White Paper

Wireless Site Survey Best Practices

As wireless technology continues to mature, new wireless applications and appliances continue to emerge. There is increasing demand for transmitting voice and video, as well as the need for accurate positioning of users and assets accessing the WLAN. Site surveys are invaluable for designing and optimizing WLAN networks to support these applications. This paper provides insight into best practices for executing wireless site surveys.

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Wireless local area networks (WLANs) using 802.11b, 802.11g, and 802.11a technology (Wi-Fi) have been springing up practically everywhere, providing high-speed wireless data communications to millions of people around the world. Adoption of wireless technology is fueled by its low cost and by consumers' desire for the convenience of being connected to the internet while on the go. The question is no longer: "Why wireless?" It has become: "Why not wireless?" So, considering the maturity of WLAN technology, planning and deploying a wireless LAN network in the office must be easy, right? Guess again!

Using the right tools for the job

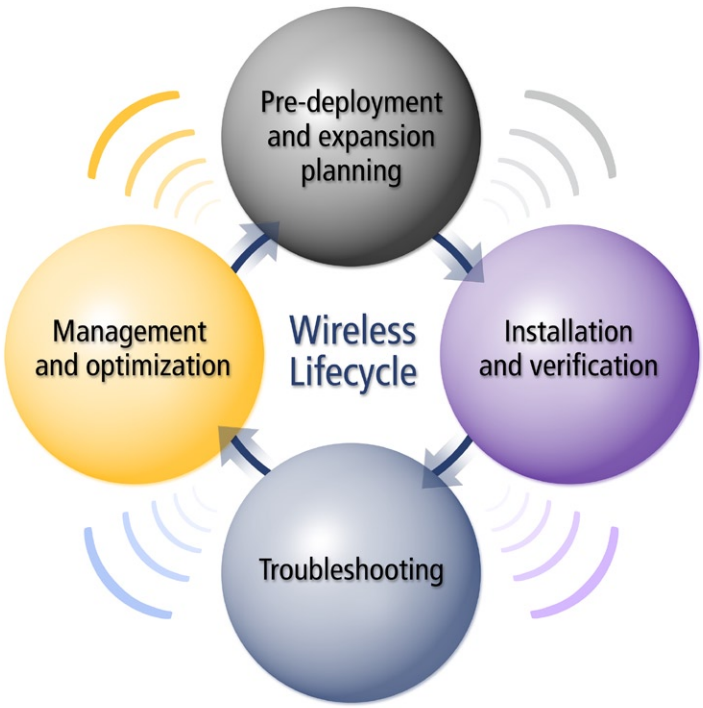
End users only see the results of the hard work of the WLAN operators, systems integrators, value-added resellers, engineers, and IT departments that implement these networks. If you are in one of these categories, you probably already know that planning and deploying a WLAN is not as simple as it sounds. You know you need the right tools to help you navigate the wireless lifecycle as you plan, install, maintain, and optimize the WLAN network.

Wi-Fi installers need to:

- Achieve the best possible WLAN performance.
- Optimize network performance for a variety of applications (data and voice).
- Minimize co-channel interference.
- Determine the quantity and best locations for access points.
- Locate unauthorized "rogue" access points and neighboring networks.
- Document installation characteristics.
- Ensure redundant coverage to support seamless roaming.
- Verify post-installation that the WLAN performs as designed.
- Fully document the entire network for reference and future verification purposes.

The importance of site surveys

WLAN network design and site survey are part of the initial phase of the wireless lifecycle. Any company that considers deploying WLANs is destined to go through all phases. These phases include pre-deployment, including network design and site survey, post installation verification, troubleshooting, management and optimization. Automating the site survey process simplifies pre-deployment design and post deployment verification.



Despite the emergence of WLAN systems that advertise the ability to manage themselves, eliminating the need to perform a site survey, most WLAN systems manufacturers will readily acknowledge that site surveys remain an important part of designing a WLAN network. A site survey enables more accurate prediction of infrastructure needs prior to purchasing a WLAN infrastructure, resulting in more accurate time and cost estimates for the network deployment. It is also a process to help verify the WLAN is performing as designed after installation. Using a full-featured wireless site survey software can save an enormous amount of time, money, and a great deal of frustration when compared to paper based site survey techniques.

There are many things to consider when planning a WLAN. Coverage areas must be sufficient to meet the customer requirements, yet they should not extend far outside the boundaries of the desired serving area. There needs to be enough signal overlap from adjacent access points to ensure seamless roaming, but not so much as to cause significant channel interference. In addition, there usually will be requirements for total throughput, throughput per user, and signal-to-noise ratio. Moreover, the deployment should stay on-time and on-budget.

Deploying a WLAN includes several phases. If the first steps are performed carefully, time and effort will be saved in the subsequent phases. The unpredictable nature of high-frequency RF signals causes most of the extra work when compared to wired networks.

What you need to consider

When conducting a site survey, it is important to consider a number of factors that could affect the performance of the WLAN. For example, is the network going to be installed in an open environment where there aren't many walls or large structures to block the signal? Will the network be installed in a warehouse or office that has steel beams, concrete pillars, large filing cabinets, and heavy machinery that can dramatically reduce the range of wireless access points? Does the environment include machinery, electronic devices, cranes, cordless phones, lighting, satellite dishes, microwave ovens, or other things that could generate interference or block wireless signals? Will the company be expanding its physical plant and/or adding more people which can affect wireless transmissions? Will partitions and walls be moved frequently? All these factors can change the performance of the WLAN.

