



best practice guide

Ruckus SPoT™

Best Practices

**SOLUTION OVERVIEW AND BEST
PRACTICES FOR DEPLOYMENT**



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.

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 WiFi in mobile devices, it's ideal to tap WiFi signals for indoor positioning without any additional dedicated hardware. Since WiFi 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.

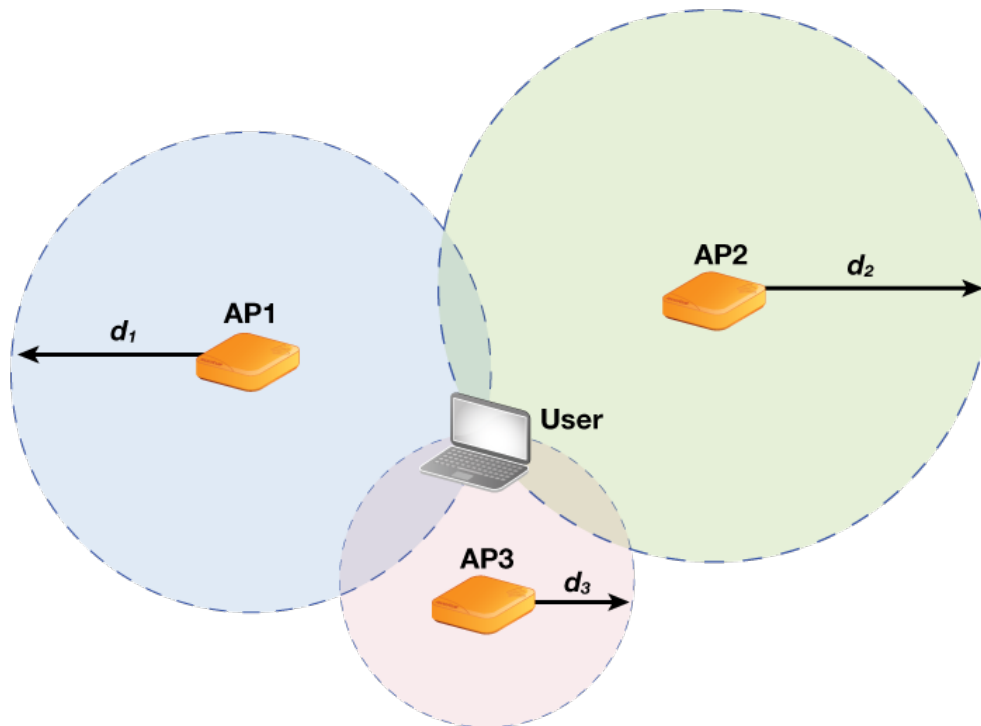


Figure 1. Positioning a device/user by means of trilateration.

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.

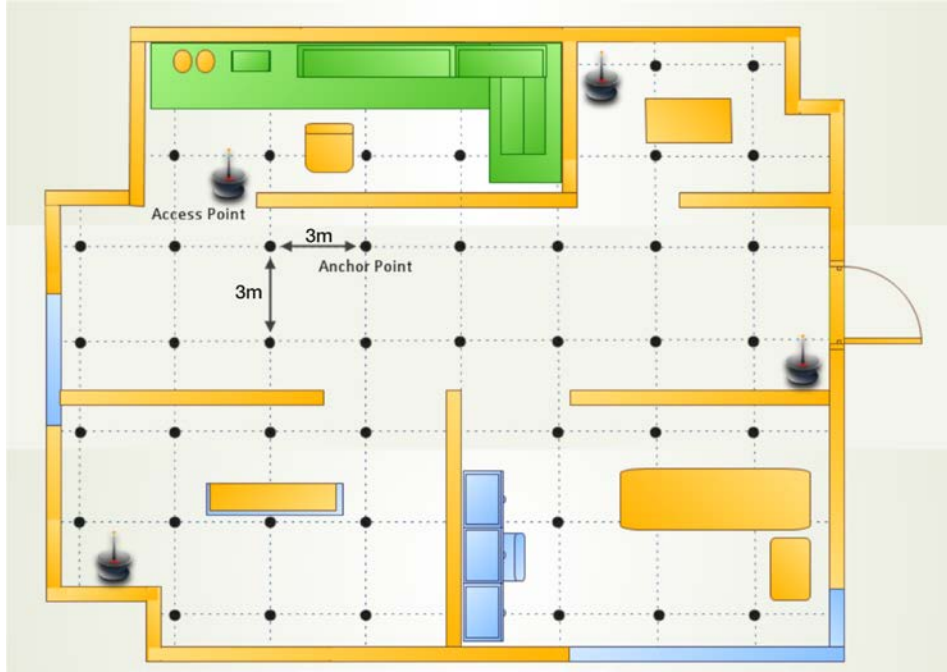


Figure 2. Indoor positioning based on RF fingerprinting.

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.

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 may still be 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.

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.

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 VoWiFi 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.

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. General best practices and recommendations are always helpful and will improve accuracy, but if you meet these density and signal strength goals, accuracy should follow.

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 ZoneDirector and APs (internal) to reach the SPoT server (external) via port 8883.



Conclusion

Wi-Fi design can always be improved by following best practices for the applications needing support. However, proper implementations always rely on the expertise and experience of the engineers doing the network planning and design. The goal of this document is not to guarantee that “if, then.” This document is here as a helpful reference to enable strategic network planning and to characterize some of the criteria that should be considered for a Ruckus SPoT™ location deployment.