FORTINET

Best Practices towards Designing Wi-Fi Networks

Md. Faridul Alam, System Engineer II

Fortinet Bangladesh

Wi-Fi Design Tools

- Ekahau Pro
- IBWave Wi-Fi
- Net Ally - Airmagnet Survey Pro
- Tamosoft - Tamograph Site Survey
- Acrylic Wi-Fi Heatmaps
- Solarwinds Wi-Fi Heatmaps via NPM
- Site Survey by VisiWave
- FortiPlanner

Note: It is highly recommended to only use up-to-date Wi-Fi design software.

- Contains latest model APs
- Antenna plots are correct

Gathering Information - 1/4

- Understand the customers use case. What will the Wi-Fi network be used for:
  - Guest access
  - Corporate Data
  - Voice, Video
  - High-Density
  - Barcode Scanning etc….
  - Key applications, Skype, Web Browsing, E-mail, etc.
  - Number of users

  This will give you some insight into the necessary performance and roaming requirements

- Determine the minimum throughput required per device i.e. 10Mbps. This will help determine the number of AP radios required to meet this requirement.

- Find out exactly what type of devices is the customer using. It's key to determine what the least capable most important (LCMI) device that will be used on the Wi-Fi network. Always use the LCMI as a design reference point. For example their LCMI is an iPhone 7. You would want to design the network using an iPhone 7 as a reference point.
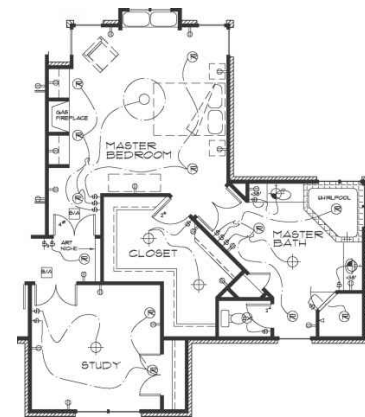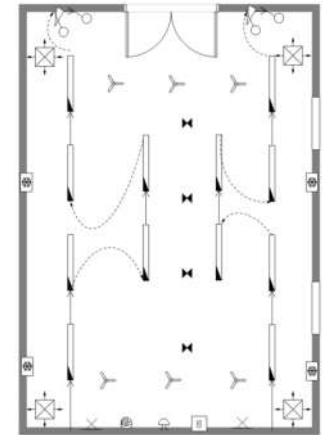
Gathering Information - 2/4

- ## How many SSID does the customer need for their use case/s?

  - Always try to keep to the lowest number of SSID's possible. Thinking of one SSID per room? Think again! Advertising an SSID consumes radio airtime, known as SSID overhead. Too many SSID can result in 100% airtime used, before anyone is even connected.

  - SSID Overhead Calculator
    https://fortinet.egnyte.com/dl/ucXxp0IR4G

Wi-Fi SSID Overhead Calculator

VARIABLES:
Beacon Data Rate (Mbps)	802.11b 1 Mbps
Beacon Frame Size (Byte	380
Beacon Interval (ms)	102.4

ASSUMPTIONS:
802.11b Long Preamble used for 1 Mbps; Short Preamble used for 2, 5.5, 11
802.11g short slot time is assumed, with no 802.11b clients within range
WMM is enabled and beacons are transmitted using Best Effort AC

| Amount of Overhead: | 0-10% Low | 10-20% Medium | 20-50% High | >50% Very High |

Number of APs on Channel*	Number of SSIDs									
	1	2	3	4	5	6	7	8	9	10
1	3.22%	6.45%	9.67%	12.90%	16.12%	19.35%	22.57%	25.80%	29.02%	32.25%
2	6.45%	12.90%	19.35%	25.80%	32.25%	38.70%	45.14%	51.59%	58.04%	64.49%
3	9.67%	19.35%	29.02%	38.70%	48.37%	58.04%	67.72%	77.39%	87.06%	96.74%
4	12.90%	25.80%	38.70%	51.59%	64.49%	77.39%	90.29%	100.00%	100.00%	100.00%
5	16.12%	32.25%	48.37%	64.49%	80.62%	96.74%	100.00%	100.00%	100.00%	100.00%
6	19.35%	38.70%	58.04%	77.39%	96.74%	100.00%	100.00%	100.00%	100.00%	100.00%
7	22.57%	45.14%	67.72%	90.29%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
8	25.80%	51.59%	77.39%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
9	29.02%	58.04%	87.06%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
10	32.25%	64.49%	96.74%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
11	35.47%	70.94%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
12	38.70%	77.39%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
13	41.92%	83.84%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Wi-Fi SSID Overhead Calculator

VARIABLES:
Beacon Data Rate (Mbps)	802.11g 6 Mbps
Beacon Frame Size (Byte	380
Beacon Interval (ms)	102.4

ASSUMPTIONS:
802.11b Long Preamble used for 1 Mbps; Short Preamble used for 2, 5.5, 11
802.11g short slot time is assumed, with no 802.11b clients within range
WMM is enabled and beacons are transmitted using Best Effort AC

| Amount of Overhead: | 0-10% Low | 10-20% Medium | 20-50% High | >50% Very High |