Sometimes even a subtle environmental change can have an adverse effect on WLAN performance. For example, will employees be opening and closing office and conference room doors? Closed doors could effectively block or degrade wireless signals, so meeting rooms and offices should be surveyed with the doors closed.

The types of applications running on the network determine the bandwidth needs and help determine wireless performance requirements. Applications such as wireless Voice over IP (VoIP) require extremely reliable, high-speed transmissions. Corporations are increasingly using WLAN as the transport for VoIP. Network Quality-of-Service (QoS) is critical for this application. Ongoing site surveys are important to ensure satisfactory QoS is maintained.

Periodic site surveys can help spot potential problems before they become serious. Network engineers and technicians should perform their own site surveys for validation and documentation purposes. During periodic site survey auditing, rogue access points, and wireless coverage issues can easily be identified, enabling quick resolution.

Locating "foreign" hotspots – indoors and out

The tremendous popularity of 802.11 a/b/g networks is spawning hundreds of thousands of wireless hotspots around the world. This presents potential interference problems for corporate networks, compounded by two major factors:

1) WLAN operates in an unlicensed spectrum, enabling anyone to use the channel of their choice
2) The price of WLAN network equipment is dropping at a very fast pace, making wireless increasingly economical and resulting in increased access point (AP) density at hotspots.

These factors lead to areas of dense WLAN saturation. Also, consumers often do not change access point channel settings from the factory default. This leads quickly to saturation in channel 6 (typical default), causing difficulty and frustration for the enterprise located near residences or small businesses.

Access points are being installed by municipalities in public areas and by private network owners in corporate facilities. Wireless is now commonplace in residential areas and in apartment complexes. All these access points create potential interference for new wireless networks that are within range. **Your WLAN performance will more accurately match your design if you know more about the intended network environment.**

When performing a site survey, it's especially important to identify and locate any nearby neighboring access points. For companies offering public hotspots, site surveys are necessary to search for competing access points and other potential sources of interference.

Requirements specification and network planning

The starting point of the process is the requirements specification. This is often created by interviewing the customer, analyzing or estimating network user behavior and estimating the wireless WLAN capability. Planners gather as much information as possible about the facility, the customers, and their needs. Development of the requirements specification is typically a manual process, requiring expertise in WLANs and involving discussions with network users.

The purpose of network design is to determine access point locations. The more design work that can be conducted off-site, the more time will be saved in the subsequent phases. Access point locations must be determined to ensure coverage requirements are met. There should be sufficient overlap in the coverage areas to provide seamless roaming, while a minimal number of APs should be planned for cost-efficiency. In addition to the access point locations, antenna types, and power levels will need to be determined.

There are several schools of thought for planning access point locations for a WLAN. Some methods are explained below, starting from the least accurate methods.

- Neglect – Ignore the planning, go on site and place the access points in "obviously good locations." At the very least, a paper floor plan can be marked up to create a survey.
- Flooding – To "make sure," crowd the area with access points
- Rule of thumb – Use some ground rules, such as one AP per 10,000 square feet
- Computerized planning – Use a computer program to assist in network planning

Use simulation tools to predict performance and plan building design

Computerized planning is highly recommended to save time and costs in the actual deployment phases. It will deliver the most accurate design and help you avoid surprises during the deployment phase. In many cases, the WLAN design must be completed based solely from construction drawings, as in the case of new buildings. There are many wires required to operate a wireless network! The planning of cable paths and spaces must be accommodated up-front in building design. This is only effectively possible when using PC-based tools that can simulate different building materials and construction methods, as well as the placement of access points, allowing a prediction of wireless network performance even before construction begins.

Pre-deployment site survey

The pre-deployment procedure is optional, if the network planning procedure is done carefully enough. If you are confident the network plan created off-site will suffice, then you can move directly to deployment phase. If there is any doubt about the network plan, a pre-deployment survey should be conducted on-site prior to the deployment.

The pre-deployment survey is performed using one or more access points. The access point(s) are temporarily placed in the planned locations throughout this process. Multiple measurements are made and documented for each access point location to ensure the access points in each location will provide the planned coverage and performance. The access point is then moved to the next location after the measurements are made and the process is repeated.

This approach works well with computerized planning tools that track and record wireless signal measurements from access points that are then moved to new locations. Without such tools, it is difficult to visualize coverage and interaction between adjacent areas.

Deployment

Prior to deployment, the network plan should be accepted by the end customer and/or project management.

WLAN deployment includes installing cabling, switches, access points, and antennas. Access points and switches are configured, and installation notes are added to site survey documentation.

Using traditional methods, the deployment of WLANs is very time-consuming, manual work. Without using computerized site survey tools, the performance of the deployed network is often inconsistent with the design. Some issues related to manual surveys that affect deployed performance are explained below.

The locations for access points are estimated manually, without using appropriate tools. This leads to guesswork on the coverage areas, co-channel interference, signal-to-noise ratio and – in the end – WLAN performance. The lack of network planning often leads to a "better safe than sorry" approach where an unnecessarily high number of access points are deployed at a high cost. In many cases, fewer access points deployed in optimal locations would have performed just as well, or even better.

