



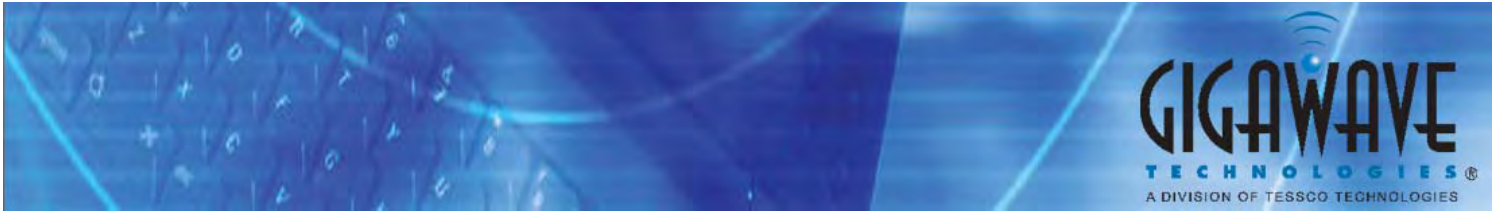
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Where's Wi-Fi Waldo: A White Paper on Location-Based Services



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A White Paper on Location-Based Services

Author: Dennis Nofsinger, Senior Wireless Training Specialist, CCSI, CCNA and CCNA Wireless





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Introduction

I remember playing a game when I was younger named *Where's Waldo?* The objective of this game is to find the cartoon character, named Waldo, in a crowded and busy environment, like an amusement park. At first, you think this will be easy, because Waldo always wears his signature red and white striped shirt, blue pants, and black round glasses. The illustrator of *Where's Waldo?* would go to great lengths to hide Waldo from you. So your search for Waldo takes more time than you ever expected. Eventually, you would spot Waldo standing by the double-loop roller coaster, eating a raspberry snow cone, and the game is over.

Physically keeping track of all of your expensive mobile assets can be like playing a real world version of *Where's Waldo?* The object of this game is for you to do a physical floor-by-floor search, looking for these devices without losing your mind. This physical procedure is very inefficient, time consuming, and often results in missing mobile assets, which are unaccounted for.

Cisco has a location-aware solution that puts an end to this daunting task. This solution consists of Cisco's Wireless Control System (WCS), controller-based access points, Cisco 3300 Series Mobility Service Engine, and Cisco compatible radio frequency identification (RFID) tags. These location-aware devices will enable you to play a high-tech version of *Where's Waldo?*, which I like to call "Where's Wi-Fi Waldo." By using Cisco WCS, you can locate your mobile assets by looking at a digitized version of your floor plan. You will see an icon that represents the device or devices you are tracking displayed right on your floor and the accuracy is very impressive. If the mobile asset you want to track does not have an imbedded radio, for example a wheel chair, simply attach an active RFID tag to it and you are all set. Currently, 802.11 active RFID tags are designed to operate in the 2.4-GHz (802.11b) radio band. Cisco's location-aware devices and RFID tag partners can also extract location data from your mobile assets. Valuable information like: where is it now (location tracking services), where has it been (location tracking history), how long did it take to get there (assembly line material in process), has it left a secured area (chokepoints), and even the temperature around the specialized RFID tag (hourly temperature monitoring of hospital refrigerators and freezers).

The objective of this document is to help you have a better understanding of what is required to design and implement an indoor location-aware network. The topics covered in this document are:

- Proper Access Point Positioning
- Viewing Location Information
- The Heart of Real-Time Location Tracking

Proper Access Point Positioning

The main contributing factor to unacceptable wireless LAN (WLAN) performance is poor access point positioning (separation). Performing a site survey that focuses on the main WLAN application, for example Voice over Wireless LAN (VoWLAN), is the keystone of a successful WLAN installation.



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To help illustrate why proper access point positioning is essential, a little WLAN history is in order. In the early 1990's, indoor WLAN deployments started to emerge in warehouses, distribution centers, and factories. This was due to the new business paradigm called "Just in Time." This new shift in the way inventory was managed required companies to invest into wireless inventory systems. At that time, many 2.4 GHz wireless solutions were available, but they all were proprietary and that locked a company into a one vendor solution.

In 1997, wireless interoperability went from an idea to reality thanks to the ratification of IEEE 802.11. This generated a renewed interest in the use of Star Trek looking wireless handheld devices. These devices contained a laser for reading barcodes and a wireless 802.11 radio to transmit data in real-time conditions. Main frame emulation software was the most common application these devices ran, making the 802.11 wireless devices a perfect fit using 1 to 2 Mbps data rates. The proper access point positioning for 802.11 data collection devices works out to be approximately 200 to 275 feet. Of course, this all depends on the condition of the indoor environment, which may cause distances to vary. By determining the correct access point positioning, data collection devices could seamlessly roam throughout millions of square feet without disruption to the client emulation application.

