# Performing Radio Frequency Site Surveys to Effectively Support VoWLAN Solutions

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## About the Author


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Jim is the founder and principal consultant of Wireless-Nets, Ltd., an independent consulting firm assisting companies with the development and deployment of wireless LAN products and systems. Jim is the author of several books: Wireless LANs, Wireless Networking Handbook, and Network Reengineering, as well as numerous articles. He is a voting member within the Wi-Fi Alliance. He served as Chairman of the IEEE Computer Society, Dayton Section, and Chairman of the IEEE International Conference on Wireless LAN Implementation. He has been an active member of the IEEE 802.11 Working Group.

# Performing Radio Frequency Site Surveys to Effectively Support VoWLAN Solutions

***(How accurate site surveys help enterprises avoid costly wireless LAN management and network scalability issues)***

## Introduction

Wireless LAN applications have been evolving over the past decade, from initial bar code solutions to the deployment of voice-over-wireless LAN (VoWLAN) applications. Wireless LANs are rapidly becoming a core part of an enterprise communication infrastructure. In many installations, wireless LANs are the primary network that provide real-time access to information located on the intranet or internet. Moreover, enterprise wireless LAN deployments are

expected to reliably support a significant number of roaming users and mission-critical applications, including VoWLAN solutions within extensive coverage areas.

After witnessing a significant number of wireless LAN deployments in a variety of venues, such as hospitals, warehouses, airports manufacturing facilities, and corporate offices, it's very clear to us that the completion of an effective radio frequency (RF) site survey is absolutely necessary as the basis for installing access points. In addition, the conductance of a RF site survey that specialists can complete efficiently and accurately is imperative for supporting VoWLAN applications. Unreliable and interference-ridden wireless coverage could prevent network connectivity, limit network capacity, and cause dropped network connections. This leads to thousands of dollars in lost employee productive time as well as IT troubleshooting and maintenance costs and in many cases, potential disruption of an organization's operation.

## Why Perform RF Site Surveys?

The primary reasons for conducting a RF site survey are to determine the number and location of access points and antennas that provide optimum RF signal strength throughout the facility. A RF site survey is initially done prior to installing the access points and indicates access point positions throughout the facility that will provide radio cells that overlap sufficiently. The report from a RF site survey identifies the exact mounting location for each access point and antenna, with enough detail so that the installation of access points at a later date will produce similar RF signal coverage as found during the initial RF site survey testing. Follow-on RF site surveys of the installed wireless LAN enable effective operational support.

An issue with radio signals is that they don't propagate away from an access point or radio card in equal distances in all directions. If you place an access point in the center of a warehouse, for example, wireless users may only be able to connect with the access point from twenty five feet away in one direction and up to a hundred feet in another direction. Obstacles, such as walls, filing cabinets and people cause more or less signal attenuation as the signals emanate from the access point. This causes the RF signal propagation around an access point to have jagged coverage pattern.

In addition, the actual propagation pattern can differ significantly as you move the access point throughout the facility. Even moving the access point a few feet can cause dramatic changes in the propagation pattern. To make matters worse, it's not possible to accurately predict the propagation of radio waves without performing active RF testing. Thus, a RF site survey becomes absolutely necessary to ensure RF signal coverage is sufficient to support usage of all wireless applications in areas where users may roam.

In order to optimize the performance of wireless applications, a RF site survey must also assess potential interfering sources. Microwave ovens, cordless phones, and other nearby wireless LANs introduce signals that may be strong enough to cause performance degradations. The 802.11 protocol, which is the basis for wireless LAN operation, is very polite and will give way to interfering signals if they are above a specific threshold. For example, the operation of a microwave oven within fifty feet of a wireless LAN device, such as a wireless laptop or access point, will cause the devices to incur relatively high packet retransmissions. The result is lower throughput, which the user experiences as poor performance. The RF site survey should characterize potential interference that factors into the optimum access point placement and choice of RF operating channels. As an example, it may be necessary to place an access point

near a microwave oven to provide stronger wireless LAN signals in that area for users connecting to the access point near the oven. This can lesson the impacts of the microwave oven interference.

