



White Paper

## Wi-Fi Based Real-Time Location Tracking: Solutions and Technology

This white paper provides an overview of Wi-Fi based real-time location tracking. It discusses the business problems that location tracking addresses, introduces the Cisco® Wireless Location Appliance, provides an overview of the three methods used to track Wi-Fi devices (closest access point, triangulation, and RF fingerprinting) and discusses the underlying location tracking approach used by the Cisco Wireless Location Appliance.

### CHALLENGE

While mobility brings freedom and increased productivity to businesses, it also poses challenges for the enterprise. These challenges include:

- Lack of visibility into the location of people and assets
- Inefficient allocation and use of staff and equipment
- Excessive cost of leasing and purchasing equipment to offset losses and theft
- Unsatisfactory service resulting from long wait times and time wasted searching for assets
- Security issues linked to the lack of insight into the location and movement of people and assets

Additional challenges associated with network visibility, specific to Wi-Fi deployments, include:

- Locating rogue wireless LAN (WLAN) access points, devices, or users that attempt to access or attack the network
- Visibility into the WLAN for capacity planning and ongoing network tuning
- Isolation of WLAN devices for troubleshooting purposes
- Locating Wi-Fi devices for asset tracking and security policy enforcement

Location tracking is an essential feature for enterprises building business-critical wireless networks. If IT staff can identify and track the location of wireless clients and highly mobile assets, they can improve the accuracy of WLAN planning and deployment, optimize ongoing network performance, enhance wireless security, and improve the usefulness and value of important business applications. Location tracking provides enhanced visibility and control of the air space, helping IT staff deploy wireless networks that are as easy to manage and as effective to deploy as traditional wired networks.

### SOLUTION

Cisco Systems® has revolutionized Wi-Fi networking by providing advanced location tracking within the WLAN infrastructure through the Cisco Unified Wireless Network. This innovative solution supports two location tracking options:

- On-demand location tracking that provides visual location tracking of a single device based on a specific query or lookup via the Cisco Wireless Control System (WCS) with embedded location.
- Simultaneous location tracking of thousands of 802.11 wireless devices by adding a Cisco Wireless Location Appliance in conjunction with a Cisco WCS.

## Cisco Wireless Location Appliance

The Cisco Wireless Location Appliance, a component of the Cisco Unified Wireless Network, is the industry's first location solution that simultaneously tracks thousands of devices from directly within the WLAN infrastructure—bringing the power of a cost-effective, high-resolution location solution to critical applications such as high-value asset tracking, IT management, and location-based security. This appliance uses advanced radio frequency (RF) fingerprinting technology to track wireless devices to within a few meters for increased asset visibility and enhanced control of the air space.

The Cisco Wireless Location Appliance tackles the challenges associated with tracking thousands of clients in a Wi-Fi environment. This appliance tracks any Wi-Fi device, including Wi-Fi clients, Wi-Fi active radio frequency identification (RFID) tags, rogue access points, and rogue devices. It was designed with the following requirements in mind:

- **Manageability**—The same easy-to-use, browser-based interface that is used for the Cisco WCS is also used for the appliance. Moreover, the location appliance integrates directly into the WLAN architecture, providing one unified network to manage instead of multiple disparate wireless networks.
- **Scalability**—The appliance was built as a dedicated device that scales to simultaneously track up to 1500 wireless devices. For greater scalability, multiple appliances can be managed by the Cisco WCS.
- **Security**—Separation of the network management solution from the location solution delivers a more secure and robust architecture. Rogue access points and rogue devices are easily located by the appliance. Rich historical location information, which can be used for audit trails and regulatory compliance, is recorded.
- **Open and standards-based**—The appliance has a rich Simple Object Access Protocol/Extensible Markup Language (SOAP/XML) application programming interface (API) that can be integrated with other business applications that can use its location information for a variety of purposes, including inventory management, streamlining operations and workflow, enabling code blue and Enhanced 911 (E911) services, and enforcing security policies. The appliance can track any standards-based 802.11 tag or device. Many Cisco partners offer specialized location services that integrate with the API of the Cisco Wireless Location Appliance, including [PanGo](#), [AeroScout](#), [Appear Networks](#), and [G2 Networking](#).
- **Cost-effective**—The appliance eliminates the need for dedicated overlay readers and client software by using any Cisco Aironet® lightweight access point. This allows the same Cisco Aironet lightweight access points that are used for data, voice, and video to serve as “location readers” for location tracking. Since these access points have a broad coverage range that extends to several hundred feet, this provides a cost-effective solution relative to short-range readers that need to be deployed more densely.
- **Easy deployment of business applications**—Asset tracking, inventory management, location-based security, automated workflow management, and other new business applications can be easily integrated with the appliance.
- **Increased accuracy**—The appliance uses patent-pending Cisco RF fingerprinting technology to determine the location of wireless devices. It correlates the known RF characteristics of a building with real-time user information to track mobile devices to within a few meters.

