A6:71:A5:0A	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-45	00:14:01....	14 280/10 637	16.2 MiB/1371.7 ...	
AP-mobile-23	E8:8D:28:AA:E6:20	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-58	00:08:08....	333/565	80.6 KB/64.1 KiB	
AP-mobile-23	48:D2:24:40:BB:83	58.5Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-55	00:01:53....	1 343/1 384	786.7 KB/174.4 ...	
AP-mobile-23	48:D2:24:20:F5:1D	65Mbps-20MHz/1S	130Mbps-20MHz/2S	0	-40	00:00:45....	363/934	64.3 KB/289.0 KiB	
AP-mobile-23	3C:E0:72:12:F4:3E	1Mbps	58.5Mbps-20MHz/1S	0	-40	00:00:24....	10/97	1490 B/14.2 KiB	
AP-mobile-23	2C:5B:B8:4E:BB:93	5.5Mbps	65Mbps-20MHz/1S	0	-41	00:00:23....	127/95	62.3 KB/8.6 KiB	
AP-mobile-23	78:D7:5F:DD:52:9B	1Mbps	65Mbps-20MHz/1S	0	-41	00:00:09....	5/48	1110 B/4632 B	
AP-mobile-23A	8C:70:5A:29:03:9C	243Mbps-40MHz/2S	270Mbps-40MHz/2S	0	-36	03:04:10....	68 250/75 571	45.1 MiB/23.1 MiB	
AP-mobile-23A	00:13:E8:BD:5A:C5	135Mbps-40MHz/1S	270Mbps-40MHz/2S	0	-23	02:57:55....	45 697/29 175	53.3 MiB/3757.9 ...	
AP-mobile-23A	E8:50:8B:72:D0:28	18Mbps	162Mbps-40MHz/2S	0	-59	00:54:48....	1 235/1 349	450.9 KB/239.5 ...	
AP-mobile-23A	74:E5:43:11:B6:B5	135Mbps-40MHz/1S	243Mbps-40MHz/2S	0	-46	00:26:38....	1 540/4 338	611.5 KB/515.7 ...	
AP-mobile-24A	34:E6:AD:F6:35:D3	121.5Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-52	03:02:03....	31 305/61 179	14.5 MiB/7.1 MiB	
AP-mobile-24A	64:20:0C:D5:51:5B	6Mbps	65Mbps-20MHz/1S	0	-55	00:00:35....	14/41	1824 B/3080 B	
AP-mobile-25A	00:21:6A:51:90:CA	270Mbps-40MHz/2S	270Mbps-40MHz/2S	0	-46	01:55:16....	16 603/15 232	20.0 MiB/1582.3 ...	
AP-mobile-25A	28:CF:E9:20:EA:C3	270Mbps-40MHz/2S	108Mbps-40MHz/1S	0	-64	00:24:29....	107 280/88 369	137.4 MiB/6.8 MiB	

# Key RF relationship

AP -> Client



Client -> AP



AP -> AP



# On AP

Channel	Address	SSID	Signal	Of Freq. (%)	Of Traf. (%)	Bandwidth
2412/2...	00:0C:42:D5:4A:F2	SBI-Secure	-51	0.3	9.5	21.3 kbps
2452/2...	00:0C:42:D5:4B:12	SBI-Secure	-63	0.4	100.0	21.5 kbps
2412/2...	E4:8D:8C:18:D4:D3	SBI-Secure	-62	0.3	9.5	21.3 kbps
2437/2...	64:66:B3:ED:CE:26	BEST_JGSEE	-80	5.8	14.1	56.6 kbps
2437/2...	00:1A:70:DE:49:41	csscmeeting	-81	0.3	0.8	7.6 kbps
2412/2...	EA:BB:A8:D8:4A:80		-87	0.0	0.0	0 bps
2437/2...	58:6D:8F:25:E9:54	AccessCSSC	-89	4.8	11.6	47.3 kbps
2437/2...	B0:C5:54:0E:F4:DB	AccessCSSC	-89	13.7	33.1	187.0 kbps
2412/2...	F4:F2:6D:B7:15:0F	ScientRoom	-90	2.3	55.1	21.0 kbps
2412/2...	0C:84:DC:A4:52:28	HP-Print-28-LaserJ...	-91	1.0	25.8	8.8 kbps
2437/2...	B0:C5:54:0E:F4:D8	csscmeeting	-91	6.3	15.3	62.3 kbps
2412/2...	B8:EE:65:AF:02:A3	nop	-94	0.0	0.0	0 bps
2412/2...	B4:75:0E:B2:7E:BC	CSSC2015	-94	0.0	0.0	0 bps
2412/2...	14:CC:20:A8:CA:65		-97	0.0	0.0	0 bps