Two or more access points operating within range of each other and set to the same RF channel will incur co-channel interference. This situation occurs frequently in crowed metropolitan areas. For example, a large office building may include several companies. Two or more of them may have wireless LANs, and they usually don't coordinate the channel assignments. Also, a company deploying a large wireless LAN may accidentally choose overlapping RF channels for adjacent access points. Without any user traffic on either access point set to the same channel, the only packets that will contend with each other are the beacon frames being set by the access points. The capacity of both access points, however, is roughly half of the maximum because the users and access points content for the same medium. This is extremely detrimental when supporting VoWLAN applications. A RF site survey is necessary to ensure access points have non-overlapping channels.

In some cases, it may be necessary to conduct a RF site survey as part of selecting hardware and determining configurations of a wireless LAN. The survey, for instance, offers valuable information regarding the selection of antennas. For example, engineers may desire the use of directional antennas mounted along the edge of exterior walls of a building and aimed inward will yield the optimum RF coverage while minimizing leakage of RF signals outside the building in physically uncontrolled areas. In order to deploy a secure system in this manner, engineers should utilize a RF site survey for a limited number of potential installation locations and pay close attention to RF range boundaries both inside and outside the building. After determining which antennas will effectively satisfy requirements, a survey specialist can perform a complete RF site survey with the specified antennas when determining the number and placement of access point antennas.

If a company doesn't perform a RF site survey prior to installing the access points, then coverage holes will persist. While performing assessments of dozens of existing wireless LANs, we have found that most existing wireless LANs have very poor RF coverage in many areas of the facilities. The reason for this is that either the RF site surveys were not done at all or they were performed inaccurately. Of course the existence of coverage holes and weak signal areas inhibit the ability for users to have access to wireless applications. Coverage holes are especially damaging to VoWLAN applications because they result in dropped calls as users roam throughout the facility while talking on a phone.

After installing a wireless LAN, it's very important to re-survey the facility periodically because the environment that impacts radio wave propagation often changes over time. For example, a company may construct or remove walls in parts of the building. Or, a warehouse manager may reconfigure the layout of shelves in portions of the warehouse. These types of physical changes significantly alter the propagation of radio waves. If follow-on site surveys are not done, then coverage holes will likely occur, which disrupts performance of the wireless LAN.

Instead of performing RF site surveys, some companies may be tempted to rely on the use of switches and access points that claim real-time RF management capabilities. These built-in mechanisms, however, don't provide adequate coverage assessment tools needed for VoWLAN applications. They generally only determine the optimum RF channel for access points, not an accurate assessment of coverage throughout the facility. As mentioned before, it's crucial that the RF site survey involve the use of tools that accurately assess RF coverage.

## The Need for Accurate RF Site Surveys

A RF site survey must accurately portray RF coverage. Traditional RF site survey tools that merely measure signal and noise levels are not good enough for precisely identifying range boundaries and providing a solid picture of the coverage quality. With these methods, there is too much opportunity for human error and significant inefficiencies in producing accurate coverage maps that illustrate the coverage areas and range boundaries of the radio cells associated with each access point. The manual methods of collecting signal data with traditional tools results in insufficient numbers of data points to adequately describe the coverage areas. This again allows coverage holes to occur that plague operation of the applications.

Coverage holes frustrate users as they attempt and fail to utilize wireless applications. If possible, users may try moving to different parts of the facility, and they may eventually learn where to find good signal strength. Eventually, these user experiences may drift back to operational support staff, who might resolve the problems after a considerable amount of time. Meanwhile, the wireless applications are not providing the value and return-on-investment that business managers were counting on. In addition, users sometimes become angry and decide not use the wireless applications.

In warehouses, wireless terminal-based bar code scanning applications often cause database record errors due to coverage holes. A bar code scanner may have wireless connectivity when scanning a shelf label as part of an inventory transaction, but then a disconnection may occur prior to the user inputting the count of the items for that shelf. Database errors generally happen because the transaction doesn't complete. Many applications such as this one are not smart enough to recover from network connection problems because the software had been written for terminals that connect directly to the server via a more reliable physical network. Companies frequently move these terminal-based applications to wireless bar code scanners, and the RF coverage holes provide the basis for costly support. Users bombard the help desk repeatedly with log in complaints, and support staff must resolve corresponding data errors.

Coverage holes result in much more severe problems, as well, depending on the application. For example, many hospitals deploy wireless patient monitoring devices. The monitor keeps track of heart rate and other vital signs, which are sent in real-time to nurses' stations over a wireless LAN. Of course coverage holes with this application disrupt extremely valuable information. When lives are at stake, there's absolutely no question about needing reliable RF coverage. In these cases, a company must be very meticulous in performing an effective RF site survey.

