Best Practice Guide
v2 .1

Ruckus SPoT™ Best Practices

SOLUTION OVERVIEW AND BEST PRACTICES FOR DEPLOYMENT

Executive Summary

Factors affecting location accuracy:

Wi-Fi Client behavior	
Is client connected to Wi-Fi?	Much better! More RSSI samples for location engine to eliminate errors. But sometimes, the client can change transmit power frequently, throwing accuracy off at those times. Location engines cannot plan or account for such variations. Clients not connected to Wi-Fi, only probe once in a while (average once per minute, varies by manufacturer and model). That implies less data sample for location engine to work with.
AP Deployment/Design	
Designing Wi-Fi with location accuracy in mind?	In many situations, location requirement is an afterthought. It is an add-on to an age-old AP deployment that was deployed with the objective of providing good Wi-Fi coverage. Customer does not plan to add APs or change AP placements as those costs are budgeted for. Months go by, from location demo to actual deployment and then, customer is unhappy that location accuracy SLA is not being met. Everyone forgets that location accuracy has a lot to do with the design in place, and understanding the variations and unpredictability that exists. How to resolve this? Setting the right expectation with the customer is the best starting point. The main objective, or the end goal, of the location requirement is a key component that needs to be understood. Reading this document will help all parties involved (from sales to channel to customer).
3-channel setup in 2.4 and 5GHz radios?	3 or more APs must see the same client for location calculation. The more channels are enabled in the venue, the less the likelihood that a Wi-Fi device can be seen by 3 APs.
Distance between APs?	3 or more APs must see the same client for location calculation. The ideal distance varies for venue types. Open spaces, vs, narrow pathways with thick walls all will require intelligent AP placements for better accuracy results.
AP install height	Ideal in normal situations to be installed 12-15ft from ground. Slightly more distance is OK for APs with narrow-beam antenna. AP should not

	be placed too low on the walls - that would cause the signal from client to AP to get impacted with increase of people traffic in-between. These would cause inaccurate RSSI reading to location engine and run-time location results would degrade.
Dynamic Variations	
	Object and material effect: Large water bodies, big metal structures or concrete walls all create RF challenges (absorption, reflection…). Some of these can be captured during fingerprinting of the venue, but redesign and structural changes to the venue can introduce inaccuracies to the location solution. People effect: An empty hall has a different RF propagation than a full hall. Human bodies (which is 60% water) absorb RF and depending on how many such bodies are between the device and the APs, the dynamic variation of the signal strength can throw the location accuracy further.
Building types	
Stadium	Boy - this is one challenging place for indoor locationing. The Wi-Fi is designed for density, with minimal overlap to avoid interference. Client cannot be seen by 3 or more APs. Big issue for location accuracy. To get anywhere close to expected accuracy, it would be important to add APs with a listen-only configuration. Mesh can be enabled for backhaul to help with lower cabling costs. Second issue with stadiums is that while the bowl/seating area is covered well with Wi-Fi, many of the other sections of the stadium (like back offices, food stands etc.) are not adequately deployed with APs. We generally recommend SPoT Presence for Stadium deployments since good location accuracy is difficult to achieve. With SPoT Presence, we are still able to provide zonal location of devices and the location analytics as well. All of the above are only focusing on Wi-Fi based locationing. If there is a mobile app designed for the venue that can be effectively pushed to the customers, then one can utilize BLE, phone's internal sensors etc to compensate and compliment Wi-Fi locationing for a great personal

	location-enabled experience. More on this in the summary section below.
Malls	Unless designed from the ground-up for location accuracy, the APs are typically placed far apart for providing basic Wi-Fi coverage only. Unless more APs are installed with careful positioning, accuracy will be poor and unpredictable. Malls also have challenging sections such as atriums, high-ceiling areas and isolated corridors where additional AP placement can be tricky and expensive. Fingerprinting of the entire venue might be a good option in such cases to get better location accuracy.
Outdoors	Outdoor deployments are in majority cases designed around coverage, and placed far apart, as APs themselves are expensive and so is the installation, cabling, permits etc. It is perhaps not practical to expect the same client to be seen by 3 or more APs. SPoT fingerprinting can be employed at certain points to get an idea of the current coverage, but SPoT Presence would be a better algorithm to be chosen at that point and only zonal accuracy should be expected (closed AP location).

Summary

Set your expectations. Consider factors above.