# SNR and datarate

MCS Index - 802.11n and 802.11ac

HT MCS Index	VHT MCS Index	Spatial Streams	Modulation	Coding	20MHz		40MHz		80MHz		160MHz	
					Data Rate No SGI	Data Rate SGI	Data Rate No SGI	Data Rate SGI	Data Rate No SGI	Data Rate SGI	Data Rate No SGI	Data Rate SGI
0	0	1	BPSK	1/2	6.5	7.2	13.5	15	29.3	32.5	58.5	65
1	1	1	QPSK	1/2	13	14.4	27	30	58.5	65	117	130
2	2	1	QPSK	3/4	19.5	21.7	40.5	45	87.8	97.5	175.5	195
3	3	1	16-QAM	1/2	26	28.9	54	60	117	130	234	260
4	4	1	16-QAM	3/4	39	43.3	81	90	175.5	195	351	390
5	5	1	64-QAM	2/3	52	57.8	108	120	234	260	468	520
6	6	1	64-QAM	3/4	58.5	65	121.5	135	263.3	292.5	526.5	585
7	7	1	64-QAM	5/6	65	72.2	135	150	292.5	325	585	650
	8	1	256-QAM	3/4	78	86.7	162	180	351	390	702	780
	9	1	256-QAM	5/6	n/a	n/a	180	200	390	433.3	780	866.7
8	0	2	BPSK	1/2	13	14.4	27	30	58.5	65	117	130
9	1	2	QPSK	1/2	26	28.9	54	60	117	130	234	260
10	2	2	QPSK	3/4	39	43.3	81	90	175.5	195	351	390
11	3	2	16-QAM	1/2	52	57.8	108	120	234	260	468	520
12	4	2	16-QAM	3/4	78	86.7	162	180	351	390	702	780
13	5	2	64-QAM	2/3	104	115.6	216	240	468	520	936	1040
14	6	2	64-QAM	3/4	117	130.3	243	270	526.5	585	1053	1170
15	7	2	64-QAM	5/6	130	144.4	270	300	585	650	1170	1300
	8	2	256-QAM	3/4	156	173.3	324	360	702	780	1404	1560
	9	2	256-QAM	5/6	n/a	n/a	360	400	780	866.7	1560	1733.3
16	0	3	BPSK	1/2	19.5	21.7	40.5	45	87.8	97.5	175.5	195
17	1	3	QPSK	1/2	39	43.3	81	90	175.5	195	351	390
18	2	3	QPSK	3/4	58.5	65	121.5	135	263.3	292.5	526.5	585
19	3	3	16-QAM	1/2	78	86.7	162	180	351	390	702	780
20	4	3	16-QAM	3/4	117	130	243	270	526.5	585	1053	1170
21	5	3	64-QAM	2/3	156	173.3	324	360	702	780	1404	1560
22	6	3	64-QAM	3/4	175.5	195	364.5	405	n/a	n/a	1579.5	1755
23	7	3	64-QAM	5/6	195	216.7	405	450	877.5	975	1755	1950
	8	3	256-QAM	3/4	234	260	486	540	1053	1170	2106	2340
	9	3	256-QAM	5/6	260	288.9	540	600	1170	1300	n/a	n/a

802.11n 802.11ac

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 8	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
- 802.11a/g
- 802.11n
- 802.11ac