## Location Tracking Technology

Before deploying a location tracking solution, it is valuable to understand the various methodologies used for location tracking. Traditionally, WLANs have used three different methods for locating wireless users or devices—closest access point, triangulation, and RF fingerprinting. Each of these methods provides a varying degree of WLAN visibility and device location information. The Cisco Wireless Location Appliance uses RF fingerprinting for location tracking.

### Closest Access Point

The closest access point method finds devices within the total coverage area of a single access point. It is the simplest but least accurate way to locate a device or user.

With the closest access point method, the location tracking system identifies only devices within the total coverage area of a single access point, which can be quite large and include multiple rooms. Using the closest access point method, IT managers use their network management system

to search for the user by name, for instance, by entering, “Find Bob” into the search field. After the query has been submitted, the access point that Bob’s device is associated with responds and thus the user is “found.”

However, the result might not provide the degree of accuracy necessary to pinpoint device locations. For example, if an access point covers (roughly) a 70 square foot area, then the closest access point method only narrows the location of Bob’s device down to a 4900 square foot area. This method is even less accurate for greater coverage areas. Depending on a company’s location requirements, the services that it has deployed, government regulations, and plans for future services, this method may be adequate, but in most cases it is not sufficient.

## Triangulation

Triangulation uses multiple access points to find a device based on the received signal strength of the device at each access point. Using algorithms, the location tracking system determines the intersection point of the device’s signal at each access point to identify the device’s most likely location. Triangulation is more accurate than the closest access point method, but not as precise as RF fingerprinting.

Using triangulation in a WLAN, an IT administrator initiates a command to find a wireless device and a call goes out to all access points on the network. Each access point that “hears” the device’s signal responds to the request with information regarding signal strength. Access points that fail to hear the device do not respond.

The IT administrator waits an interval to ensure that each access point has had the opportunity to hear the device and that all access points have had a chance to report back. The more access points that respond, the greater the accuracy of the final result with the device’s approximate location.

The location tool then draws coverage circles on a map around each access point that hears the device. Each coverage circle defines the boundary of the signal strength of the access point receiving the signal from the device. If an access point hears the device at –65 dBm, then the network management system draws a circle defining a –65-dBm area. If another access point hears the device at –45 dBm, then that coverage circle is drawn smaller, indicating that the signal strength was higher. Signal strength information provided by each access point is factored into the final determination of the device’s location.

When the location tool finishes recording the information, it identifies a number of line intersections. Algorithms are then used to determine the most likely location of the device within the intersections. There is a high probability that the area with the highest density of intersecting lines is the correct location.

Triangulation can define a location of 30x30 feet (900 square feet), equivalent to approximately nine office cubicles. In an area with no walls or objects that can block a signal, triangulation yields fairly accurate results. With triangulation, accuracy is reduced if the signal is reflected off of the walls in a room or if the signal has taken multiple paths before reaching the device. Triangulation does not take into account the effects that a building and/or other objects can have on a signal. Triangulation does not take into account characteristics such as:

- **Reflection**—A wireless signal’s reflection off of an object.
- **Attenuation**—A physical object’s effect on a signal. The coverage circles on the triangulation map are usually perfect circles and do not reflect the effect that walls, glass, and other building materials exert on RF. For instance, a wall might take away –4 dBm of device signal strength.
- **Multi-Path**—Multiple paths that an RF signal might take to arrive at a destination. A signal heard at –65 dBm may actually be well within the coverage circle, but since it did not take the most direct path to the access point, it registers on the edge of the coverage area. Any given spot on a coverage map can be reached via multiple paths.

## RF Fingerprinting

RF fingerprinting is much more comprehensive than triangulation and the closest access point methodologies. With RF fingerprinting, RF prediction is used to create a grid mapped to a floor plan that includes all physical characteristics and access points in a given area. For finer accuracy, actual measurements and a calibration can be taken. With RF fingerprinting, real-world data regarding physical objects in a given area is gathered by access points and compared to the grid to determine the device's location to within a few meters. A point on a grid can represent an area as small as six inches. For this reason, RF fingerprinting is the most accurate location tracking technology.

To determine how the RF signal sounds at each location in an enterprise, the RF fingerprinting location tool must predict how the signal will likely interact with the building. With RF prediction, factors including reflection, attenuation, and multi-paths are calculated. Then, the location tracking system populates the database with information about each coordinate and how each access point views that coordinate from a signal strength perspective.

Since there can be many reflections and paths, RF fingerprinting is computationally intensive with computation repeated for every coordinate and access point on the grid. Many different access points may be able to hear a device from a location point on the grid. Each access point will hear the device at different signal strengths.

With RF fingerprinting, when a network administrator tries to find a wireless device, each access point replies with the signal strength of the devices it hears—just like in triangulation. However, with RF fingerprinting, the location tracking system takes the information it receives from the access points and matches it against its database of location fingerprints. When it finds a likely match, it is reported.