| Number of APs on Channel*	Number of SSIDs									
	1	2	3	4	5	6	7	8	9	10
1	0.56%	1.11%	1.67%	2.22%	2.78%	3.33%	3.89%	4.45%	5.00%	5.56%
2	1.11%	2.22%	3.33%	4.45%	5.56%	6.67%	7.78%	8.89%	10.00%	11.11%
3	1.67%	3.33%	5.00%	6.67%	8.33%	10.00%	11.67%	13.34%	15.00%	16.67%
4	2.22%	4.45%	6.67%	8.89%	11.11%	13.34%	15.56%	17.78%	20.00%	22.23%
5	2.78%	5.56%	8.33%	11.11%	13.89%	16.67%	19.45%	22.23%	25.00%	27.78%
6	3.33%	6.67%	10.00%	13.34%	16.67%	20.00%	23.34%	26.67%	30.01%	33.34%
7	3.89%	7.78%	11.67%	15.56%	19.45%	23.34%	27.23%	31.12%	35.01%	38.90%
8	4.45%	8.89%	13.34%	17.78%	22.23%	26.67%	31.12%	35.56%	40.01%	44.45%
9	5.00%	10.00%	15.00%	20.00%	25.00%	30.01%	35.01%	40.01%	45.01%	50.01%
10	5.56%	11.11%	16.67%	22.23%	27.78%	33.34%	38.90%	44.45%	50.01%	55.57%
11	6.11%	12.22%	18.34%	24.45%	30.56%	36.67%	42.79%	48.90%	55.01%	61.12%
12	6.67%	13.34%	20.00%	26.67%	33.34%	40.01%	46.68%	53.34%	60.01%	66.68%
13	7.22%	14.45%	21.67%	28.89%	36.12%	43.34%	50.57%	57.79%	65.01%	72.24%

Gathering Information - 3/4

- Every Wi-Fi enabled device has variances. For example, looking at two identical iPhone 12 Pro's, the Wi-Fi adaptor has an allowable tolerance of 6dB from the manufacturing reference design. 6dB is a 400% variance. An iPhone is a highly QA'd device. This makes you wonder what the variance on low cost LCMI devices could be?

- Floor Plans - You cannot design a Wi-Fi network without floor plans. If someone asks for a Wi-Fi design and cannot provide floor plans. Well that means no design. End of Story!

- Confirm your plans have an accurate scale. If not you will need to take measurements during the pre-deployment audit.

- The best plans to ask for are a reflected ceiling plan (RCP). The RCP is a drawing that shows which shows the items are located on the ceiling of a room or space. It is referred to as a reflected ceiling plan since it is drawn to display a view of the ceiling as if it was reflected onto a mirror on the floor. This allows you to place AP's without interfering with other items on the ceiling.

Gathering Information - 4/4

- Ask for plans in both CAD (*.dwg) and PDF or picture file formats. Some design tools can work with CAD files. This will save you a lot of time when needing to draw in walls/doors/windows etc. i.e. You can select the internal wall layer during the planning phase and apply the attenuation for that type of wall, all walls of this type would then be drawn in using the selected wall type.

- Don't make assumptions. Ask the hard question i.e. Do you want Wi-Fi coverage in the bathrooms/toilets? This might seem embarrassing but if you don't ask it could come back to bite you.

- If unsure about the user case plan for a PoC. This should confirm it meets the customer use case. If a feature required is missing we it is ideal we recognise this during the Pre-Sales stage and request this feature be added.
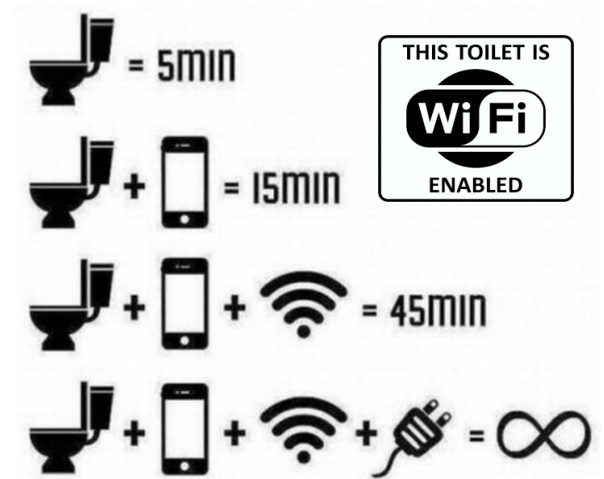
Pre Deployment Survey Audit - 1/2

- Always attempt to visit the site you are design the Wi-Fi network. If the site is under construction, confirm if you require PPE, before attending.

- You cannot accurately design a Wi-Fi network without knowing the attenuation (RF loss) of the construction materials used in a building.

- Measuring the RF loss (attenuation) through all internal/external walls, doors, windows, floors in their final state when fixtures are fitted is recommended. Working in pairs this is a task that can be completed relatively quickly. Most FortiAPs can be placed in Site Survey mode in order to assist with this exact task. This is a step often left out by many I.T. professional who design a Wi-Fi networks.

- Confirm your floorplan scale is correct. Take measurements of a large area, not a standard doorway. This will ensure accuracy.

- Use a spectrum analyser throughout the site. Connectivity issues and poor performance can and do arise as a result of non Wi-Fi interference. Technically referred to as poor SNR. This can occurs on both the 2.4GHz and 5GHz bands. Third party tools such as the Ekahau SideKick and NetAlly AirCheck are best for performing this task.

Pre Deployment Survey Audit - 2/2

- If the building is not constructed and you are working from building plans. This means you are guessing. If there are similar sites you can first visit to obtain information to help improve your design you should attempt to do this. The accuracy of your design is key. If you put garbage information in, you can expect garbage information out (GIGA) when generating the report.

  - Whilst it might be an educated guess it's still a guess. As stated on the previous slide this results in GIGA. Which means your predictive design will not be accurate.

- Using a FortiAP-U with SD code in site survey mode, or a FAP in Stand-Alone mode can help assist you with taking attenuation measurements. The earlier being the best option, as will be explained in the following slides.

- Attempt to determine how far the cable runs will be to the closest comms cabinet. Remember CAT5e/CAT6 will struggle to carry PoE and support 1Gbps at cables length nearing 100 metres. Low quality cabling will result in voltage drops occurring over shorter lengths.

Enable FAP Site Survey Mode - FWC - 1/2

- Site Survey mode is supported from FortiWLC (SD) 6.1-2 or higher.

- Site Survey is supported on AP122, AP822, AP832, FAP-U32XEV, FAP-U42XEV and FAP-U43XF

- The enabled site survey mode;
    - FAP-U console port has a default of baud rate of 115200.
    - Or if the AP is connected to a FWC you can connect to the AP via the FWC CLI using the command 'conn AP ID#' i.e. 'conn AP 18'
    - ss enable - will enable site survey mode on a System Director AP.
    - ss disable - will disable site survey mode on System Director AP.