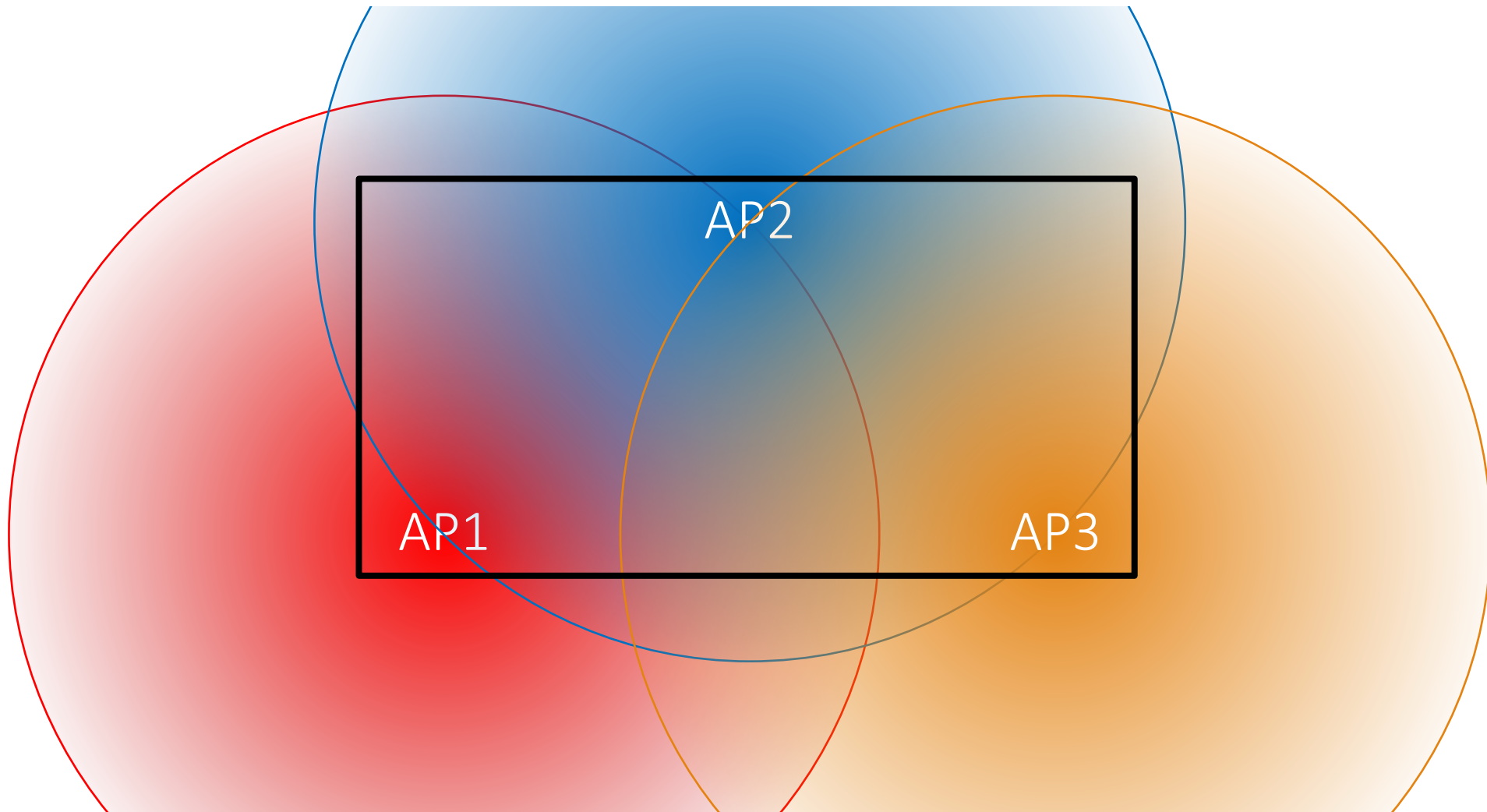
# On AP

Interface	MAC Address	Tx Rate	Rx Rate	Tx Signal	Rx Signal	Uptime	Tx/Rx Packets	Tx/Rx Bytes	Comment
AP-mobile-11	C0:D9:62:76:D6:B0	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-54	03:04:07....	24 897/17 793	27.8 MiB/2942.1 ...	
AP-mobile-11	38:B1:DB:C8:53:53	58.5Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-55	01:58:20....	54 723/42 289	59.1 MiB/5.1 MiB	
AP-mobile-11	24:FD:52:9A:55:AD	52Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-48	01:13:24....	21 118/15 775	21.8 MiB/2861.3 ...	
AP-mobile-11	00:24:D6:15:53:C6	130Mbps-20MHz/2S	65Mbps-20MHz/1S	0	-48	01:11:43....	2 067/4 433	465.4 KiB/1094.3...	
AP-mobile-11	B8:76:3F:58:35:7F	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-35	00:23:00....	151 769/18 594	217.6 MiB/1309.6...	
AP-mobile-11	00:21:6A:51:97:86	65Mbps-20MHz/1S	78Mbps-20MHz/2S	0	-29	00:17:42....	4 856/4 393	6.2 MiB/668.3 KiB	
AP-mobile-11	C0:14:3D:C4:F0:7F	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-53	00:17:30....	2 202/5 068	379.8 KiB/462.9 ...	
AP-mobile-11	20:7C:8F:59:54:82	130Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-49	00:11:38....	13 732/11 580	11.2 MiB/1399.5 ...	
AP-mobile-11A	00:88:65:93:56:2E	18Mbps	135Mbps-40MHz/1S	0	-61	00:01:57....	49/98	47.2 B/7.7 KiB	
AP-mobile-12A	48:E9:F1:98:10:09	12Mbps	135Mbps-40MHz/1S	0	-39	00:04:53....	34/90	5.6 KiB/9.9 KiB	
AP-mobile-13A	A4:5E:60:C1:D6:FD	130Mbps-20MHz/2S	162Mbps-40MHz/2S	0	-61	02:10:50....	621 564/358 721	747.0 MiB/42.2 MiB	
AP-mobile-13A	C8:E0:EB:BB:89:D1	135Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-47	00:10:10....	2 121/1 723	2347.3 KiB/222.6 ...	
AP-mobile-14A	04:0C:CE:D5:F6:D2	270Mbps-40MHz/2S	270Mbps-40MHz/2S	0	-42	02:57:17....	17 424/13 298	18.9 MiB/4027.4 ...	
AP-mobile-15	00:1F:3C:0C:1F:7F	48Mbps	54Mbps	0	-52	02:53:45....	40 769/32 799	49.0 MiB/2928.4 ...	
AP-mobile-15	78:DD:08:CA:4F:19	135Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-37	02:29:42....	74 988/51 336	91.8 MiB/6.0 MiB	
AP-mobile-15	6C:71:D9:77:C4:D9	135Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-52	02:20:20....	24 275/30 431	19.4 MiB/5.8 MiB	
AP-mobile-15	28:C2:DD:86:28:F9	108Mbps-40MHz/1S	65Mbps-20MHz/1S	0	-59	01:15:14....	32 791/16 522	38.7 MiB/2803.6 ...	