It is the RF fingerprinting database that sets RF fingerprinting apart from triangulation. The RF fingerprinting database is comprehensive—it takes into account the building's floor plan as well as attenuation, reflection, and multiple paths.

The Cisco Wireless Location Appliance uses RF fingerprinting technology to track mobile devices to within a few meters. RF fingerprinting complies with E911 standards in all 50 states in the United States.

## SUMMARY

To address problems associated with a lack of visibility, organizations need a cost-effective, easy-to-deploy solution for tracking and managing thousands of Wi-Fi devices and tags across a variety of business environments. They also need to deploy mobility services that enhance their business applications and meet regulatory requirements for enhanced security, asset visibility, and E911 calls. The Cisco Wireless Location Appliance, a component of the Cisco Unified Wireless Network, provides the location resolution and visibility required to address these business needs. This appliance uses RF fingerprinting to more accurately predict the location of a Wi-Fi device to within a few meters.

## FOR MORE INFORMATION

For more information about the Cisco Wireless Location Appliance, contact your local account representative or visit:

<http://www.cisco.com/en/US/products/ps6386/index.html>

For more information about the Cisco Wireless Control System (WCS), contact your local account representative or visit:

<http://www.cisco.com/en/US/products/ps6305/index.html>

For more information about the Cisco Unified Wireless Network, contact your local account representative or visit:

<http://www.cisco.com/go/unifiedwireless>

**Corporate Headquarters**

Cisco Systems, Inc.  
170 West Tasman Drive  
San Jose, CA 95134-1706  
USA  
www.cisco.com  
Tel: 408 526-4000  
800 553-NETS (6387)  
Fax: 408 526-4100

**European Headquarters**

Cisco Systems International BV  
Haarlerbergpark  
Haarlerbergweg 13-19  
1101 CH Amsterdam  
The Netherlands  
www-europe.cisco.com  
Tel: 31 0 20 357 1000  
Fax: 31 0 20 357 1100

**Americas Headquarters**

Cisco Systems, Inc.  
170 West Tasman Drive  
San Jose, CA 95134-1706  
USA  
www.cisco.com  
Tel: 408 526-7660  
Fax: 408 527-0883

**Asia Pacific Headquarters**

Cisco Systems, Inc.  
168 Robinson Road  
#28-01 Capital Tower  
Singapore 068912  
www.cisco.com  
Tel: +65 6317 7777  
Fax: +65 6317 7799

Cisco Systems has more than 200 offices in the following countries and regions. Addresses, phone numbers, and fax numbers are listed on **the Cisco Website at [www.cisco.com/go/offices](http://www.cisco.com/go/offices).**

Argentina • Australia • Austria • Belgium • Brazil • Bulgaria • Canada • Chile • China PRC • Colombia • Costa Rica • Croatia • Cyprus  
Czech Republic • Denmark • Dubai, UAE • Finland • France • Germany • Greece • Hong Kong SAR • Hungary • India • Indonesia • Ireland • Israel  
Italy • Japan • Korea • Luxembourg • Malaysia • Mexico • The Netherlands • New Zealand • Norway • Peru • Philippines • Poland • Portugal  
Puerto Rico • Romania • Russia • Saudi Arabia • Scotland • Singapore • Slovakia • Slovenia • South Africa • Spain • Sweden • Switzerland • Taiwan  
Thailand • Turkey • Ukraine • United Kingdom • United States • Venezuela • Vietnam • Zimbabwe

Copyright © 2006 Cisco Systems, Inc. All rights reserved. CCSP, CCVP, the Cisco Square Bridge logo, Follow Me Browsing, and StackWise are trademarks of Cisco Systems, Inc.; Changing the Way We Work, Live, Play, and Learn, and iQuick Study are service marks of Cisco Systems, Inc.; and Access Registrar, Aironet, BPX, Catalyst, CCDA, CCDP, CCIE, CCIP, CCNA, CCNP, Cisco, the Cisco Certified Internetwork Expert logo, Cisco IOS, Cisco Press, Cisco Systems, Cisco Systems Capital, the Cisco Systems logo, Cisco Unity, Enterprise/Solver, EtherChannel, EtherFast, EtherSwitch, Fast Step, FormShare, GigaDrive, GigaStack, HomeLink, Internet Quotient, IOS, IP/TV, iQ Expertise, the iQ logo, iQ Net Readiness Scorecard, LightStream, Linksys, MeetingPlace, MGX, the Networkers logo, Networking Academy, Network Registrar, Packet, PIX, Post-Routing, Pre-Routing, ProConnect, RateMUX, ScriptShare, SlideCast, SMARTnet, The Fastest Way to Increase Your Internet Quotient, and TransPath are registered trademarks of Cisco Systems, Inc. and/or its affiliates in the United States and certain other countries.

All other trademarks mentioned in this document or Website are the property of their respective owners. The use of the word partner does not imply a partnership relationship between Cisco and any other company. (0601R)