Manual pre-deployment and verification processes are time-consuming and inaccurate. Think about walking around with a laptop or a PDA, manually writing down signal readings at each location. Taking one measurement per room is usually not enough given the fact that measured signals tends to change significantly depending on the surveyor's physical orientation within rooms.

There is no way to determine the co-channel interference of WLAN networks in the planning or pre-deployment phases using manual processes. This is because co-channel interference is best measured when the users actually start using the network. Automated tools and pre-deployment site surveys enable more accurate prediction and analysis of co-channel interference.

Documentation, including installation notes, is often created on paper or on a laptop computer. **Constructing the final report** to include all necessary information includes copying the survey notes to the report as well as coverage area maps and all other required elements (such as data rate maps and detailed access point information).

Planning for added capacity to the network becomes difficult if there is little understanding of the current network.

Verification

The WLAN verification process should be conducted immediately after deployment of the WLAN. Measurements are taken and stored in a similar fashion as the pre-deployment survey, except during this survey, the access points are no longer being moved. The verification results are then compared to the network plan and any differences between the plan and the actual performance are corrected. Performance tuning may include shifting antennas, adjusting power levels, and adding or moving access points.

Reporting

Network coverage and performance, as observed in the verification survey, must be documented. Preferably two reports are created: one for internal use by the deployment company, and one for the end customer. The internal report usually contains more data than the end customer report.

The report will include information such as:

- Coverage area maps
- Number of audible access points per location for backup purposes and to visualize significant overlap
- Data rate estimation, preferably on a map
- Signal-to-noise ratio per location
- Interference caused by other access points in the network and access points outside your own network
- Installation notes, including cabling, transmit power levels, access point and antenna mounting information, access points locations, technologies used, access point MAC addresses, channel numbers, and network names
- Information about network security measures

For some end customers, the implemented security measures, coverage maps, expected data rate and access point locations are sufficient information. For the internal report, all the information above should be reported.

Designing and deploying wireless LANs using InterpretAir ™ WLAN Survey Software

InterpretAir WLAN Survey Software requires only a laptop and a wireless network card to operate. It supports 802.11a/b/g, displays security measures (WEP, WPA) used, and locates all access points – even those that are hidden or "closed" (depending on the network card used). InterpretAir software supports multi-floor surveys, which means a whole building, or even several buildings, can be included in a single project file. Access points located on the floors above or below the current floor will also be discovered and displayed properly when surveying using the InterpretAir application.