AP-mobile-15	E0:AC:CB:9D:99:B0	117Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-60	01:13:05....	1 563/1 738	881.9 KiB/253.8 ...	
AP-mobile-15	44:6D:57:57:6A:C6	58.5Mbps-20MHz/1S	135Mbps-40MHz/1S	0	-55	01:11:09....	106 007/31 981	142.1 MiB/3093.1 ...	
AP-mobile-15	10:F6:81:F9:4E:C5	48Mbps	52Mbps-20MHz/1S	0	-52	01:10:37....	4 501/4 185	4000.4 KiB/563.5...	
AP-mobile-15	20:16:D8:C7:3D:B3	135Mbps-40MHz/1S	108Mbps-40MHz/1S	0	-57	00:59:34....	73 171/42 397	102.4 MiB/3040.2...	
AP-mobile-15	14:10:9F:E7:16:5E	65Mbps-20MHz/1S	130Mbps-20MHz/2S	0	-55	00:58:00....	138 260/117 912	137.4 MiB/16.0 MiB	
AP-mobile-15	90:48:9A:3F:C7:CB	58.5Mbps-20MHz/1S	121.5Mbps-40MHz/1S	0	-56	00:34:45....	9 466/10 493	6.7 MiB/2943.1 KiB	
AP-mobile-15	8C:A9:82:7B:EB:DA	58.5Mbps-20MHz/1S	58.5Mbps-20MHz/1S	0	-66	00:29:50....	594/2 910	155.9 KiB/317.5 ...	
AP-mobile-15	B0:10:41:E1:39:21	121.5Mbps-40MHz/1S	108Mbps-40MHz/1S	0	-59	00:24:12....	1 234/2 331	1085.2 KiB/267.5...	
AP-mobile-15	C0:CB:38:07:12:2C	135Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-64	00:13:55....	807/1 877	447.9 KiB/185.6 ...	
AP-mobile-15	50:7A:55:15:95:39	65Mbps-20MHz/1S	26Mbps-20MHz/1S	0	-51	00:08:28....	879/921	697.3 KiB/107.0 ...	
AP-mobile-15A	64:76:BA:95:8D:6E	117Mbps-80MHz/2S	162Mbps-40MHz/2S	0	-58	00:04:00....	158/337	17.8 KiB/46.1 KiB	
AP-mobile-15A	3C:15:C2:EA:69:62	117Mbps-80MHz/2S	216Mbps-40MHz/2S	0	-58	00:02:28....	180/490	17.8 KiB/46.6 KiB	
AP-mobile-21A	EC:22:80:72:B9:FF	234Mbps-80MHz/2S	234Mbps-80MHz/2S	0	-58	00:43:00....	240 964/161 207	258.6 MiB/33.0 MiB	
AP-mobile-22A	7C:D1:C3:7A:BB:F4	270Mbps-40MHz/2S	270Mbps-40MHz/2S	0	-37	01:29:46....	177 717/166 682	141.1 MiB/139.9 ...	
AP-mobile-22A	10:40:F3:99:F6:6C	130Mbps-20MHz/2S	243Mbps-40MHz/2S	0	-42	00:10:08....	268/458	40.0 KiB/52.0 KiB	
AP-mobile-22A	AC:3C:08:82:B8:1F	121.5Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-37	00:05:28....	751/907	667.2 KiB/150.0 ...	
AP-mobile-23	24:EC:99:4D:1A:99	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-28	03:04:54....	198 201/110 754	275.4 MiB/7.5 MiB	
AP-mobile-23	E0:B9:A5:67:63:F3	58.5Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-53	02:59:13....	229 928/132 388	299.0 MiB/12.1 MiB	
AP-mobile-23	C0:18:85:0E:27:23	52Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-42	02:35:23....	36 213/24 729	41.8 MiB/2718.0 ...	