- Please note from SD 8.5-2 the AP has a default login password set. This is the serial number of the AP. This password can be changed from the default using the command 'pwconfig admin' via the AP CLI.

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Enable FAP Site Survey Mode - FWC - 2/2

- Once SSID is enabled you should see two SSID's. By default these will be broadcast as the following:
  - FORTINET_SITE_SURVEY_2.4 on the 2.4GHz radio
  - FORTINET_SITE_SURVEY_5 on the 5 GHz radio

- Connect to the SSID and the open your browser to the AP IP address which is 192.168.0.1 by default.

- You will the see a page as shown in the image. The key value here is your connected RSSI.

AP-MAC-Address	00:0C:E6:12:7A:2B
Station-MAC	38:00:25:64:68:47
SSID	FORTINET_SITE_SURVEY_5
Channel Number	36
ChannelWidth	80 MHz
S/N Ratio	51 dB
RSSI	-41 dB
Tx Power	25 dBm
802.11 Tx Rate	0 Mbps
802.11 Rx Rate	650 Mbps
Tx Retry count	0
Tx Failure	0
Tx Packets	155
Rx Packets	786

- First take a measurement in the same room as the AP, ideally 5 metres away (due to inverse square law) then take a measurement on the other side of a wall for example. The variance in RSSI would equate to approx. the attenuation of the wall. i.e. 8dB.

- The fact the FAP-U shows your connected RSSI makes this the best option for determining attenuation of building material without the need for 3rd party tools.

- Use the 5GHz SSID to determine the attenuation

Enable FAP Site Survey Mode - FortiAP OS - 1/2

- To enable site survey mode on a FAP/FAP-U via the GUI login to the AP via HTTPS, under Network Configuration > AP Mode select Site Survey. Then click on the Apply button at the bottom of the page

- To enable site survey mode via the CLI

        cfg -a AP_MODE=2 (service mode = 0)
        cfg -c (commit changes and reboot)
        Additional site survey mode options that can be applied prior cfg -c
        cfg -a SURVEY_SSID= Site survey SSID default FAP_SURVEY
        cfg -a SURVEY_TX_POWER= Transmitter power in site survey mode. Default: 30dB (radio max)
        cfg -a SURVEY_CH_24= Site survey transmit channel for the 2.4 GHz band. Default: 6
        cfg -a SURVEY_CH_50= Site survey transmit channel for the 5 GHz band. Default: 36
        cfg -a SURVEY_BEACON_INTV= Site survey beacon interval. Default: 100 ms (there is no reason to change this)

- Note: FAP console port has a default of baud rate of 9600.

Enable FAP Site Survey Mode - FortiAP OS - 2/2

- The FortiAP site survey option only enables the AP to beacon an SSID. You cannot associate to this SSID (this is a limitation of the current feature).

  - It is more beneficial to use a FAP that has been configured to operate in stand-alone mode (via FortiAPCloud or FortiGate). Once in stand-alone mode it will retain the set configuration locally on the AP. This configuration is retained even when the AP is power-cycled.

- You will need to use a third party tool to measure the RSSI. The AP will not provide this information. If your LCMI has a way to provide connected RSSI this would be the best device to use.

- As mentioned previously, first take a measurement in the same room as the AP, ideally 5 metres away (due to FSPL and Inverse Square Law) then take a measurement on the other side of a wall for example. The variance in RSSI would equate to approx. the attenuation of the wall. i.e. 8dB.

  - FSPL shows TXP levels drop approx. 38/45dB on 2.4GHz/5GHz bands after just one metre from the transmitting radio, over the next 2 metres drop another 10dB. Hence due to this is best to measure attenuation at a distance from the radio so FPSL doesn't have an impact on the reading.

Measuring RSSI with a Mobile Device

- On an Apple iOS mobile device you can use the Apple Airport Utility. Within the app settings you need to enable the Wi-Fi Scanner feature. Once this is done you can take measurements of the Wi-Fi signal strength as seen by the device (RSSI)

  https://wifi.rainbird.com/wp-content/uploads/2018/12/Using-Airport-Utility-to-Scan-WiFi-Network-Signal-Strength.pdf

- On an Android mobile device you can use the 'Wifi Analyzer' App to take measurements of the Wi-Fi signal strength as seen by the device (RSSI)


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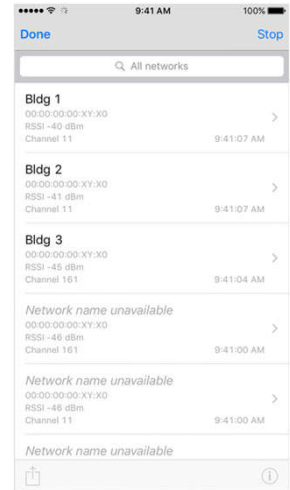
Predictive Design - 1/4

- Number 1 Rule: User Experience is KING! Always design in order to provide the best user experience. No excuses!

- Design to meet the use case. Coverage is key to a great user experience (no coverage, no Wi-Fi, unhappy users).

- It is important to make the design as accurate as possible. Therefore you should go onsite and take measurements of RF loss (attenuation), for the different construction materials used at the site for which you are designing the Wi-Fi network. The worst issue to face is lack of coverage. No coverage, means no service and often this cannot be fixed without implementing more hardware.

- The 2.4GHz band has to compete with many low cost devices, along with BLE, Zigbee and appliance such as Microwave Ovens. If using BLE for beaconing or Zigbee radios (in new F series APs). Be aware this will interfere with the 2.4GHz Wi-Fi radio. If using BLE/Zigbee you might want to consider using 5GHz radios only for Wi-Fi connectivity

Predictive Design - 2/4

- 5GHz Wi-Fi is also faster as it doesn't support legacy modulation methods, such as CCK, used with 802.11b. It supports more non-overlapping channels (3 versus 24). More channels (pipes) means, more capacity. This can result in higher data rates/throughput, especially when using channel bonding. This is turn leads to a better user experience.