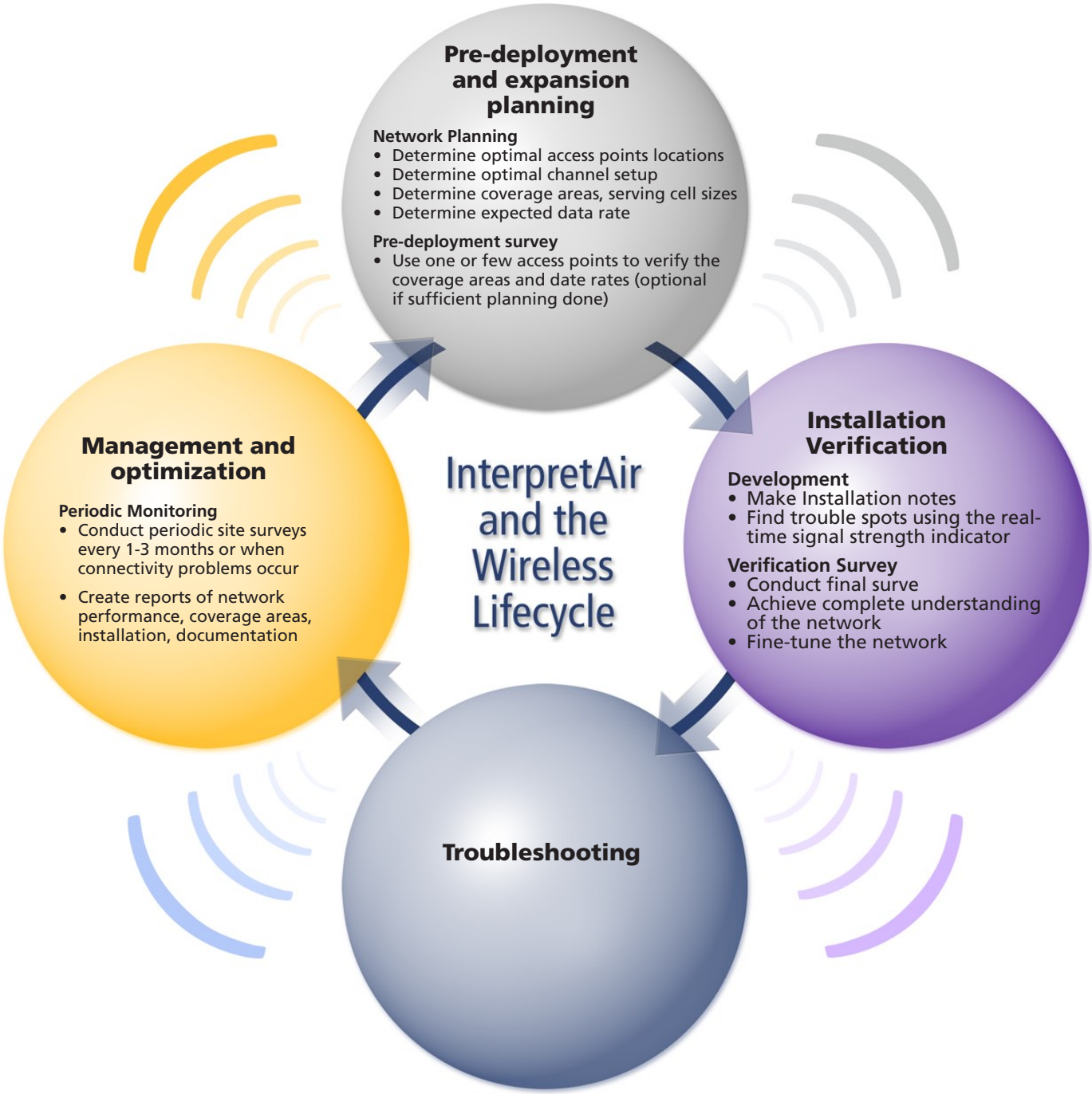


Figure 1 – InterpretAir software used throughout the wireless lifecycle

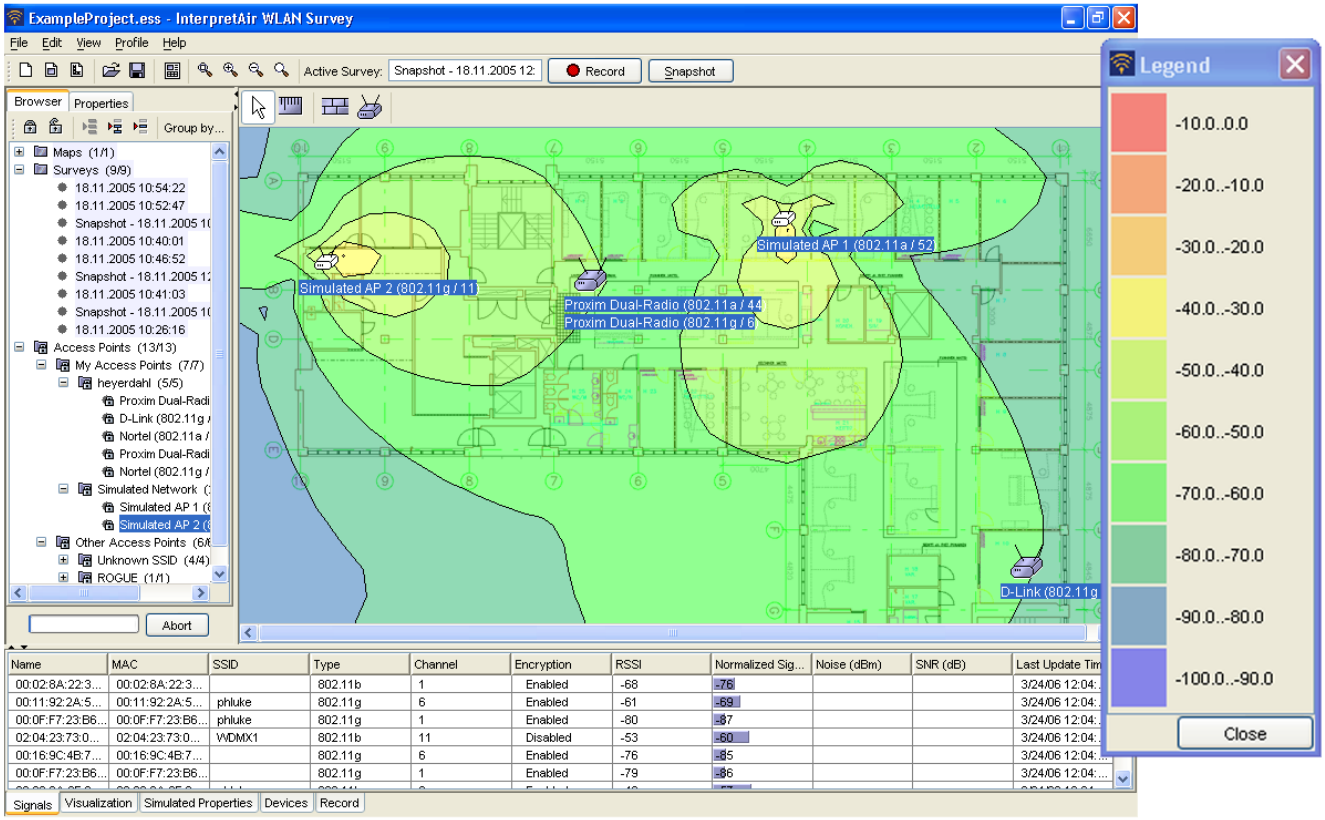


Figure 2 – The InterpretAir application's graphical user interface. An example of signal strength visualization is displayed in the main window with the matching dBm-legend on the right. The list of floor plans, access points and surveys (the Browser View) is on the left-hand side. Signal information is updated in real-time in the bottom of the screen.