AP-mobile-23	AC:85:7D:5B:CD:01	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-46	02:29:43....	41 902/40 615	44.5 MiB/9.8 MiB	
AP-mobile-23	60:57:18:67:A6:83	130Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-46	02:07:15....	288 134/87 829	385.7 MiB/7.1 MiB	
AP-mobile-23	70:F1:A1:0F:C8:EC	65Mbps-20MHz/1S	78Mbps-20MHz/2S	0	-34	01:25:33....	7 611/14 052	7.4 MiB/1286.5 KiB	
AP-mobile-23	34:36:3B:D3:91:86	130Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-38	01:18:41....	1 371/1 753	385.4 KiB/371.4 ...	
AP-mobile-23	60:57:18:B9:ED:53	117Mbps-20MHz/2S	130Mbps-20MHz/2S	0	-39	00:22:06....	1 103/1 794	778.8 KiB/176.4 ...	
AP-mobile-23	70:14:A6:71:A5:0A	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-45	00:14:01....	14 280/10 637	16.2 MiB/1371.7 ...	
AP-mobile-23	E8:8D:28:AA:E6:20	65Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-58	00:08:08....	333/565	80.6 KiB/64.1 KiB	
AP-mobile-23	48:D2:24:40:BB:83	58.5Mbps-20MHz/1S	65Mbps-20MHz/1S	0	-55	00:01:53....	1 343/1 384	786.7 KiB/174.4 ...	
AP-mobile-23	48:D2:24:20:F5:1D	65Mbps-20MHz/1S	130Mbps-20MHz/2S	0	-40	00:00:45....	363/934	64.3 KiB/289.0 KiB	
AP-mobile-23	3C:E0:72:12:F4:3E	1Mbps	58.5Mbps-20MHz/1S	0	-40	00:00:24....	10/97	1490 B/14.2 KiB	
AP-mobile-23	2C:5B:B8:4E:BB:93	5.5Mbps	65Mbps-20MHz/1S	0	-41	00:00:23....	127/95	62.3 KiB/8.6 KiB	
AP-mobile-23	78:D7:5F:DD:52:9B	1Mbps	65Mbps-20MHz/1S	0	-41	00:00:09....	5/48	1110 B/4632 B	
AP-mobile-23A	8C:70:5A:29:03:9C	243Mbps-40MHz/2S	270Mbps-40MHz/2S	0	-36	03:04:10....	68 250/75 571	45.1 MiB/23.1 MiB	
AP-mobile-23A	00:13:E8:BD:5A:C5	135Mbps-40MHz/1S	270Mbps-40MHz/2S	0	-23	02:57:55....	45 697/29 175	53.3 MiB/3757.9 ...	
AP-mobile-23A	E8:50:8B:72:D0:28	18Mbps	162Mbps-40MHz/2S	0	-59	00:54:48....	1 235/1 349	450.9 KiB/239.5 ...	
AP-mobile-23A	74:E5:43:11:B6:B5	135Mbps-40MHz/1S	243Mbps-40MHz/2S	0	-46	00:26:38....	1 540/4 338	611.5 KiB/515.7 ...	
AP-mobile-24A	34:E6:AD:F6:35:D3	121.5Mbps-40MHz/1S	135Mbps-40MHz/1S	0	-52	03:02:03....	31 305/61 179	14.5 MiB/7.1 MiB	
AP-mobile-24A	64:20:0C:D5:51:5B	6Mbps	65Mbps-20MHz/1S	0	-55	00:00:35....	14/41	1824 B/3080 B	
AP-mobile-25A	00:21:6A:51:90:CA	270Mbps-40MHz/2S	270Mbps-40MHz/2S	0	-46	01:55:16....	16 603/15 232	20.0 MiB/1582.3 ...	
AP-mobile-25A	28:CF:E9:20:EA:C3	270Mbps-40MHz/2S	108Mbps-40MHz/1S	0	-64	00:24:29....	107 280/88 369	137.4 MiB/6.8 MiB	