## RF Site Survey Steps

Companies must perform an accurate RF survey in order to avoid coverage problems. To facilitate the completion of an effective RF site survey, companies must follow a methodology that ensures compliance with application requirements and involves active testing during the design, installation, and operational support phases of a wireless LAN. The RF site survey is a key element of deploying effective wireless LANs, especially ones that support VoWLAN applications.

Be certain to first understand the requirements of the wireless applications, such as RF coverage pattern and performance. Cisco, for instance, has guidelines for their Wi-Fi phones that specify at least 25dB signal-to-noise (SNR) and 25 percent overlap between access point RF cells. This is necessary to enable smooth roaming between access points as users move about the facility while talking on the phones and enough signal strength to maintain levels of throughput desirable for phone data traffic.

Some site survey tools incorporate “point-and-click” positioning; however, they are not efficient and result in inaccuracies. With this approach, the person performing the site survey loads a map of the facility onto their laptop and periodically clicks the mouse button to identify their position on the map. The site survey software maps the signal strength and noise to that position on the map and stores this data as the basis for generating graphical coverage maps.

An issue is that the accuracy of the “point-and-click” method is prone to human error. For example, the technician may mistake their position on the map, causing the application of signal measurements to the wrong place in the facility. As a result, the coverage maps are highly inaccurate. Something that makes matters even worse is that it’s very easy for people using the tools to overlook these types of mistakes. These faults are certainly not acceptable.

Another problem with the “point-and-click” approach is that the survey specialist must keep track of their position within the facility. This is very tedious and can take a considerable amount of time for each data point, especially since most of the time the person performing the survey is unfamiliar with the building layout. Lots of time is necessary to re-orientate yourself when walking throughout the facility because it’s easy to lose track of location because you’re busy looking at the survey tool screen.  Of course the unfamiliarity with the building also leads to inaccuracies when clicking position on the map.

The outcome of these issues with the point-and-click approach is that the RF site surveys take longer to complete, cost more money, and don’t accurately portray RF coverage. As an effective alternative, choose site survey tools that efficiently and accurately determine position information automatically without the need for existing wireless LAN access points. Also, ensure that the site survey tool is capable of mapping hundreds of signal measurements to their exact locations for each access point. In this manner, the specialist performing the RF survey can be certain that coverage is adequate for supporting wireless solutions, especially demanding VoWLAN applications. The surveys will also take much less time to complete if the tools automatically and accurately map signal characteristics to the exact position in the facility without involvement from the operator.

Tools should clearly and accurately identify RF coverage and overlap between access point radio cells in multi-floor facilities. It’s impossible to meet VoWLAN requirements without having the ability to correctly portray the RF coverage of each access point and assess whether or not overlap and SNR is within specifications. Tools that have the ability to portray coverage between floors are necessary in order to properly assign RF channels and minimize the number of access points. This is crucial because radio waves propagate through adjacent floors.

When performing a RF site survey, engineers and technicians should have tools that clearly differentiate RF interference, often referred to as noise, from access point signals. This is critical when assessing the range boundaries of the radio cells in order to effectively support VoWLAN applications. Failure to recognize sources of interference causes signal quality and corresponding user performance to degrade substantially. The interfering signals end up occupying the RF channel, which reduces the bandwidth available to data signals.

With information that characterizes interference throughout the facility, engineers can better determine optimum RF channel settings and access point placement. For example, the presence of a microwave oven inside a break room should prompt a site survey specialist to place an access point in that area and configure it to a channel that avoids the interfering signal. If this isn't done based on accurate noise measurements, then users in that area will suffer from much lower performance when the microwave oven is operating. The tools should aid in similar countermeasures for combating RF interference from other sources as well, such as cordless phones and neighboring wireless LANs.

The RF site survey initially involves a "walk-around" to visually inspect the facility. This allows the survey specialist to validate building drawings, determine the construction of the facility, and identify potential sources of interference. With this information, an engineer or technician identifies preliminary access point and antenna installation locations.

Prior to installation, the person performing a survey should utilize effective RF site survey tools to fully test each proposed access point installation. The goal of the pre-installation site survey is to find the optimal installation location for each access point. This ensures appropriate locations for the access point before spending a relatively large amount of time and money installing the access points. Without accurately testing each access point installation location, coverage holes will likely be present after installing the access points. This then requires the relocation of access points, which substantially increases the cost of the installation and delays the use of wireless applications.