InterpretAir's graphical user interface is presented in Figure 2. The main window displays the layout of the site, an indoor floor plan or an outdoor map. The browser view on the left lists the maps, surveys, and access points included in the project. Only the selected access points and surveys are used to create the visualizations – which enables, for example, displaying coverage areas of just your network, all the networks or just for rogue access points. Tabs on the bottom provide additional information: real-time monitoring of signal information, visualization properties, properties of connected devices with device properties and a graph displaying signal strength variation over time.

InterpretAir software answers questions about optimal access point locations, channel numbers, and the expected coverage and performance. With the click of a mouse, the user can place and move access points, change antenna types, and modify transmission powers. The results of the predicted network coverage and performance are immediately visualized on the map without having to apply the changes and having to wait for a re-rendering of the visualizations.

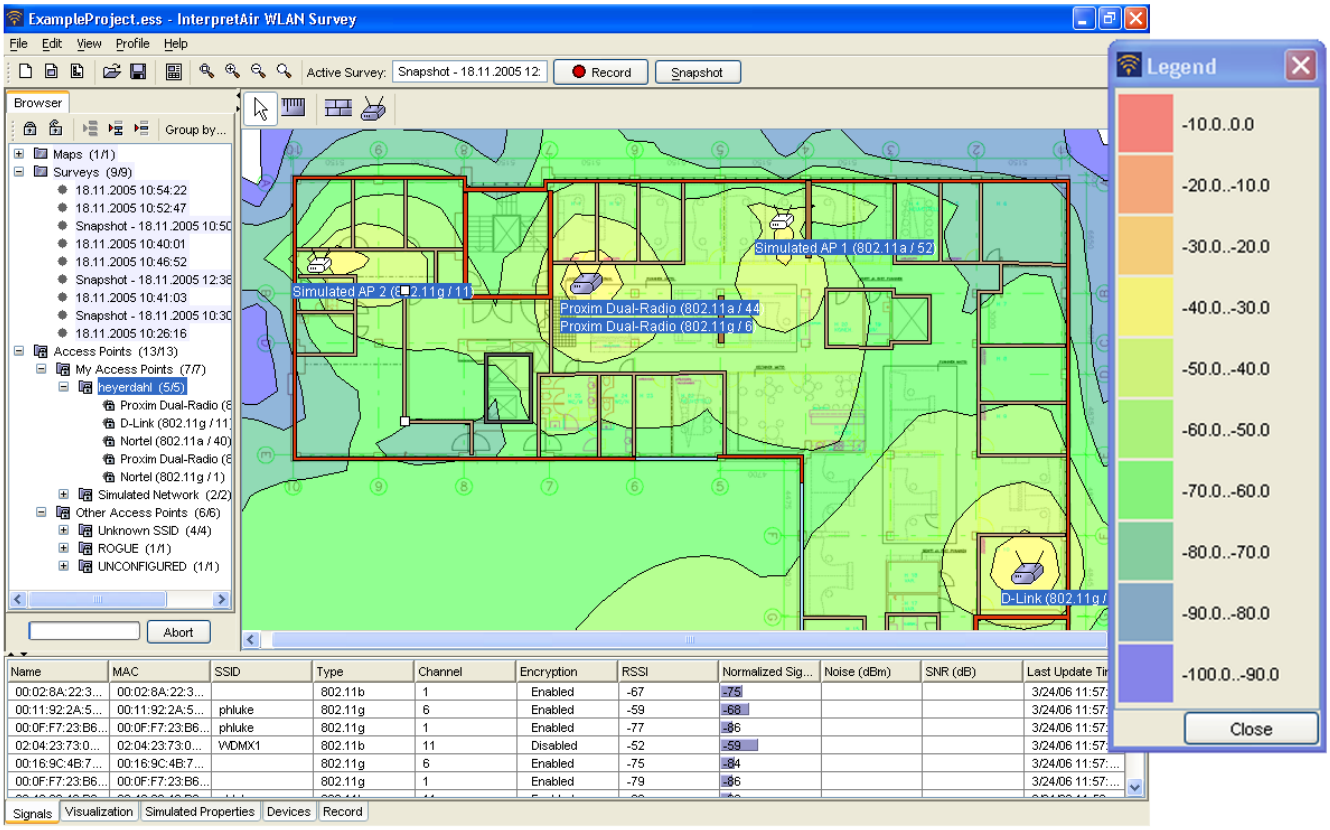


Figure 3 – InterpretAir software incorporates advanced prediction technology to provide accurate off-site results of network performance. Notice the colored walls on the map. The graphical user interface remains the same whether predicted or measured data or a combination of both is used.

One difference with network design and verification using InterpretAir is that predicted and simulated performance is often used in design instead of measured data. Wall locations and construction materials may be defined in order to provide an accurate simulation of performance. InterpretAir software provides “wall types” drawing and editing tools for this purpose.

Surveys are based on bitmap or JPEG floor plans, often created from scanned blueprints of the facility. A digital image of the fire-escape plan or even a rough sketch will do if architectural drawings are unavailable.