- 1-3meter accuracy is not practical. Too many dependencies and almost impossible for all of those factors to be right at all times.
- Rarely any deployment starts with location expectation in mind. Even then, 5-10m accuracy throughout the entire venue, and at all times, is unrealistic.
- Determine why you want that type of accuracy? Do you have alternative option that is cost effective and meets your targets? Wi-Fi based locationing is great for analytics, and all analytics have certain degree of error built into them. Wi-Fi analytics can get you visibility into 50% or more of your total visitors. Engagement with a customer is best delivered with a personal touch, on their mobile devices, with the installation of a mobile app. Mobile app penetration is < 10% currently. Mobile app with BLE, Wi-Fi location API, and utilization of the phone's internal sensors can deliver a highly accurate personal experience for those customers that download and use your application.

Overview

Since the mobile device industry is alive and well, every corner of the ever-opportunistic tech industry has a technology to offer. Most end-users, enterprises, network operators, and venue owners see value to gain from a marriage between mobile devices/users and Wi-Fi location technologies.

The exact uses vary from one organization to another and deployment best practices follow the intended use. In this document, we will discuss general guidelines for network design that meet the requirements and fulfill the purpose of the location solution.

Two key use cases for Wi-Fi based location solutions revolve around analytics, and engagement. Analytics refers to client location data over time collected for the purpose of the venue owner to make informed decisions about the users of the venue. Engagement deals more with interaction with the Wi-Fi client user. It is important to set the right expectations with respect to each of those two use cases, with regard to Wi-Fi based locationing.

Quick Solution Overview

There are a number of techniques for positioning using radio frequency (RF) waveforms, such as time-of-arrival (TOA), time-difference-of-arrival (TDOA), and path loss determination. TOA and TDOA are often used in proprietary wireless positioning systems with dedicated hardware, such as GPS, to provide accurate location.

Due to the ubiquity of Wi-Fi in mobile devices, it's ideal to tap Wi-Fi signals for indoor positioning without any additional dedicated hardware. Since Wi-Fi in general does not provide TOA or TDOA information today, the path loss determination method takes priority. This method is based on the fundamental physical phenomenon of signal path loss: the amplitude of an RF waveform decreases as distance increases, according to the environmental path loss model.

In other words, if the transmit power is known and the RF power is measured at the receiver, the difference between the transmitted and received power corresponds to end-to-end channel attenuation. Presuming that the path loss model of an environment is known and then applied to the measured channel attenuation, the distance between transmitter and receiver can be easily calculated. If three Wi-Fi access points can receive a device's transmissions and apply channel attenuation measurements to received data, simple trilateration techniques can be used to position the transmitting device, as shown in Figure 1.

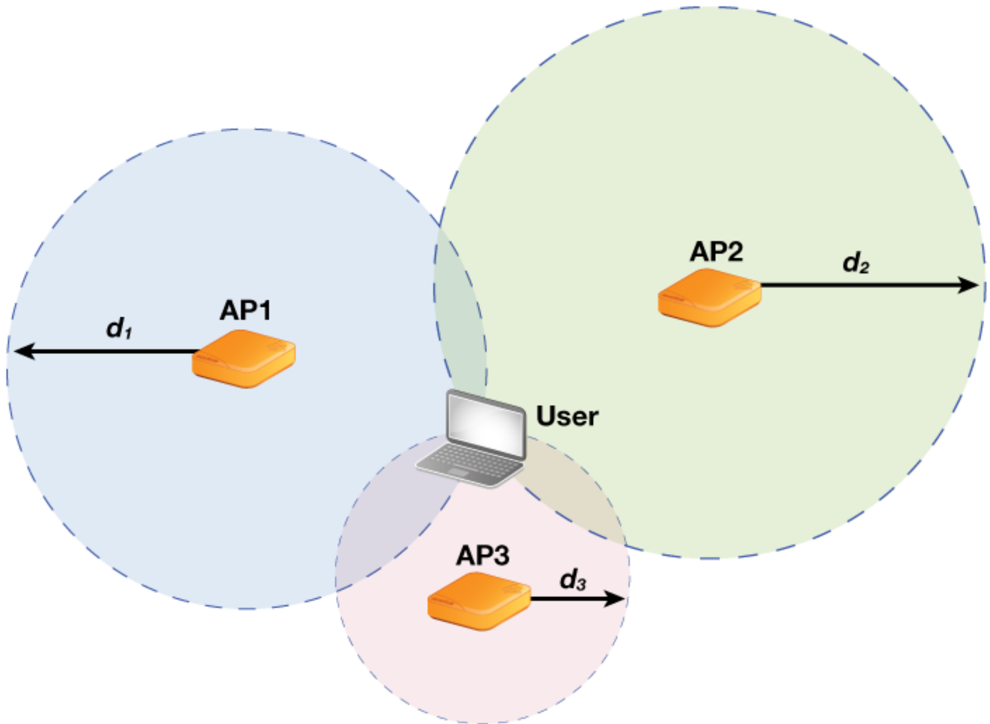


Figure 1. Positioning a device/user by means of trilateration.