High coverage  
or  
High density ?

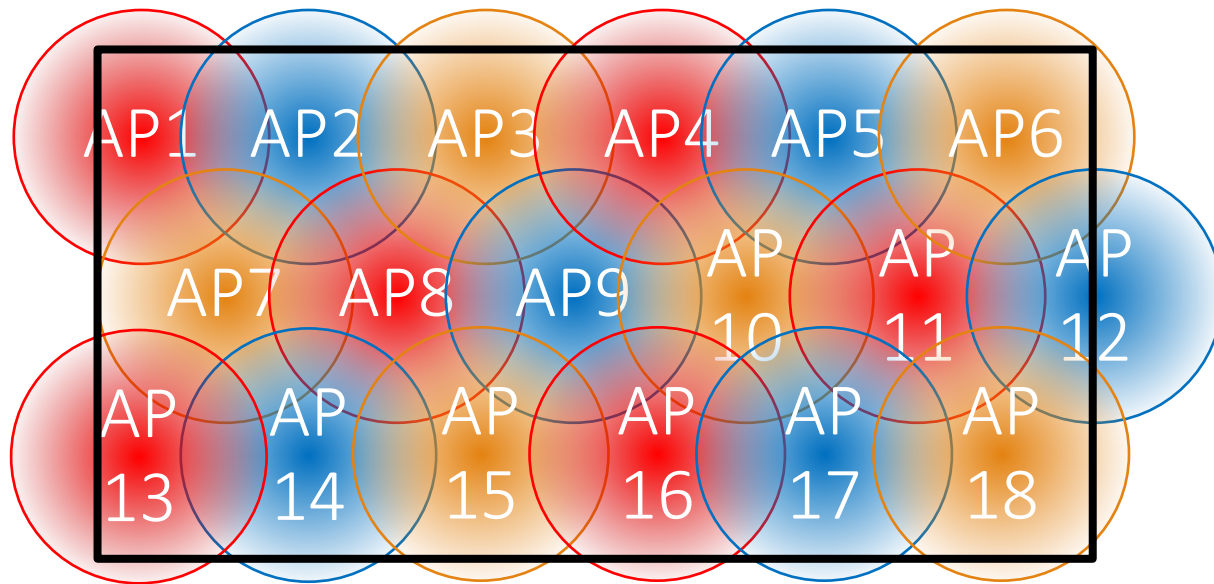
The concept are different.

# High Coverage Design





# High Density Design



# Things you should know before design wireless network

Pich Tantichukiatikul