In 1999, 802.11b became the new hot technology in town. The access point positioning design goal needed to be improved to accommodate the higher data rates of 5.5 Mbps and 11 Mbps, while maintaining support for 802.11's original data rates of 1 Mbps and 2 Mbps. Proper access point positioning now requires an access point to overlap another access point's basic coverage area (BSA) by 10 to 15 percent. This translates to an approximate access point separation of 100 to 150 feet. Again, this all depends on the condition of the indoor environment. By having the proper 10 to 15 percent overlap, your access points positioning will provide data collection devices and laptops with the necessary coverage and bandwidth needed to communicate effectively with the network.

Voice over WLAN has become a popular mobile *telephony* solution. Wireless IP phones require a constant steady signal. As a result, the access point positioning design goal needs to be modified to accommodate VoWLAN. The proper access point positioning for VoWLAN requires an access point to overlap another access points by 20 percent. To ensure smooth performance, a site survey engineer will want to verify that the signal strength at the edge of the access point basic service area (BSA) is no less than -67dBm. This roughly translates to an approximate access point separation of 80 to 130 feet. Once again, this all depends on the condition of the indoor environment.

To accommodate future Wi-Fi widgets, network engineers need to future-proof their WLAN design. By following the 20 percent overlap with a -67 dBm signal strength edge rule, your WLAN is ready to support data collection devices, laptops and VoWLAN. You might have noticed I left location tracking off of the list. There is a perfectly good explanation and it brings me to the main point of this section.

Location tracking will require more access points to achieve the desired accuracy. If you follow the VoWLAN design goals, you are well on your way, but additional access points will still be needed. These additional access points will ensure that the mobile assets you are tracking will be "seen" by a minimum of three, but preferably four to five, access points at all times. That translates to a proper access point positioning of 50 to 70 feet or one access point every 2,500 to 4,900 square feet. Figure 1 illustrates how more access points are required to accurately track a mobile device. Notice how the recommended design always has at least three or more access points in view of the mobile device at all times.





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Cisco WCS can also be used to display on-demand lookups of a single device or many devices in real-time WLAN conditions. However, what is required to perform on-demand versus what is required to perform real-time can be confusing. I would like to take a moment to clarify what is actually needed.

Single Device on Demand Lookups

If all you want is **on-demand** lookup of a single device, for example Wi-Fi enabled laptop, Wi-Fi enabled *personal digital assistant (PDA)*, VoWLAN phone, rogue access point or a mobile asset equipped with 802.11 RFID tag, you will want to purchase Cisco **WCS with location**. In addition to WCS, you will need to purchase location-aware licenses for all of your access points. These access point licenses can be purchased in allotments that fit anyone's needs. When you exceed your access point licenses, simply purchase additional licenses and update WCS with your new access point licenses.

This on-demand solution uses Cisco's patent-pending "RF Fingerprinting" technology. RF Fingerprinting compares real-time client RSSI information to known RF building characteristics. This means the mobile asset you are performing an on demand lookup on will appear on the WCS location screen. This screen will show you where the mobile asset is by placing an icon that represents the mobile asset on the virtual floor plan. The accuracy of RF fingerprinting falls into the category of 90 percent of the time the mobile asset you are tracking is 10 meters from the icon shown on WCS (50 percent of the time you are with in five meters). As a side note, location accuracy is dependant on the quality of the floor plan you import into WCS. Cisco introduced the support for AutoCad (*.dwg) floor plans into WCS version 4.2. This feature eliminates the painstaking task of sizing you floor plans.

Real Time Device Location Tracking

To simultaneously monitor and track thousands of wireless clients in **real-time**, you will need to purchase Cisco **WCS with location** and location-aware licenses for all of your access points. In addition, you will need to purchase Cisco's **3300 Series MSE** along with element licenses (devices you want to track). The Mobility Service Engine is the hardware device that makes real-time location tracking and location history a reality. This solution also provides real-time contextual information about mobile assets location, temperature, availability, and applications in use. Cisco created a very powerful real-time location tracking solution by combining Cisco WCS and MSE together. That means you now get Cisco's patent-pending RF fingerprinting technology in real-time. Cisco WCS will show you all your mobile assets (the ones you have element licenses for) simultaneously by placing icon(s) that represents the mobile assets on the virtual floor plan. The accuracy of RF fingerprinting is still the same, but the visibility goes from on-demand to real-time conditions.

The Heart of Real Time Location Tracking

The 3300 Series Mobility Service Engine is the heart of Cisco's real-time location tracking. Without it, you would not be able to simultaneously monitor, track and record the history on thousands of wireless clients. Cisco offers a development kit that utilizes an open *application programming interface (API)* based on Simple Object Access Protocol/Extensible Markup Language (SOAP/XML). This allows Cisco's mobility application partners to take advantage of this northbound interface to create applications that interact with 3300 Series MSE, for example a chokepoint application could be created that sets off cameras, sends e-mails and even calls the police when a security perimeter has been breached. Cisco MSE makes this all possible without interruption to the primary production network.