In real-world environments, the path loss model cannot be accurately estimated since it depends heavily on non-constant variables—the structure of the building, placement of furniture and interior obstacles, human traffic conditions, and more. To overcome this problem, an RF fingerprint of the whole environment is performed.

As shown in Figure 2, the environment is divided roughly into grids, where the distance between each neighboring anchor point is defined (3m used as an example in Figure 2). Note that a formal "grid" is not necessary; irregular calibration anchor patterns still work equally well. A calibration transmitter (i.e. mobile device) is then successively placed at each anchor point where it will transmit signals. The surrounding access points will measure the received signal strength (RSS) and tag this vector of RSS to the anchor point on the map. The AP's measurements are saved, being used to build a database. After capturing data at all anchor points, the completed database will form the radio map of the environment. Thus the radio map gives us a one-to-one mapping of received power from access points (identified by their MAC addresses) and the actual position within the environment.

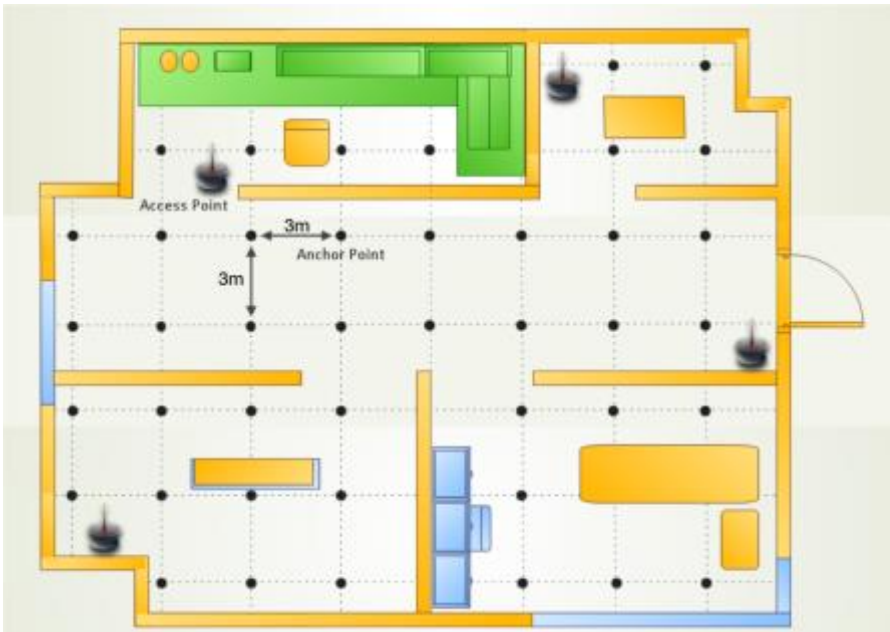


Figure 2. Indoor positioning based on RF fingerprinting.

In actual deployments, the location engine utilizes the radio map as a positioning reference to locate devices on a map. By selecting the position of the closest RSS vector on the map via pattern matching algorithms, very close accuracy can be achieved.

Better Accuracy with RF Fingerprinting

Despite all desire, there are few absolutes in Wi-Fi network design. Best practices are merely that, best practices. Much like Wi-Fi design for connectivity, in Wi-Fi design for location, there is no catch-all statute that guarantees perfect functionality in every environment. Network owners and installers must apply sound RF engineering and environmentally-specific design principles to each installation, keeping business requirements in mind.

Given those caveats and forewarnings, much like proper Wi-Fi design, there are several best practices and general principles that we can offer as guidance for most environments.

Boiling it down to basics, design goals for location technologies like Ruckus' SPoT™ system (i.e. RF fingerprinting with pattern matching algorithms) should focus on a few key accuracy factors:

1. The calibrated data in the radio map should be as close as possible to actual RSS vectors from that same physical location
2. The calibrated data for other calibration points is as different as possible from the data for the true position
3. RSS should be as high as possible

1. Building an Accurate Data Map

Due to natural fluctuations in every RF environment, we have minimal control over some components of the first accuracy factor. Even slight changes in the RF environment (e.g. a person walking through a room) can change the physics of radio propagation from one moment to the next. The instantaneous RSS vector will always be different from the calibrated data in the radio map; but thankfully, system intelligence in the Ruckus SPoT™ algorithm reconciles this variability while maintaining reliable location estimates.