During the survey process, a surveyor walks around the facility with InterpretAir on a laptop PC. WLAN measurements are gathered constantly, rather than only at specific points. While collecting measurements, the user clicks on the map whenever he stops or changes direction, and InterpretAir interpolates the data for the locations between clicking beginning and end points. For example, in a long hallway, a surveyor only clicks on the map at the beginning of the hallway, and then clicks on the map when he reaches the end. The measurement data collected is automatically spread out all along the hallway. An example of a survey route is displayed in Figure 4.

The coverage area or data rate visualizations can be updated in real-time as the user conducts the survey. There may also be several surveys in one project file. At a large site, walking around the site alone may take hours and surveyors will need to take an occasional break. Storing data from multiple surveys enables comparison over time; every one to three months, the network administrator should survey the site again to immediately visualize the differences in coverage areas, to locate broken and rogue access points.

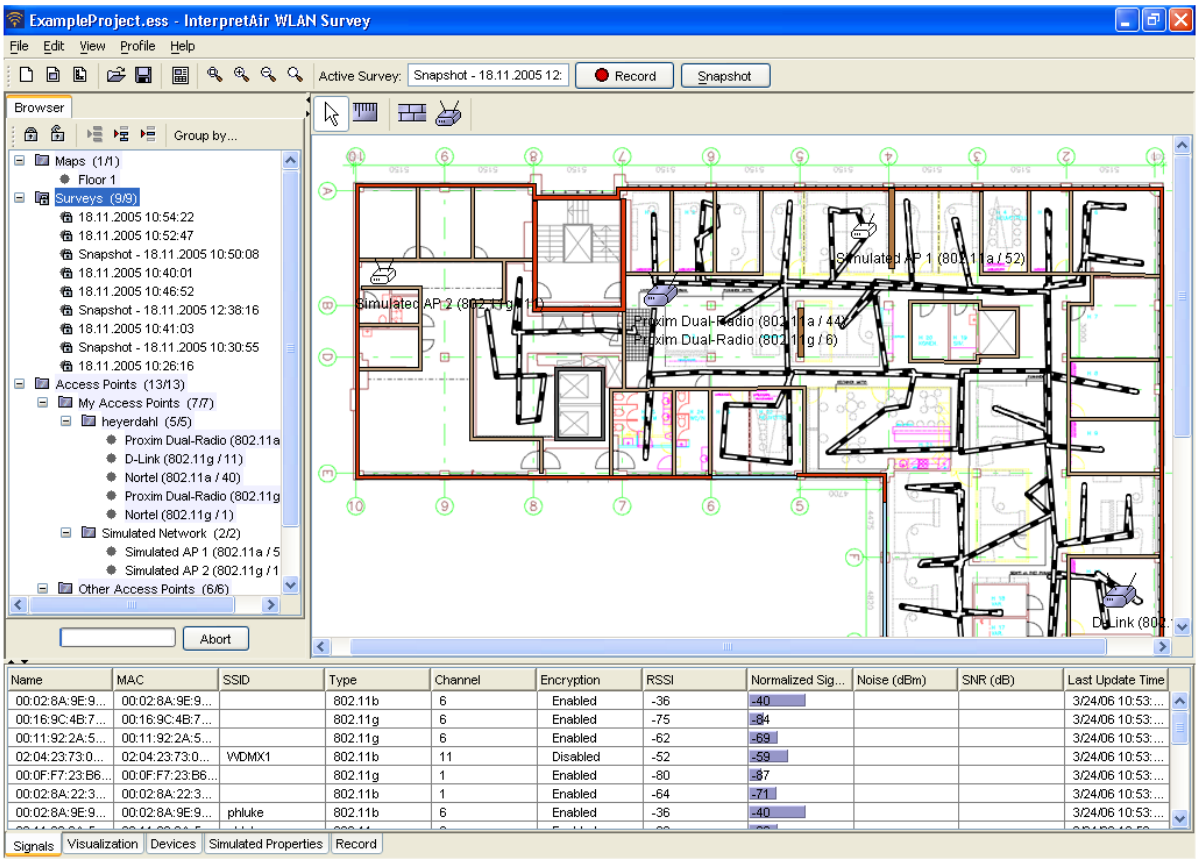
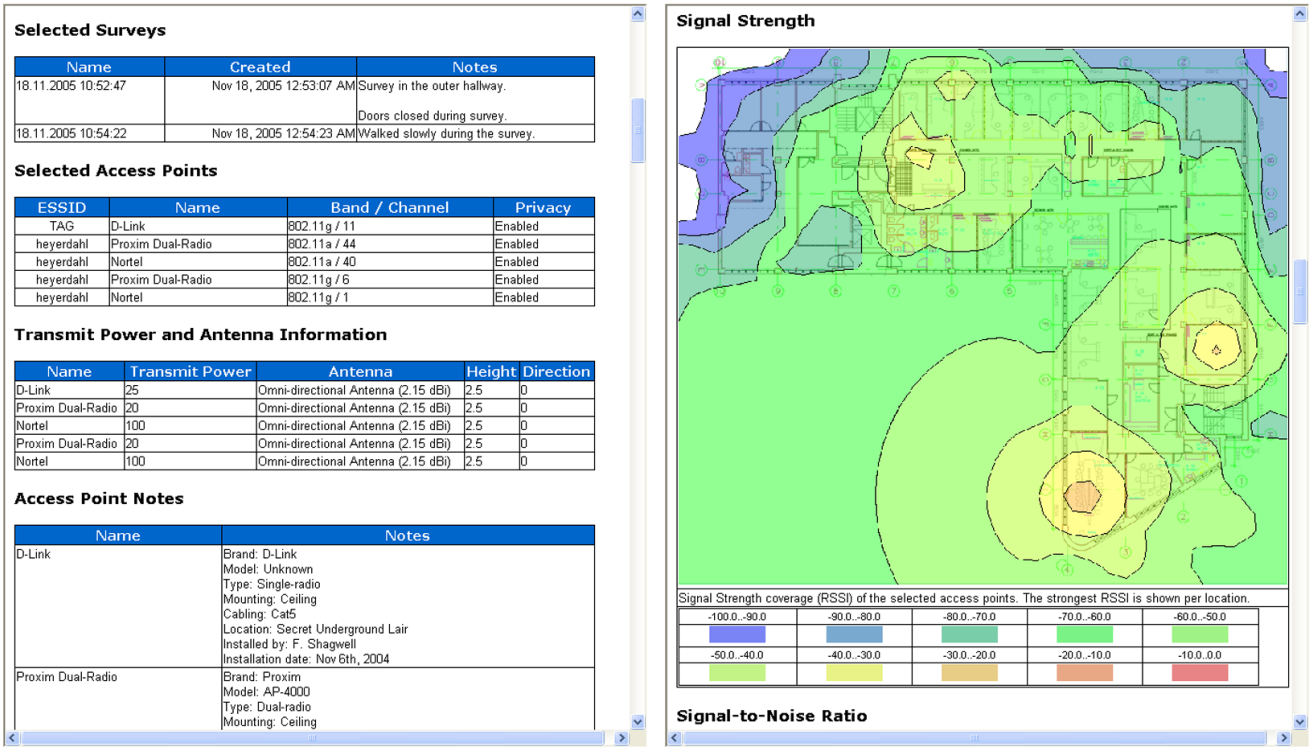