- Don't design with AP radio's set to full TXP. Design using ~75% radio transmit power (TXP) (or lower in high density spaces). This will allow you to properly tune the network post implementation. If you've designed at 100% TXP and find you need more Wi-Fi coverage post Implementation, the only fix is to add more APs.

  - Recommendation is to use 17dBm/50mW EIRP on 5GHz and 14dBm/25mW EIRP on 2.4GHz. Think about the LCMI. Many devices cannot transmit at 14dBm and may have on chip antennas.

- Don't use AP's with internal antennas on walls, like a clock.
 https://youtu.be/uz17IfqQNK4
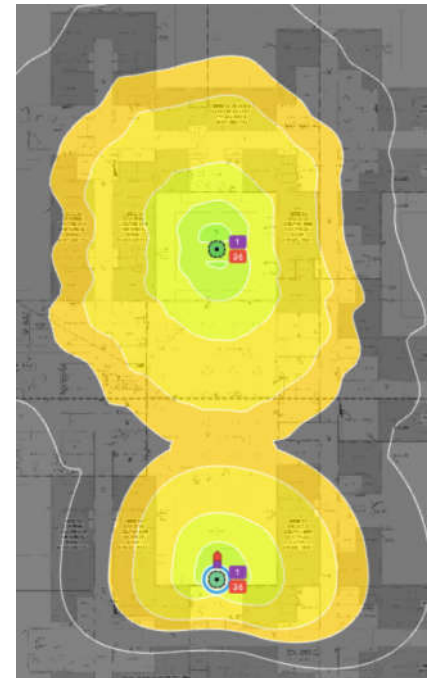
Predictive Design - 3/4

- Always design using 5GHz. 5GHz has a wavelength of approx. <6cm, compared to 2.4GHz approx. <12.5cm. Shorter wavelengths don't travel as far as longer wavelengths . 5GHz typically will travel ½ the distance of 2.4GHz in free space when operating at the same TXP. This results in 5GHz being inherently less prone to interference.

Attenuation Values for Concrete @50mm thick

— 5GHZ — 2.4GHZ
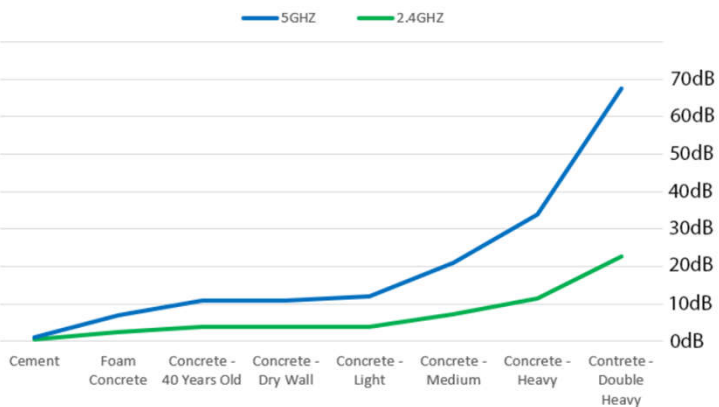
Attenuate Values for Different Glass Types

— 2.4GHZ — 5GHZ
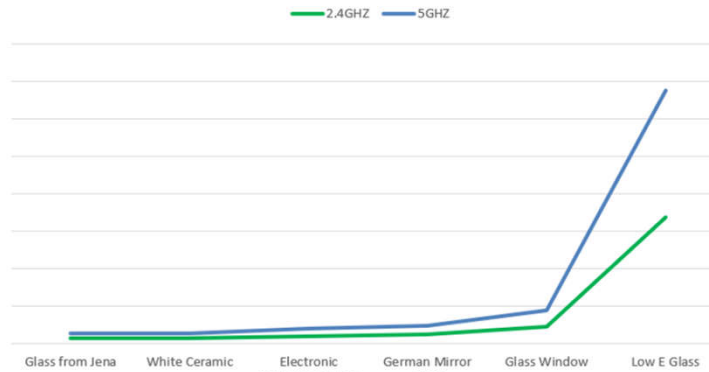
MATERIAL	LOSS IN DECIBELS AT 5 GHZ
Concrete (203 mm)	55,1581
Reinforced concrete	53,7989
Brick-faced concrete	39,8953
Brick-faced masonry block	32,6320
Concrete (102 mm)	26,0008
Brick	15,2806
Masonry block	14,9250
Timber	3,2778
Glass	0,0688
Drywall	~ 0
Plywood	~ 0

These figures are taken from the report "Electromagnetic Signal Attenuation in Construction Materials", NIST Construction Automation Program Report No. 3 from the National Institute of Standards and Technology.

Predictive Design - 4/4

- How much is enough coverage? This depends on use case. A recommended minimum RSSI is best for these use cases

- -75dB for Basic Data rates

- -70dB for High Data rates

- -67dB for Voice (some vendors recommend -65dB)

- -62dB for Location Services

- Plan to meet the capacity requirements. This is key to a great user experience.
  - Planning for high-density environments, such as Airports, Convention Centres and Stadiums. Require more APs radios to handle the concurrent transmissions. Lower radio TXP and or direction antennas should be used to reduce CCC.