Calibration Best Practices

The component of radio map accuracy that we can control is to follow best practices for calibration.

First, since most businesses are interested in locating mobile devices, it is generally recommended to use a calibration device that possesses the same transmit characteristics as the devices being tracked, such as a mobile phone or tablet. This ensures that the radio map is as close as possible to real-world received signals in the operational phase of the deployment.

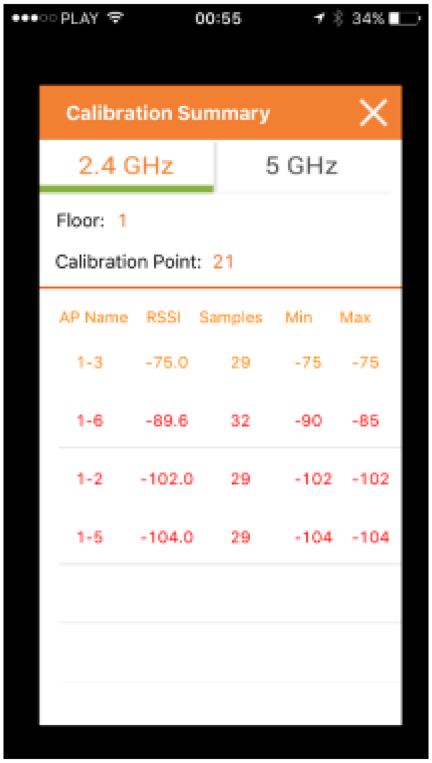
Despite that recommendation, location algorithms used with Ruckus SPoT™ will normalize signal strength variability by focusing on the *relative reference* of matched patterns. This adaptation enables SPoT™ to position devices with different transmit characteristics than the one used during calibration. Put more simply, a laptop may have transmit characteristics that are 3 dB higher power than a mobile phone, so its RSS vectors will differ from those on the radio map. However, that 3 dB difference is consistent for all reference points (i.e. each of the APs), and thus the algorithm can still perform pattern matching to accommodate this factor.

Second, the density of anchor points in the calibration map can also increase accuracy. In Figure 2, we used the example of 3m, but anchor point distance can be in the range of 3-5m for most indoor environments. For very large venues or areas where slightly lower accuracy is acceptable, 8m anchor points is a good recommendation.

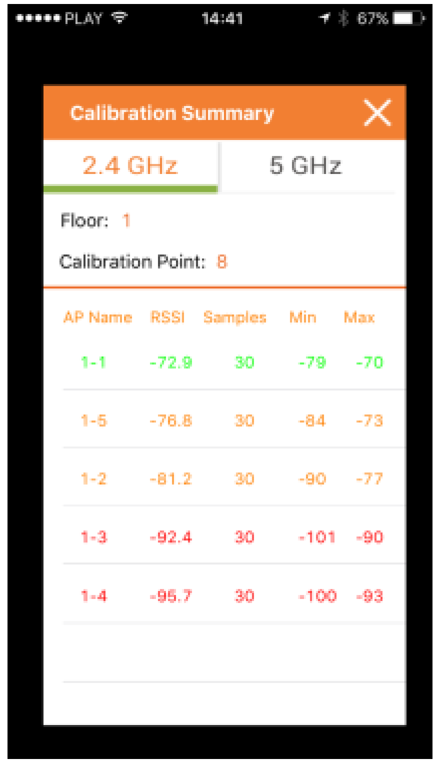
2. Differentiating Calibration Points

For the second accuracy factor, our goal is to ensure that each anchor point is as different as possible (in RSS characteristics) as other anchor points. Network designers have firsthand control, primarily via judicious AP placement. The aim is to place the APs such that the RSS vector at each calibration point is as dissimilar as possible. This radio map differentiation enables better estimation accuracy.

How to read the calibration result on the SPoT app



[not so good]

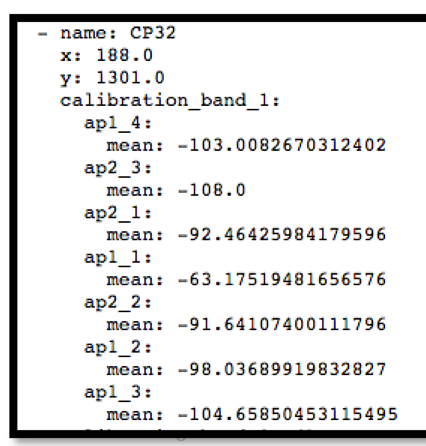


[OK]

Below is a screen capture of a just completed calibration on a calibration point. The reading here suggests on the 2.4GHz radio, only AP 1-3 has provided usable RSSI reading (-75) with 29 samples. The rest three APs (1-6, 1-2 and 1-5) have unusable RSSI readings, suggesting that area in the venue will have poor (>15-20m) location accuracy. You will want to have at least 3 or 4 APs reporting varying RSSI readings between -30 and -85, with good sample rate (>20 samples).