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The 3300 Series MSE is a combination of hardware and software. The 3300 Series MSE is synchronized with predetermined WLAN controllers to feed it live location information. The floor plans are imported into the Mobility Service Engine by also using the network design synchronization procedure. The 3300 Series MSE operates headless and it is solely managed by the Cisco WCS. This next-generation open platform also allows for the addition of other mobile applications across different types of networks including Ethernet, cellular, and WiMAX. The top-of-the-line model is the Cisco 3350 Mobility Service Engine and is capable of tracking up to 18,000 mobile assets.



3300 Series Mobility Service Engine

Active RFID Tags

Two popular RFID tag tracking methods are Time Distance of Arrival (TDoA) and RSSI. To use TDoA you will need to purchase and deploy additional receivers though out your building to listen for the RFID tags. You will also need to purchase a location-aware management system from the RFID tag manufacture so you can track your mobile assets. Time Distance of Arrival is a great location tracking method however, the extra cost of buying equipment can sometimes makes it cost prohibitive.

Another option is to use RSSI by using Cisco's Unified Wireless Network, which consist of controller-based access points, WLAN controllers, Cisco WCS and Wi-Fi active RFID tags. The RFID tags need to be compliant with the Cisco Compatible Extensions program which defines the Wi-Fi tags specification. These RFID tags are readily available from many of the top RFID tag manufactures. Most of the RFID tag models offer standard features such as telemetry, battery level, and sensor information. Some of the more advanced RFID tags will also offer additional features such as a panic button, tampering alerts, temperature sensing, and a motion sensing feature that "wakes" the RFID tag up on when the mobile device is moved. This feature helps to prolong the battery life of the RFID tag.

Fine Tuning and Tweaking

Because Cisco WCS provides the visual aspect of location tracking, it is very critical to correctly import scaled versions of the floor plans as part of the normal work flow procedure. It is equally important to place the access point icons (that represent the real access points) as close to their real location on the floor plan as possible. This will deliver an acceptable out-of-the-box location tracking experience of 90 percent of the time the icon on the WCS screen is 10 meters from where the actual device is located, 50 percent of the time five meters away.

For some location-aware applications, the out-of-the-box accuracy of the WCS will do the job perfectly. However, when location accuracy plays a critical role in your tracking of mobile assets, for example, a hospital environment you can fine-tune and tweak location tracking accuracy by performing an RF calibration model using WCS.





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The calibration feature is the best way to bring the delta between location prediction and the actual location a lot closer. This is made possible by creating an RF calibration model for each floor of your building where location accuracy is crucial.

To perform the RF calibration, you will need at minimum, one building, one imported floor plan and at least three access points configured into position on your WCS floor plan. Once that has been completed, you are just about ready to create a custom RF model of your floor.

The calibration procedure requires the calibration engineer to stand physically on the actual floor area with a wireless 802.11 a/b/g laptop associated to the WLAN. By using an 802.11 a/b/g radio, the calibration engineer will be more productive by calibrating 2.4 GHz and 5 GHz at the exact same time. Next, the calibration engineer will need to login to the WCS to create the RF model and have the actual floor plan displayed on the laptop. At this point, the calibration engineer is now ready to start collecting data points. This is accomplished by clicking the area of the floor plan with a mouse that accurately represents where the calibration engineer is actually standing. Every time a data point is collected the WCS places a splash of color to represent the area you just created a data point for. The WCS also has a progress bar that graphically represents 802.11 a/b/g devices showing how far along you are in the calibration process. Now comes the redundant part of the task, the calibration engineer will need to collect minimum of 150 data points per floor. If the calibration engineer tries to apply the new RF model to the floor area with less than 150 data points, a “not enough data points” error will be displayed on the WCS. The calibration engineer will need to continue collecting more data points until enough are collected. When enough data points have been collected, the RF model can be applied to the floor plan using the WCS. You will be well-rewarded for all of the data points you painstakingly collected. The RF calibration feature of WCS will greatly improve location accuracy without moving a single access point.

Conclusion

A wireless location-aware network is definitely one of those cutting edge technologies that require advance planning. It all starts with proper access point positioning regardless if you are deploying on demand tracking of a single device or deploying a real-time location-aware system. Automating the location tracking of your valuable mobile assets can quickly provide a return on your investment by saving the money spent on manual tracking methods.





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About the Author

Dennis Nofsinger is the Senior Wireless Training Specialist at GigaWave Technologies. Dennis has over 18 years of experience in wireless communications. Dennis joined GigaWave Technologies in December of 2000 and over the last eight years Dennis has trained thousands of students interested in expanding their career focus on Cisco's Enterprise Wireless Networks. He holds a CCSI, CCNA and CCNA Wireless.

Suggested Cisco Unified Wireless Courses and Technical Training Cisco Unified Wireless Networking (CUWN)

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10521 Gulfdale
San Antonio, Texas 78216
210-375-0085 Phone
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info@giga-wave.com
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