802.11ac - VHT   MCS, SNR and RSSI

VHT MCS	Modulation	Coding	20MHz Data Rate 800ns	20MHz Data Rate 400ns	20MHz Min. SNR	20MHz RSSI	40MHz Data Rate 800ns	40MHz Data Rate 400ns	40MHz Min. SNR	40MHz RSSI	80MHz Data Rate 800ns	80MHz Data Rate 400ns	80MHz Min. SNR	80MHz RSSI	160MHz Data Rate 800ns	160MHz Data Rate 400ns	160MHz Min. SNR	160MHz RSSI
									1 Spatial Stream									
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	QPSK	1/2	13	14.4	5	-79	27	30	8	-76	58.5	65	11	-73	117	130	14	-70
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	16-QAM	1/2	26	28.9	11	-74	54	60	14	-71	117	130	17	-68	234	260	20	-65
4	16-QAM	3/4	39	43.3	15	-70	81	90	18	-67	175.5	195	21	-64	351	390	24	-61
5	64-QAM	2/3	52	57.8	18	-66	108	120	21	-63	234	260	24	-60	468	520	27	-57
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	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									
0	BPSK	1/2	13	14.4	2	-82	27	30	5	-79	58.5	65	8	-76	117	130	11	-73
1	QPSK	1/2	26	28.9	5	-79	54	60	8	-76	117	130	11	-73	234	260	14	-70
2	QPSK	3/4	39	43.3	9	-77	81	90	12	-74	175.5	195	15	-71	351	390	18	-68
3	16-QAM	1/2	52	57.8	11	-74	108	120	14	-71	234	260	17	-68	468	520	20	-65
4	16-QAM	3/4	78	86.7	15	-70	162	180	18	-67	351	390	21	-64	702	780	24	-61
5	64-QAM	2/3	104	115.6	18	-66	216	240	21	-63	468	520	24	-60	936	1040	27	-57
6	64-QAM	3/4	117	130.3	20	-65	243	270	23	-62	526.5	585	26	-59	1053	1170	29	-56
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
									3 Spatial Streams									
0	BPSK	1/2	19.5	21.7	2	-82	40.5	45	5	-79	87.8	97.5	8	-76	175.5	195	11	-73
1	QPSK	1/2	39	43.3	5	-79	81	90	8	-76	175.5	195	11	-73	351	390	14	-70
2	QPSK	3/4	58.5	65	9	-77	121.5	135	12	-74	263.3	292.5	15	-71	526.5	585	18	-68
3	16-QAM	1/2	78	86.7	11	-74	162	180	14	-71	351	390	17	-68	702	780	20	-65
4	16-QAM	3/4	117	130	15	-70	243	270	18	-67	526.5	585	21	-64	1053	1170	24	-61
5	64-QAM	2/3	156	173.3	18	-66	324	360	21	-63	702	780	24	-60	1579.5	1755	27	-57
6	64-QAM	3/4	175.5	195	20	-65	364.5	405	23	-62			26	-59	1579.5	1755	29	-56
7	64-QAM	5/6	195	216.7	25	-64	405	450	28	-61	877.5	975	31	-58	1755	1950	34	-55
8	256-QAM	3/4	234	260	29	-59	486	540	32	-56	1053	1170	35	-53	2106	2340	38	-50
9	256-QAM	5/6	260	288.9	31	-57	540	600	34	-54	1170	1300	37	-51			40	-48

Source: https://www.wlanpros.com/mcs-index-charts/

What about Antennas? 1/2

- Currently there are no antennas on the Mid Q4 Price List ☹☹☹

- A new antenna portfolio from Ventev to be released in Q1 ☺☺☺

- The new portfolio should meet all but niche use cases

- Always connect antennas to AP's before powering them on. Radio energy that cannot be transferred into an antenna is reflected back on the transmission line. This can damage radios. Referred to as SWR. AP's radio do have filters to prevent damage but it's best practise not to rely on these

- Fortinet AP's come with two antenna connector types. RP-SMA and N-Type (N-Style)
  - RP-SMA is used on indoor APs (RP-SMA is very common for Wi-Fi use across many vendors bar Cisco)
  - N-Type is used on outdoor APs
  - For FortiAP the RPSMA/N-Type connector is always female on the AP, the antenna side is always male.
  - Fortinet doesn't supply ULL antenna cables i.e. LMR400. These should be purchased locally to meet specific use case requirements
  - Please note FEX uses SMA not RP-SMA. You cannot use Wi-Fi antennas on a FEX

What about Antennas? 2/2

- Only use antennas designed for the relevant radio band. Do not attach a 2.4GHz antenna to a 5GHz radio.
  - Current FortiAPs using external antennas, 5GHz antennas included are marked with a yellow band and/or 5GHz stamp.

- Most antennas are resonant devices, converting an electric signal into electromagnetic waves, They operate efficiently over a relatively narrow frequency band. An antenna must be tuned (matched) to the same frequency band as the radio system to which it is connected, otherwise reception and/or transmission will be impaired. Typically an antenna element is the half, quarter length as the wavelength for the band is it operating on.
  - Wavelength is determined using this formula ($\lambda = c/f$) Wavelength in m (λ) = Speed of Light in a Vacuum @ m/s (v) divided by Frequency (f) i.e. .125m = 299,792,458m/s / 2,400,000,000Hz.

Design Review

- Always Review Your Design, double check
  - Scale
  - AP model
  - Orientation of AP/antennas
  - EIRP

- If something doesn't seem right in the predictive design. Validate with a peer. Don't just assume it'll be ok.
  - We've had ongoing issues with AP antenna plots in most Wi-Fi design tools. This should be resolved in the next Ekahau release.
  - Implement a PoC to confirm the solution will work as designed.

- It's perfectly acceptable to have a colleague with Wi-Fi knowledge i.e. Wi-Fi SME/CSE review your WLAN design. Especially if you are just starting out. We are human, mistakes can be made.

Design Use Case - Warehouse 1/2

- Connectivity for barcode scanners, forklifts, tablets, robotics, etc.
  - Determine the LCMI. Typically a $4K hand-scanner with an 802.11b/g Wi-Fi adaptor.

- High levels of user roaming.
  - Confirm devices supports enterprise roaming standards 802.11k/v/r
  - If no fast roaming other features such as OKC can be used to assist
  - Roaming will take longer using enterprise auth methods i.e. WPA2-enterprise. If devices don't support 802.11k/v/r it may be required to avoid these auth methods in order for hand-off to be fast enough.