Calibration quick tips:

- Make sure you have created a single SSID for 2.4, and another for 5GHz only.
- Put all APs on the same channel, during calibration process only.
- After couple of measurements, check the result on the mobile app, as well as on the SPoT admin page under radiomaps->files->venue_calibration.yml (see below: calibration point 32 has 6 separates APs readings with AP1_1 as the only AP seeing the client with a good RSSI value (-63) and the rest APs are too far away from the calibrating client. The result will be poor.



AP Placement Best Practices

A summary of best practices for AP placement follows.

Avoid straight lines and hallways

Many legacy Wi-Fi installations prescribed AP mounting in hallways and corridors. This might be a result of lazy design or limited access permissions—such as in hospital rooms, dorms, or hotel rooms. Regardless of the reasons, long straight lines of APs will typically decrease location accuracy (and often Wi-Fi performance). Where possible, all efforts should be made to stagger APs and avoid mounting consecutive APs in hallways.

Large open spaces may need more APs

In Wi-Fi design for large open areas, we're accustomed to planning for capacity and coverage. We've traditionally recommended a pre-deployment "capacity analysis" to determine the number of users and committed bandwidth, and then deploy APs according to expected load. This is still recommended, but we must remember that in low capacity areas where a single AP may provide the requisite signal coverage and data throughput requirements, additional APs are required to supply a minimum of three received signals for accurate location estimates.

AP location estimations and heuristics from one or two APs are often highly inaccurate and lack real value because many points around the APs will have identical RSS vectors. The aim of increasing AP density is to have the RSS vector at each calibration point is as dissimilar as possible. This is particularly challenging in large open spaces.

In the event that AP density cannot be increased, SPoT Point without calibration may be a better option to SPoT Point with Calibration. SPoT Point without calibration has a lower error variance even though accuracy is not as high as SPoT Point with Calibration. This will decrease the "hopping" behavior seen in the positioning of Wi-Fi devices in this environment

High Ceilings

Such environments are a challenge for Wi-Fi and will certainly be a challenge for location accuracy as well. The high ceiling will reduce the RSSI quality for indoor positioning. In order to mitigate the effects of the high ceiling, either increase the AP density or mount the APs at a lower height.

For the purposes of location accuracy, a 4m ceiling height or AP mounting height has generally been acceptable. While it is not a hard limit, 4m is the recommendation.

Mount some APs near the edges

Akin to the prior point about AP density in open spaces, some environments may also benefit from additional APs near the edges of the coverage area. As a caution, it's not necessary to add a long line of APs everywhere along the perimeter. More commonly, existing deployments will have sparse coverage near the edges and corners of service, where only a single AP provides service. Supplemental APs will often be needed, based on signal characteristics, to provide accuracy in these areas.

Have APs where it is important to have good Location

Every venue will have areas where the ability to accurately position Wi-Fi devices is important. This could be entrances/exits including lift lobbies and escalators or cashier counters. Placing an AP in these areas will enable better location positioning as the RSS vectors will be stronger.

VoIP designs often work well

Many documents have been written to describe the requirements of "voice-grade" Wi-Fi. In general, the same design requirements (AP density, optimal AP placement, minimum primary and secondary coverage, transmit power, etc.) that make for a good VoWi-Fi network will also provide accurate location services.

Outdoor guidelines

Wi-Fi location technologies excel where GPS and other technologies are not accessible, but in outdoor environments, there may be a preference for alternate technologies. Outdoor Wi-Fi networks are often deployed in lower density with larger coverage areas than indoor Wi-Fi networks. For that reason, deploying outdoor areas with the AP density necessary for Wi-Fi location systems may not be ideal—due to insufficient AP density, budget, limited mounting assets, etc. However, as with any environment, the signal guidelines shown in **Table 1** can be used to determine whether an outdoor design meets accuracy requirements for the business objectives of a Wi-Fi LBS solution. As a generic guideline, two APs at -85 dBm can provide 15m accuracy, which may be sufficient for outdoor applications.