The testing of each proposed access point installation location should involve signal measurements that correspond to exact locations on a building diagram. After mapping the RF coverage of a particular access point, the site survey specialist should be able to observe a coverage map image and determine if adjustments with the access point and antenna positioning are necessary. After making position changes and verifying proper coverage with the site survey tool, then testing can continue at the next access point location.

Be certain to fully understand the requirements of the survey before interpreting the results. A definition of the range boundary, such as a value of SNR, should be known and applied when assessing the range and overlap of radio cells. It's very important to not base the range boundary on the data rate that the test tool associates with the access point. For example, a laptop equipped with 802.11b may associate with the access point at 11Mbps. When moving about the facility, the laptop will probably continue to display a data rate of 11Mbps until just before losing connection with the access point. Actual measurements of throughput in this scenario, though, will indicate a steady increase in retransmissions as the user moves away from the access point. Even though the laptop indicates 11Mbps data rates, the throughput due to excessive retransmissions may in fact be very low. SNR measurements, however, map directly to throughput. As SNR goes up or down, throughput will follow. Thus, never perform a RF site survey using association data rate as the definition for range boundary. SNR provides a much more accurate value that correlates well with levels of user performance.

Immediately after installing the access points, perform an "as-installed" RF site survey to verify proper installation and RF coverage. This provides a baseline for RF coverage and identifies any potential connectivity problems. After observing the as-installed coverage maps, only slight adjustments may be necessary to tune the coverage in a manner that completely eliminates coverage holes.

The baseline coverage maps are vital when re-engineering the system in the future. A company, for example, may initially deploy a wireless LAN for supporting a bar code application throughout a warehouse. At a later date, the company may decide to implement the use of VoWLAN phones in the same area. The RF survey baseline, which includes coverage maps indicating exact signal characteristics throughout the facility, offers valuable information when determining whether the existing wireless LAN will support the new application. If alterations are necessary, then the company should re-survey the area after making the changes in order to update the baseline data.

A company should also periodically re-survey the facility because of the dynamic nature of radio waves. This is crucial for maintaining sufficient coverage and performance, especially for VoWLAN solutions. If the facility undergoes any new construction, such as adding walls or moving large pieces of equipment, then an immediate re-survey is necessary. Otherwise, it's possibly to get by with performing re-surveys once or twice each year to catch changes that go by unnoticed or occur gradually. An increase in the number of employees working in the facility, for instance, will change the RF coverage patterns of the access points, which may create coverage holes in some parts of the facility.

## Selecting the Right Site Survey Tool

RF Site survey tools must accurately assess and portray RF coverage. If deploying VoWLAN solutions, then the RF site survey becomes crucial. This involves accurate mapping of signal measurements with exact position within the facility. Coverage maps that effectively illustrate signal quality and radio cell overlap are critical for ensuring that the wireless LAN meets requirements for SNR and cell overlap throughout the entire facility. A good RF site survey tool should have a feature that does auto channel assignments using the real overlapping signal measurements and take into consideration the 3D nature of wireless propagation. For example, the tools should adequately analyze the propagation between multiple floors of the facility. Companies such as Airmagnet, Berkeley Varitronics Systems, and Helium Networks offer RF site survey tools that you should consider. However, only Helium's Wireless Recon tool has patented technology that measures exact position information, automatically, and ties it with all the wireless data captured (not just in places where someone points-and-clicks)! Wireless Recon provides a new level of accuracy and detail to analyze and design with to meet specific application requirements like voice.

## Conclusion

The completion of initial and periodic RF site surveys is very important for optimizing the installation of a wireless LAN. In the absence of effective RF site surveys, coverage holes persist, which causes degradation in performance and havoc for operational support staff. The result is a costly wireless LAN that doesn't adequately support applications. In order to effectively complete a RF sites survey, it's imperative to select the right tools. Tools are available from companies such as Airmagnet, Berkeley Varitronics Systems, and Helium Networks. Site survey tools that allow accurate assessment of the RF coverage with limited human intervention enables the completion of accurate surveys that most effectively support VoWLAN solutions. Helium has an edge here with the level of accuracy and reliability and is a vendor agnostic VoWLAN grade design tool.


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