- Typically basic data rates are suitable
  - 20MHz channels should be sufficient for bandwidth needs.
  - -75dBm RSSI validated using LCMI device for coverage. (Don't validate -75dB with an Ekahau Sidekick, due to device RSSI offset)

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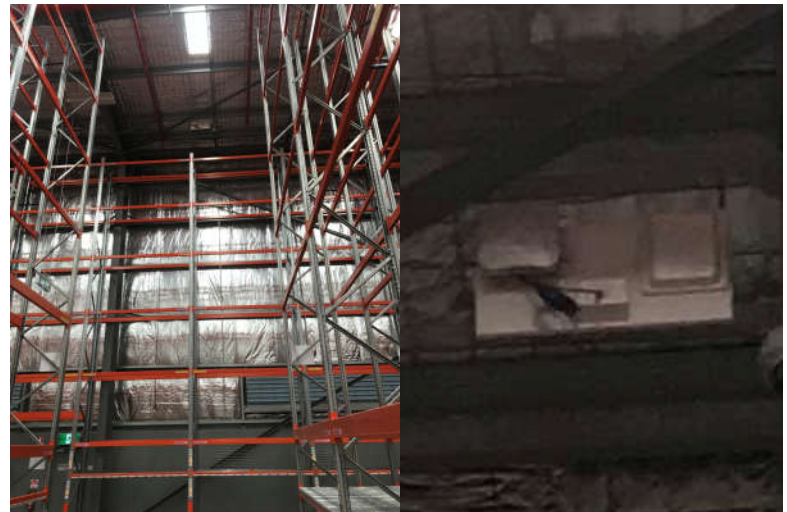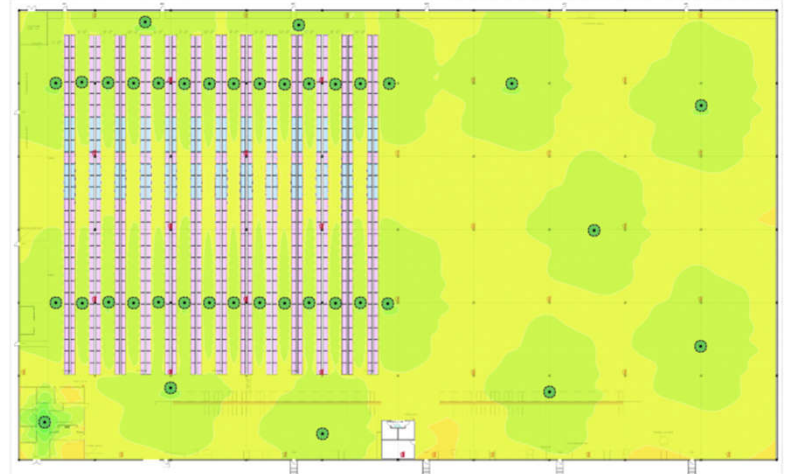
Design Use Case - Warehouse 2/2

- High ceilings - It is not recommended to use APs with internal antennas in this environment. For the best user experience Wi-Fi radio energy needs to be focused where it is needed. Why?

    - Users are not located near the ceiling so don't provide the RF coverage here.

    - Unnecessary CCI/CCC will occur between Wi-Fi radios if RF is not managed using directional antennas.

- The best design is to implement Wi-Fi much like the lighting is. Notice typical Warehouse lighting has the energy focused towards the ground where it is needed.

    - (Light is another form of RF.) Yet is an even shorter wavelength so won't penetrate solid objects. Because of this we shouldn't need as many AP's antennas as lights. But the concept is similar.

- Typically dense separation between aisles

    - Metal racking and objects in racking means radios per aisle are mandatory for coverage

Design Use Case - Office Space 1/2

- Connectivity for Laptops and Mobile Devices

- Low levels of roaming, typically users will be working stationary from desks, offices and meeting rooms.
  - No real requirement for enterprise roaming standards 802.11k/v/r. Many devices such as MacBook Pro's don't support it. https://support.apple.com/en-us/HT206207
  - Meeting room may have devices that interfere with Wi-Fi i.e. Click Share/Apple TV/Google ChromeCast. Plan to put AP's on different channels to these devices.

- Support for streaming voice/video and downloading/uploading data.
  - Channel bonding recommended if possible. Implement 40MHz wide channels on 5GHz. If the environment is noisy 20MHz channels may be required to provide good SNR.
  - Anything that can be wired should be. Printers for example can be wireless, but RAW data files are large transmitting them will consume considerable airtime
  - Users that need to transfer large amount of data should be wired. i.e. Developer backing up large project files i.e. 50GBs during the day.

Design Use Case - Office Space 2/2

- Standard height ceilings
    - APs with internal antennas are recommended, unless they are to be mounted above the ceiling for aesthetics reasons. Then ideally an AP meeting or using a flush mount antenna should be used.

- Typically wood/drywall/glass used for internal walls.
    - AP shouldn't required in every room. Wi-Fi should easily pass from common open-plan areas into surrounding offices.
    - Large meeting rooms should be provided with a dedicated AP in order to meet user density requirements

- Question: The CEO working in from the offices you've just deployed a new Fortinet Wi-Fi solution in, has complained that the Wi-Fi is rubbish and doesn't work. You've confirmed good coverage in all work spaces. What could be the problem?

Post Deployment/Validation Survey

- Validate the implemented security methods. WEP/TKIP are legacy security methods come with a penalty of only being able to achieve max data rate of 54Mbps

- Confirm AP's have been installed as per the predictive design locations. Incorrect placement can impact the APs performance.

- Confirm channel plan is correct.

  - Channel 1, 6 and 11 ONLY for 2.4GHz. And no 1,5,9,13 shouldn't be considered.

  - 5GHz channels not overlapping, i.e. OBSS issues.