SPoT Point without Calibration, or SPoT Presence are recommended for such deployments, since very accurate location data is generally not needed in outdoor areas.

Sector Access Points

In planning for high density deployments, sectorized access points are typically used in order to improve Wi-FI performance. As signal is concentrated in a specific angle, the rest of the areas will not be serviced. It is safe to say that there will not be location data for angles outside of the sector APs.

In deployments where Location accuracy is poor and needs to be improved, adding sector APs may help to improve the RSS of the venue. The potential issue however is in the differentiating of RSS across the venue. Since sector AP have stronger transmit power the change of RSS over distance is minimal. The preference to improve accuracy is adding more APs rather than employing the use of Sector APs

A reality check

Of course, all design principles must be checked against the business case for a location solution. If lower accuracy is acceptable in certain areas, use discretion and plan accordingly. But whether the end-goal is analytics, customer engagement, navigation, or any other application, remember that accuracy is a critical foundation that is often tightly wed to the value of the location service itself.

3. Maximizing Accuracy with High RSS

For the final accuracy factor, the solution is quite simple. Due to the physical characteristics of RF path loss paired with the logarithmic techniques used to measure/define signal strength, accuracy is improved by increasing signal strength. We can increase RSS by placing the APs closer together. And as always, this design objective must be balanced with the connectivity requirements of client devices and wireless applications on the network. Unless LBS is the sole purpose of a network, we cannot design for LBS in a vacuum.

Ruckus SPoT™ functionality follows similar requirements as for VoIP. Table 1 provides accuracy resolution that can be expected according to AP density and signal requirements.

Table 1: Accuracy Guidelines for AP Density and Signal Strength

Minimum Number of APs	Mean RSSI	Average accuracy
4	-75 dBm	5m
3	-70 dBm	5m
3	-80 dBm	8m
2	-85 dBm	15m
1	-85 dBm	30m

Table 1 should serve as the primary reference for any Ruckus SPoT™ deployment. AP density is just one of many design considerations to keep in mind to get desired accuracy.

Validation surveys are recommended

If you have a favorite site survey or RF validation tool (e.g. AirMagnet Survey or Ekahau Site Survey), it is often a best practice to perform a site validation to ensure that all areas of the service area provide the minimum signal requirements for location-based services (LBS). These tools often provide visual confirmation of deployment objectives. This is critical for LBS.

Cloud and Connectivity

As a cloud service, the SPoT location engine has some minimum connectivity requirements to account for. Functionally, the cloud-based SPoT server interacts with the ZoneDirector for control exchanges and it also receives location data reports directly from APs.

WAN Requirements

First, it should be known that because it is a cloud service, SPoT requires WAN connectivity for the location engine to collect location data. The SPoT-to-ZoneDirector communication process is very lean and requires minimal control bandwidth only when changes are made.

APs should have direct access to the Internet and be able to resolve the FQDN of the SPoT engine via DNS. In the SPoT architecture, APs are continuously collecting and processing client RSSI data and passing that data to the SPoT engine across the WAN link. By default, this data is sent from the AP to the SPoT server every 6 seconds.

The WAN uplink speed required will vary for each deployment, but the following guidelines will help customers to provision links. For an individual client device, each AP report to the SPoT server is 27 bytes. Given best practices for AP density to achieve maximum accuracy, if we assume that 4 APs can hear any given client and each AP reports to a cloud server in 6 second intervals, a total of 108 bytes will be required every 6 seconds. Averaging this number, total bandwidth would be 18bps (108 / 6 = 18).

As client counts and AP densities increase, this number increases in tandem. Even with bursty client counts, medium-size sites (<50 APs) should perform sufficiently well with 300kbps of available uplink bandwidth. The simple scaling guidelines below should provide typical guidance. Of course, client counts will always vary for each site, so plan your site's requirements according to your site's client behavior.

Number of APs	Average Total Uplink Bandwidth
25	100-200 kbps
50	200-300 kbps
100	300-500 kbps

WAN latency has also been tested and validated with no adverse impact at up to 500ms. Individual sites should be tested if latency is known to consistently exceed 500ms.