Figure 4 - Survey route displayed on a floor plan

Report Generation

InterpretAir automatically creates HTML reports that include all the access point information, installation notes, access point locations, and most importantly, the coverage and performance maps. The software offers a customizable reporting framework and the possibility to use several templates. Thus, complete, customized network performance reports can be created: one for the end customer and one – more detailed – for the internal use of the IT-department. Figure 5 provides two sample reports.



Selected Surveys

Name	Created	Notes
18.11.2005 10:52:47	Nov 18, 2005 12:53:07 AM	Survey in the outer hallway. Doors closed during survey.
18.11.2005 10:54:22	Nov 18, 2005 12:54:23 AM	Walked slowly during the survey.

Selected Access Points

ESSID	Name	Band / Channel	Privacy
TAG	D-Link	802.11g / 11	Enabled
heyerdahl	Proxim Dual-Radio	802.11a / 44	Enabled
heyerdahl	Nortel	802.11a / 40	Enabled
heyerdahl	Proxim Dual-Radio	802.11g / 6	Enabled
heyerdahl	Nortel	802.11g / 1	Enabled

Transmit Power and Antenna Information

Name	Transmit Power	Antenna	Height	Direction
D-Link	25	Omni-directional Antenna (2.15 dBi)	2.5	0
Proxim Dual-Radio	20	Omni-directional Antenna (2.15 dBi)	2.5	0
Nortel	100	Omni-directional Antenna (2.15 dBi)	2.5	0
Proxim Dual-Radio	20	Omni-directional Antenna (2.15 dBi)	2.5	0
Nortel	100	Omni-directional Antenna (2.15 dBi)	2.5	0

Access Point Notes

Name	Notes
D-Link	Brand: D-Link Model: Unknown Type: Single-radio Mounting: Ceiling Cabling: Cat5 Location: Secret Underground Lair Installed by: F. Shagwell Installation date: Nov 6th, 2004
Proxim Dual-Radio	Brand: Proxim Model: AP-4000 Type: Dual-radio Mounting: Ceiling

Signal Strength

Signal-to-Noise Ratio

Figure 5 – Reports automatically generated by InterpretAir

Deployment assistance features

A couple of handy deployment aids are included in the InterpretAir application. The first one is for finding optimal channels. Whether analyzing planned or measured data, the user may easily simulate the differences in network performance if channel settings are changed. For each access point, the user may change the channel in the InterpretAir user interface before making modifications to the actual access points. Interference, signal-to-noise ratio, and data rate visualizations are updated accordingly to simulate what the network performance would be if the channels were actually changed. This helps determine the optimal channel selections for your network.

Another deployment aid assists in the pre-deployment survey phase. Network professionals prefer to use one or two (perhaps battery-powered) access points that are moved around the site between the potential access point deployment locations. Combining the survey information of all the planned access point locations gives a good estimate of how the actual network will perform without having to purchase all the access points beforehand. The “Freeze Access Point” feature allows a single access point(s) – when moved between several locations - to be treated as if there are several individual access points. InterpretAir can combine the gathered information to simulate as if the whole network was already in place, even if only one access point is used and placed in several locations. Every time this “mobile access point” is turned on at a different location, InterpretAir can “freeze” the previous access point information.
This enables visualization of the combined coverage areas, estimated co-channel interference, signal-to-noise ratio, and data rate of the “virtual network.” Notes are typically taken during the survey process. InterpretAir allows the surveyor to record notes on each individual access point, as well as for each survey.