  - If using DFS channels, confirm they are stable. DFS events can cause Wi-Fi radios to stop operating/fallback to a non-DFS channel. This will interrupt connectivity, resulting in poor user experience. In some areas DFS channel may be impacted i.e. near Airports, Shipping lanes, Weather Stations etc. Don't just assume DFS won't work because of these factors. It's worth trying to use the DFS part of the spectrum as more channels can result in a better user experience.
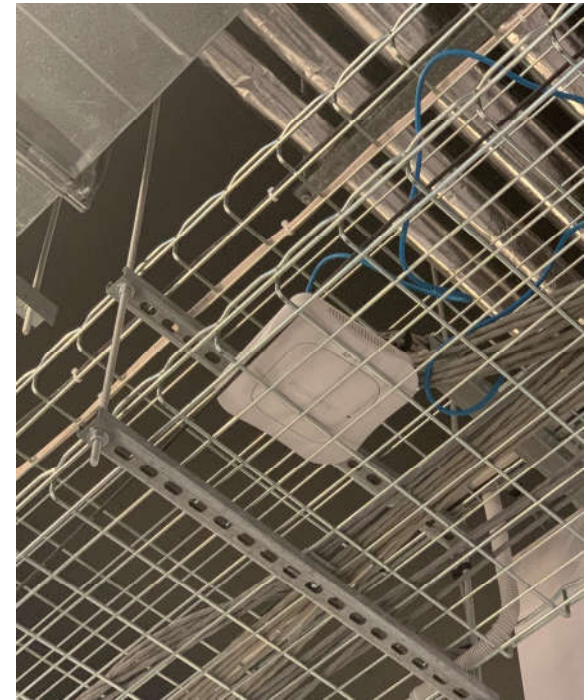
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Final Adjustments - Fine Tuning

- There are many features that can be used to tune a Fortinet wireless network. Such as those listed below. These can be used to improve performance, but may also cause significant performance issues if used incorrectly. Don't change the default settings unless you understand the impact.

- DARRP (if using set a schedule)
- RXSOP
- Short Guard Interval
- Radio Band Adjustments b/g/n verses g/n
- Airtime Fairness
- Max-Clients

- Channel-Width
- Beacon-Interval
- Call-Admission-Control (CAC)
- MU-MIMO
- Protected Management Frames (PMF)
- OKC
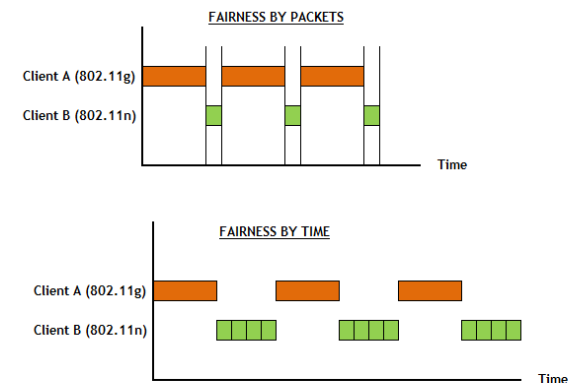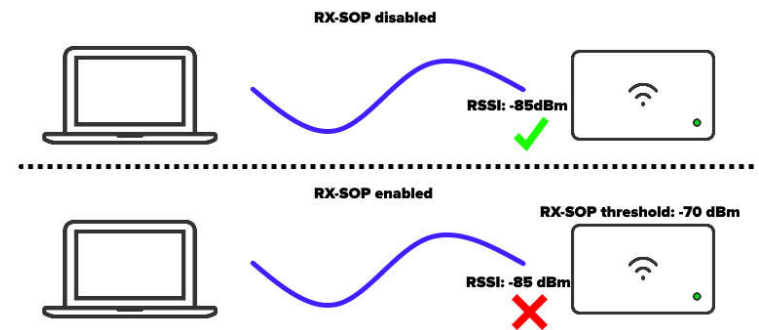
Ongoing Maintenance and Management

- Required to maintain a great user experience

- Over time, the customers environment can and will change
  - More users can be introduced (congestion, contention, capacity)
  - Business may expand requiring more floor space or use case may change. (more coverage/directional antennas)
  - Neighbours may cause changes to interference levels (ACI, CCI/CCC, non-WiFi interference)
  - Settings may be changed by inexperienced I.T. admins. Backup the original configuration.
  - Dedicated sensor radios on tri-radio APs can help monitor/detect issues.

- Product support recommended
  - Bug Fixes
  - Improved TAC Access - Fortinet Software Support
  - Escalation of Issues
  - New Feature Requests (within reason)
  - Local RMA (don't have to ship to Taiwan)

Demo - Using Ekahau Tips 1/3

- Draw in all walls, doors, windows etc. using the same 'Wall' type. Then go back and modify the various objects. This prevents gaps in wall will speed up the design process.

- Zoom into the floor plan when drawing walls, placing APs, etc. this helps ensure that they are accurately placed.

- You can move around the floor plan whilst zoomed in by holding down the spacebar. This if significantly more efficient than zooming in/out and using the scroll bars to move around.

- When doing active/passive surveys. It's key to understand device offsets. A device offset is key to accuracy. For example an Ekahau Sidekick can hear much better than a standard Wi-Fi NIC. The recommended offset to use on for an Ekahau Sidekick is 10dB. By holding down Control (Ctrl) and selecting the RSSI Legend, this will show an advanced menu where device offset can be configured.

Demo - Using Ekahau Tips - 2/3

- Key requirements for an accurate design:
  - Set the AP height
  - Set the AP radio power
  - Set the AP/antenna orientation
  - Set the AP channels. You can start by using the automatic channel planner and then tweak it manually.
  - Auto planner for AP placement, it can only be used if you draw in the coverage areas and be very detailed. Otherwise AP's will end up inside walls, elevator shafts or bathrooms. Ideally this should be avoided. As it has no idea what objects are on the ceiling/walls where you need to place you APs.

- When generating a report, the only reports that matter are, coverage, AP placement, including channel and power assignment. Reports showing information such as data rate and throughput are ambiguous and is basically junk information.