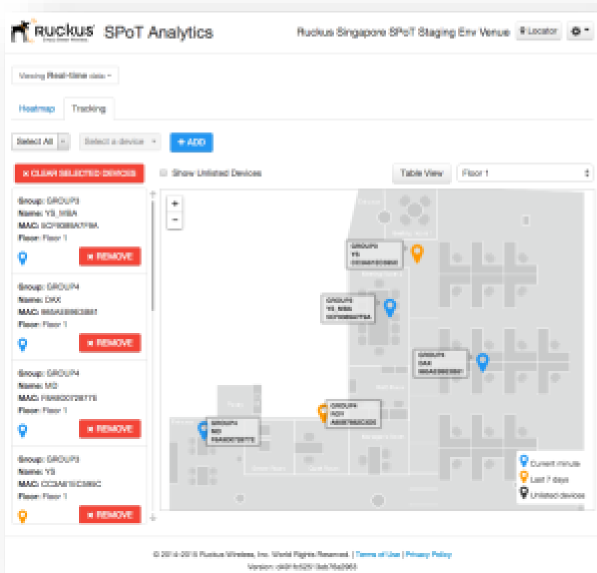
Firewall Requirements

By default, network firewalls monitoring WAN connectivity should permit traffic from the controller and APs (internal) to reach the SPoT server (external) via port 8883 as well as 1883.

Asset Tracking

Since late 2015, SPoT has offered a built-in asset tracking solution for high value Wi-Fi devices that the corporate IT would like to know the location of. This use case is not to meet the needs of a typical healthcare location requirement for roll-away patient beds, infusion pumps, who require high precision real-time location with 1m or room level accuracy without errors. Special exciters, and sometimes, proprietary wireless technologies are utilized as the stakes are high in terms of not meeting the location accuracy.

With SPoT's built-in asset tracking workflow, the aim is to help the IT view in real-time the location of their assets they have distributed to staff, employees, students. In the case of schools, they could be iPads or Chrome books. In case of retail, they could be the Wi-Fi scanners, or handheld payment devices or even iPads running payment software. In carpeted enterprises, they could be the IT supplied laptops or mobile devices. Just knowing where they were last seen in campus could give many clues to the IT in tracking the whereabouts of those devices. The cost of replacing misplaced or stolen devices is high enough that tracking them might be a business critical requirement.



Mobile Applications

If interacting and engaging with the customer is important, then it is important to have the backend smarts to realize each customer's unique interests and needs so the engagement is effective. This is where Ecosystem partners add value to Location data. Engagements are personal in nature and it starts with the customer having a compelling reason to download your mobile app to their phone. That real-estate on the phone is a very expensive, and so far, statistics show that only about 10% of the customer population for a venue or site actually downloads and actively uses the venue-specific mobile app. Bluetooth low energy based solution is useful only if the customer visiting your venue has downloaded the app and sees value in retaining your app. Deleting the app is very easy and all it takes is a couple of worthless engagements that are of no value to the customer.

Let us take an example of a football stadium. These are some of the unique venues where mobile apps can be quite useful. The customer spends a good amount of time in the facility, and can benefit from more timely information, such as closest restroom with least wait times, closest food stall with least lines, where are my friends and family etc. A well designed stadium specific mobile app can utilize the stadium Wi-Fi, the BLE, and all the other internal sensors (sensor fusion technologies) of the mobile phone to provide a highly accurate location estimate on the mobile phone. The mobile app itself needs to have many other features in there, such as food and drinks menu, loyalty login with tickets information etc, to be useful and location is just one of those many components. Stadium solutions engage with mobile app developers who continue to enhance the mobile app over time. There is no such thing as done, with a mobile app. Delivering v1.0 is the just beginning of the journey. Many stadium owners take ownership of the mobile app team and continue to develop features, revamp the design based on feedback etc. It is a continuously evolving solution.

Random Mac Addresses

In response to developments in Location Based Services and concerns regarding privacy, Apple introduced Random Mac Address in iOS8 to hide device's actual MAC from WiFi negotiations.

Since then, Random Mac Address has also been adopted by Android and Windows. While the mechanisms and triggers of the Random Mac Address differs from vendor to vendor, (for example, only in Windows 10 can Random Mac Addresses be enabled or disabled by the user) it can be safely assumed that whenever a WiFi device is probing for WiFI networks, it is probing with a Random Mac Address. In all cases though, if the WiFi device decides to associate with the WiFi service (guest SSID or employee SSID e.g.), then the device uses the actual MAC for the duration of the WiFi session.

A single WiFi device may send out multiple Random Mac Addresses while probing for WiFi networks. This further reduces the ability for WiFi based location technology to track the WiFi device across time due to a lack of a common identifier for a single WiFi device.