Analyzing the surveyed data

For analysis purposes, visualizing the data on the floor plan is the key part of an InterpretAir WLAN Survey. The visualizations are explained in Table 1.

Table 1 - InterpretAir Site Survey visualizations described

Visualization	Description
Signal strength	The signal strength in dBm: specific requirements can be set, such as minimum dBm values as well as backup requirements in case of access point break-downs.
Signal-to-noise ratio	The calculated signal-to-noise ratio: 802.11 channel overlap is taken into account.
Interference	The calculated interference. As in signal-to-noise ratio and data rate, the estimated network load can be selected.
Data rate	The expected data rate for the user: a minimum SNR threshold can be selected, as well as the network card that the users will use.
Signals at channel	Signals at selected channel only: channel overlap is taken into account.
Access point count	The number of audible access points per location, with respect to the selected minimum signal strength.
Access point placement tip	Answers the question: Where should I place my next access point in order to maximize the overall coverage of the network and minimize the interference? The most optimal location for the next AP can be analyzed for each channel.
Access point location	Locates the selected access point(s) accurately. Useful for finding rogue access points and access points of the neighboring networks.
RF health	Visualize measured metrics against user defined performance criteria, speeding network performance analysis
Fail Reason	Detailed analysis of measured metrics against customer defined performance criteria.

Comparison of survey methods

It's not easy to estimate the time consumed during a site survey when different tools are used. The estimate is based on assumptions, as well as hands-on experience and customer interviews. We assume the "traditional method" consists of using a client manager software bundled with the network card, writing down signal readings on a paper map, and manually constructing the site survey report. With InterpretAir WLAN Survey software, only InterpretAir and a laptop are required.

Consider an indoor WLAN installation of 20 access points and 100,000 square feet, 100 rooms of 1,000 feet each. The customer requires that two access points are audible at all locations to enable seamless roaming. Each access point covers about 10,000 square feet, or 10 rooms. The total number of access points in this example is 20.

The calculations in table 2 are rough estimates. The time it takes to move the access points is not taken into account because it is the same whether using InterpretAir or traditional methods.

Table 2 Method Comparison

	Traditional method	InterpretAir WLAN Survey
Network planning	Use rule-of-thumb method to estimate optimal access point locations. 2 minutes per access point **40 minutes**	Use InterpretAir to find optimal access point locations and analyze performance 1 minute per access point **20 minutes**
Constructing the proposal and work order	Manually draw estimated coverage areas. Write down planned access point information.	Report including network coverage and performance maps plus AP information automatically generated.
	Write the proposal with estimated coverage maps, AP locations, antenna types and transmit powers. **3 hours**	Write notes; generate report automatically **20 minutes**
Pre-deployment	For each planned access point location, take three readings per room using a utility shipped with the network card. Write down readings on paper.	For each planned access point location, walk around the coverage area of the AP, clicking on the map as you go.
	20 access points 10 rooms, 10,000 sq ft 2 measurements per room 20 seconds per measurement 6 minutes to walk 10,000 sq ft = **15200 second = more than 4 hours**	20 access points 10,000 sq ft / AP 6 minutes to survey 10,000 ft **=120 minutes = 2 hours**
Post-deployment	Walk the site, take three measurements **per room for each access point** using a utility provided with the network card. Write down measurements on paper.	Walk around the facility once clicking on the map as you go.
	100 rooms= 100,000 sq ft 2 readings per room 40 seconds per reading 60 minutes to walk around the site **=11600 seconds = 3 hours**	60 minutes to survey 100,000 sq ft **60 minutes**
Channel optimization	Guesswork and rework to correct **2 hours**	Visualize the effect of channel changes on performance immediately. **30 minutes**
Reporting	Draw coverage maps for each access point manually. Manually write down access point MAC-addresses, access point locations, channels, installation notes and so on. **4 hours**	Automatically generate report with two mouse-clicks. Some additions written manually. **15 minutes**
TOTAL	**~16 hours**	**~4 hours**

As the previous table indicates, InterpretAir WLAN Survey cuts manual survey time by 75%. Moreover, the survey results are more accurate, the reports are higher quality, and the overall network performance will more closely match the network design.

The future of WLAN deployment

As wireless continues to mature, new wireless applications and appliances continue to emerge. There is increasing demand for transmitting voice and video, as well as the need for accurate positioning of users and assets using the WLAN. In order to support these applications, there will be stringent requirements for wireless networks. Site survey tools are invaluable for designing and optimizing WLAN networks to support these applications.

Conclusion

Site surveys remain an important step to ensure reliable, high-performance network deployment. Intelligent software for design, deployment verification, monitoring, management, and reporting make site surveys easier to perform and simplifies analysis of WLAN performance.

WLAN design and deployment does not have to be cumbersome and time-consuming. InterpretAir software saves time and enables network professionals to easily build high-performance networks. Compared to traditional tools and methods, InterpretAir can cut your survey time in half and reduce your reporting and data analysis time by up to 90%. In addition, InterpretAir can be used in combination with other tools, such as spectrum analyzers and WLAN monitoring and management tools, to achieve optimal results.