Demo - Using Ekahau Tips - 3/3

- The report will sometimes not be able to show the AP placement in enough detail. It's best to export a separate image of this so the installer can see exactly where APs should be placed. In Ekahau this is under the menu Reporting > Export Image
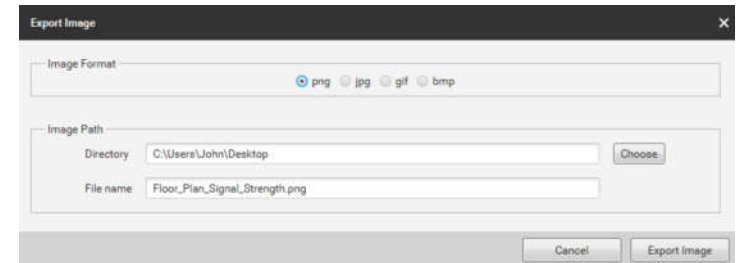
- Please use these reporting templates which will generate a reports for:
    - Voice (-67dB RSSI) - https://fortinet.egnyte.com/dl/v1phGELaEy

    Set Ekahau to Colour legend cut off to -67dB, grey legend cut off to -75dB

    - High Speed Data (-70dB RSSI) - https://fortinet.egnyte.com/dl/swMB93f3l8

    Set Ekahau to Colour legend cut off to -70dB, grey legend cut off to - 75dB

    Adjust the template description as required. E.g. If no secondary coverage in plan. The wording around this can be removed from the template.

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Demo - Using FortiPlanner 1/2

- Externally Available via Fortinet Developer Network Subscription (FNDN).
  - Once full access license is provided per FNDN Deploy Toolkit subscription (FC-10-FNDN1-652-02-DD) or Site Toolkit subscription (FC-10-FNDN2-139-02-DD).
  - Internally available to download from Infosite. You can ITF a full license, under Internal Usage (II) SKU to use is FAP-FPL-PRO
- Similar to other Wi-Fi planning tools. Same FSPL calculation are used.
- Key usage tips:
  - In APAC remember to change the units of measurement from Imperial to Metric.
  - Turn off Snap to Grid before attempting to set the scale or draw in walls.
  - Best for smaller designs due to current product limitations with floor plan image quality reduction.
- Can only be used to design WiFi networks with FortiAPs
- Can be used to survey, capture coverage heatmap of any Wi-Fi network. You must select the network SSID you are surveying in order to see a signal heat map,

Using FortiPlanner - User Experience Improvements

- Snap to grid always enabled by default - 0677422
- Antenna radiation patterns are incorrect for many current model APs. 0677482
- Importing floor plans/especially larger ones, results in resolution lost during import making it hard to determine different wall material types. - 0677464
- When drawing in the walls you cannot see the wall boundaries. Each piece just joins together looking like one piece of wall. In other planning tools the wall colour is outlined so you can see each piece as drawn. 0677438
- Unable to select multiple pieces of wall and change the wall material type - 0677466
- Requirement to confirm deletion of items should be removed i.e. deleting walls - 0677409
- Allow delete key to be used to delete an item i.e. deleting a wall - 0677409 - Workaround is to use the multi-select tool.

- License file is *.lic not *.license - 0677411
- Show cursor option causes FortiPlanner to no longer display floor plan. 0677475
- Moving around floorplan is cumbersome - 0677484
- If you have any improvement suggestions please provide feedback to the Wi-Fi CSE team cse_wireless_intl@fortinet.com

User Experience Tips

- 2.4GHz devices should be considered best effort. Don't just switch off 2.4GHz, utilise it to service devices that only support this band.

- Where voice/roaming is needed on a Wi-Fi network (non-VCell) ensure devices support 802.11 k/v/r. Typically only higher end devices support these standards. Just because something has 'Pro' in it's name i.e. Samsung Galaxy J5 Pro, doesn't make it enterprise grade. This device for example is capable of 2.4GHz only doesn't support 802.11k/v/r.

- If a device can be wired, cable it in. Some devices, such as Apple TV's will can cause congestion on the RF medium and will often attempt to create a private network on 80MHz wide channel between itself and devices, for streaming purposes. It's best to wire these devices in and switch off the WiFi adaptor.

- If a device has a business critical purpose, ideally use 5GHz channels.

- Even if you make design mistakes, Wi-Fi is extremely resilient and will still work in most cases. There are of course niche use cases which go against best practises. However a majority of the time following the recommendations provided in this deck will assist with providing an optimal user experience.

Continued Learning

- Wi-Fi is always evolving. We expect to see Wi-Fi expand into the 6GHz spectrum. Adding additional bandwidth. This will be covered by our G series APs.

- Do you know what 802.11be is? Hint Wi-Fi7

- It's always recommended to attend industry update/training events, such as Ekahau's Wi-Fi Design Day, Mobility Field Day and where possible.

- Certifications such as the ECSE (Ekahau Certified Survey Engineer) Design course are highly recommended.

- Subscribe to relevant YouTube channels i.e. Wireless LAN Professionals

- Listen to relevant Podcasts i.e. Clear to Send

- Last but not least. Read the Monthly Wireless and IAM Newsletter!

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Glossary of Wi-Fi Terms

- BLE - Bluetooth Low Energy
- Co-Channel Contention
- Co-Channel Interference
- EIRP - Effective Isotropic Radiated Power
- FSPL - Free Space Path Loss
- GIGA - Garbage In Garbage Out
- IR - Intentional Radiator
- OBSS - Overlapping Basic Service Set
- PPE -Personal Protective Equipment
- RPSMA - Reverse Polarity Sub Miniature Version A
- RSSI - Received Signal Strength Indicator
- RX - Receive

- SD - System Director (FWC OS)
- SMA - Sub Miniature Version A
- SNR - Signal to Noise Ratio
- SWR - Standing Wave Ratio
- (B)SSID - (Basic) Service Set Identifier
- TX - Transmit
- TXP - Transmit Power
- ULL - Ultra Low Loss
- VAP - Virtual Access Point (SSID)
- VSWR - Voltage Standing Wave Ratio

Still think Wi-Fi Design is easy?