When observing the effects of the Random Mac Address on SPoT Analytics, we found that it skewed the numbers for *Unique Devices* detected, *New vs Repeat* count and *Dwell Time*. Therefore, to maintain the integrity of SPoT Analytics, SPoT does not include Random Mac Address for positioning or analytics. Thus, SPoT only uses the Globally Unique Mac Address of the device. Both the Globally Unique Mac Address and the Random Mac Address follows the Standards of IEEE 802. Hence they are easily differentiated and processed accordingly.

What is certain is that once a WiFi device Associates to the WiFi Network, it must use its Globally Unique Mac Address. This is because the Globally Unique Mac Address is critical to communications at the data link layer of a network segment. This will therefore allow SPoT to identify the device, position it and include it for Analytics. *To be clear, SPoT will still be able to track devices and provide footfall analytics even though WiFi devices probe with Random Mac Addresses, as long as the WiFi device associates to the venue's WiFi service.*

In 2016, SPoT was able to detect and position 50%-70% of WiFi devices in SPoT deployments. The percentages depend on factors such as reliance on WiFi in the country, the type of deployment (transport vs retail), smart phone penetration etc. Going forward, the number of WiFi devices that SPoT can detect and position move towards the percentage of associated WiFi devices. This is currently estimated to be 20%. Again, depending on factors specific to the deployment.

We understand concerns SPoT customers may have around the decrease in detected visitors. Even so, a sample size of 20% is a substantial percentage for understanding visitor behavior. And we strive to protect and maintain the integrity of SPoT analytics so that customers can trust in the analytics they see. As leaders in WiFi technology, we see that WiFi penetration continues to grow rapidly and we are certain that more and more users will use WiFi for connectivity.

Case study: One of Europe's largest Exhibition Halls

In many cases, SPoT is needed in an existing installation that was done a while ago most likely with the objective of wide spread Wi-Fi coverage for connectivity. Whether sectorized antenna based APs were utilized, or outdoor APs were used indoors, whether high ceiling narrow beam antenna APs were used, they all play a role when trying to morph that design to support SPoT.

Case study: one of Europe's largest exhibition halls

There are many halls of almost identical size. Each hall is about 120m x 120m. Original Wi-Fi design for coverage included 18 APs with 60° beam-width directional antennas. Mounting height for ceiling mounted APs were between 7m-9m and Wall Mounted AP at 3m. While the AP density was sufficient for Wi-FI coverage, there were multiple challenges for SPoT location accuracy.

1) The AP density fell short for SPoT requirements.
2) The wide open space in empty pavilion gave very little variation in signal strength and the path loss was less than free space due to possible standing wave phenomenon (aka canyon effect)
3) The employment of wall-mounted directional antennas further exacerbated the low variation in signal strength
4) Very aggressive channel allocation with every AP on a different channel

Here the Location accuracy using SPoT Point with calibration algorithm was 40m with a standard deviation of 25m. The customer desired 4m accuracy, which was another issue of setting the right expectations - as Wi-Fi based location technologies cannot actually guarantee a specific accuracy better than 5-10m in most cases.

Solution:

To add another 18APs for the specific purpose of SPoT and treated location as an overlay technology. In order not to interfere, all APs for SPoT were kept on a single channel and with SSID broadcast turned off (so clients couldn't connect to them – removing interference).

Summary

Check the below factors again:

- Are APs in 3-channel mode?
- Distance between APs within limits?
- APs installation height?
- Fresh design of AP placement with location in mind?
- Is the Wi-Fi client connected when you are measuring location accuracy?
- Most importantly, what are you trying to achieve with location solution from Wi-Fi? Is analytics important for you?
- Have you considered a SPoT eco-system solution partner that can consume the SPoT APIs and provide you with BI (business integration) solutions?
- Want to engage a user? Thought of a mobile app that can utilize sensor fusion technologies including BLE?

Do not expect 1-3m accuracy using Wi-Fi. It is simply not practical. 5-10m accuracy 80% of the time, is possible if all the recommendations have been strictly followed. But, in most situations, one or more of those conditions are not met either for budget, time or installation challenges, and accuracy as well as probability of accuracy drops quickly. It may still not matter much if you know what exactly you want to use the location solution for. If analytics is the requirement, then certain levels of errors are quite acceptable. Every other sensor based solution for getting location also has errors, or costs are significantly high for meeting location accuracy target. Wi-Fi analytics provides just one of the many data points the marketing and business teams take into consideration for making decisions.

Achieving great Location Accuracy via Wi-Fi is hard work and in many cases challenges traditional WiFi design. This is not to say that it is impossible to get great location accuracy as we have successfully achieved it in many deployments. What is critical is to understand what the customer wants and why they want it and to manage their expectations given the realities of site challenges and available resources.